Technical Guidance for Evaluating Selected Solar Technologies on Airports

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Office of Airport Planning and Programming
Airport Planning and Environmental Division (APP-400)
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NOTE: As of October 23, 2013, the FAA is reviewing multiple sections of the "Technical Guidance for Evaluating Selected Solar Technologies on Airports" based on new information and field experience, particularly with respect to compatibility and glare. All users of this guidance are hereby notified that significant content in this document may be subject to change, and the FAA cautions users against relying solely on this document at this time. Users should refer instead to the Interim Policy (http://federalregister.gov/a/2013-24729).

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16. Abstract

Airport interest in solar energy is growing rapidly as a way to reduce airport operating costs and to demonstrate a commitment to sustainable development. In response, the Federal Aviation Administration (FAA) has prepared *Technical Guidance for Evaluating Selected Solar Technologies on Airports* to meet the regulatory and informational needs of the FAA Airports organization and airport sponsors.

For airports with favorable solar access and economics, this report provides a checklist of FAA procedures to ensure that proposed photovoltaic or solar thermal hot water systems are safe and pose no risk to pilots, air traffic controllers, or airport operations. Case studies of operating airport solar facilities are provided, including Denver International, Fresno Yosemite International, and Albuquerque International Sunport.

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Preface

Over 15 airports around the country are operating solar facilities and airport interest in solar energy is growing rapidly. In response, the Federal Aviation Administration (FAA) has prepared this report, *Technical Guidance for Evaluating Selected Solar Technologies on Airports*, to meet the regulatory and information needs of FAA personnel and airport sponsors in evaluating airport solar projects.

The guidance is intended to provide a readily usable reference for FAA technical staff who review proposed airport solar projects and for airport sponsors that may be considering a solar installation. It addresses a wide range of topics including solar technology, electric grid infrastructure, FAA safety regulations, financing alternatives, and incentives.

Airport sponsors are interested in solar energy for many reasons. Solar technology has matured and is now a reliable way to reduce airport operating costs. Environmentally, solar energy shows a commitment to environmental stewardship, especially when the panels are visible to the traveling public. Among the environmental benefits are cleaner air and fewer greenhouse gases that contribute to climate change. Solar use also facilitates small business development and U.S. energy independence.

While offering benefits, solar energy introduces some new and unforeseen issues, like possible reflectivity and communication systems interference. The guidance discusses these issues and offers new information that can facilitate FAA project reviews, including a flow chart of FAA procedures to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers, or airport operations.

The guidance includes case studies of operating solar projects at Denver International, Fresno Yosemite International, Metropolitan Oakland International, Meadows Field (Bakersfield), and Albuquerque International Sunport. Each case study highlights a particular area of interest such as the selected technology, siting considerations, financing, and regulatory requirements.

The guidance also includes a discussion of solar financing. Most existing airport solar projects involve an airport partnership with private investors. These arrangements take advantage of Federal and state tax credits and state-mandated electric utility purchases of renewable energy. Sponsors benefit from these arrangements through lower airport electric utility bills, lease revenues, and the delegation of maintenance costs. Federal resources for airport solar development are discussed also.

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1 AIRPORTS AND SOLAR ENERGY: CHARTING A COURSE

Though solar energy has been evolving since the early 1990's as a mainstream form of renewable energy generation, the expansion in the industry over the past 10 years and corresponding decrease in prices has only recently made it a practical consideration for airports. Solar energy presents itself as an opportunity for FAA and airports to produce on-site electricity and to reduce long-term electricity use and energy costs. While solar energy has many benefits, it does introduce some new and unforeseen issues, like possible glare (also referred to as reflectivity) and communication systems interference, which have complicated FAA review and approval of this technology. This guide discusses such issues and how FAA reviews for solar projects can be streamlined and standardized to a greater extent.

Given the large amount of new information being created by the solar industry, a brief overview of solar facilities is an appropriate starting point for this report, *Technical Guidance for Evaluating Selected Solar Technologies on Airports*, hereafter referred to as the "*Solar Guide*".

Chapter 1 provides an introduction to solar electricity and how it is delivered to customers. It includes a description of solar photovoltaics (PV), which is one of the more practical applications for airports, other types of solar energy systems, how systems connect and operate with the electric grid, and the specific electricity supply and demand issues associated with solar projects at airport.

Chapter 2 reviews airport site planning issues including the life cycle of a typical solar PV project, project participants, and airport planning considerations for locating solar facilities at airports (e.g., Airport Layout Plan consistency).

Chapter 3 examines the regulatory issues that FAA must consider, including Title 14 of the Code of Regulations (CFR) Part 77 (Airspace Review) and obligations under the National Environmental Policy Act (NEPA).

Chapter 4 describes the financial landscape for solar projects including the government incentives available to fund projects and how the different ownership models (e.g., public vs. private) can maximize project cost-effectiveness.

Chapter 5 reviews the Federal government's role in solar development and includes recommendations for future research and procedural efficiency.

Examples from existing solar projects operating at airports are presented throughout the *Solar Guide* to illustrate the technical, financial, and regulatory issues of solar energy at airports in a practical manner.

1.1 Purpose of the *Solar Guide*

Solar is a renewable energy source that contributes to national goals of sustainability, energy independence, and air quality improvement. It is particularly well-suited to airports because of the available space at airports, unobstructed terrain, and energy demand. A confluence of technological advances, public policy, and market penetration has produced a boom in the solar industry which is intersecting with aviation interests. In a growing number of locations, solar can provide a cost-effective and stable long-term energy supply for airports. This *Solar Guide* discusses the opportunities and trade-offs of solar energy and provides the FAA with clear and consistent procedures for reviewing solar

projects. It also provides the airport sponsors (referred to henceforth as "sponsors"[1]) and the aviation community with a reference for technical, financial, and regulatory issues associated with solar energy.

1.1.1 What is Driving Solar Energy Development?

Governments have a strong interest in furthering the research and development of renewable energy technologies, including solar energy. Renewable energy sources, by definition, utilize natural power produced by atmospheric forces of the earth: sun, wind, river current, tidal current, and waves. These energy sources require no fuel, provide continuous long-term production, and do not create emissions. Fossil fuels (oil, gas, coal), in comparison, are finite and require combustion to release stored energy, which produces gas emissions as a byproduct. Beyond initial developments for the military and space programs, advances in commercial solar energy technology have been catalyzed by periodic disruption of fossil fuel supplies and the escalation in energy prices starting in the early 1970's. Significant investments by government and private capital have increased exponentially since then through a confluence of forces including awareness of climate change and concerns about national security and energy independence. In addition, the U.S. has benefitted from investments by European nations over the past 20 years, particularly in the areas of wind and solar, which have broadened the technology and commercialization, resulting in higher system efficiencies and lower prices.

The types of public policy enacted by government include changes in laws, regulations, tax policies, and agency programs. For example, the U.S. Congress approves Federal tax credits and appropriates funds for renewable energy research and development programs administered by the Department of Energy (DOE) and its National Laboratories and Technology Centers. Federal agencies establish policies for leasing Federal lands for private renewable energy development. States enact laws that require electric utilities to provide a minimum amount of production through renewable energy sources. In addition, States offer tax credits to lure renewable energy manufacturing facilities to set up business in their State. These credits help private renewable energy developers to either offset the initial high capital costs of equipment or to reduce the cost of renewable electricity as it is produced. The financial implications of government stimuli, in terms of legislative reform and in funding appropriations and tax credits, bear significantly on the economic feasibility of solar technologies at airports and are explored in detail in Chapter 4.

1.1.2 How is Solar Energy Impacting Airports?

Growth of the solar energy industry has led developers to approach airports with a business prospect of locating solar facilities on airport due to the availability of cleared open space and high energy and electricity use. More indirectly, private developers have proposed large-scale solar developments off airport in areas utilized by aviation either near airports or along common flight paths. These interactions have caused the aviation community to question in a broad sense whether solar energy generation is compatible with aviation due specifically to issues such as glare, radar interference, and physical penetration of airspace. The FAA also has had to consider whether airport solar projects it approves are consistent with an airport sponsor's Federal obligations regarding financial self-sustainability and retention of airport revenue, as well as national environmental policy.

Before these specific issues can be addressed, however, it is important to discuss the basics of solar technology and electric generation.

[1] Airport "sponsors" are planning agencies, public agencies, or private airport owners/operators that have the legal and financial ability to carry out the requirements of the Airport Improvement Program (AIP). The term is also used in this document to refer to the Passenger Facility Charge (PFC) program, which is restricted to "public agencies."

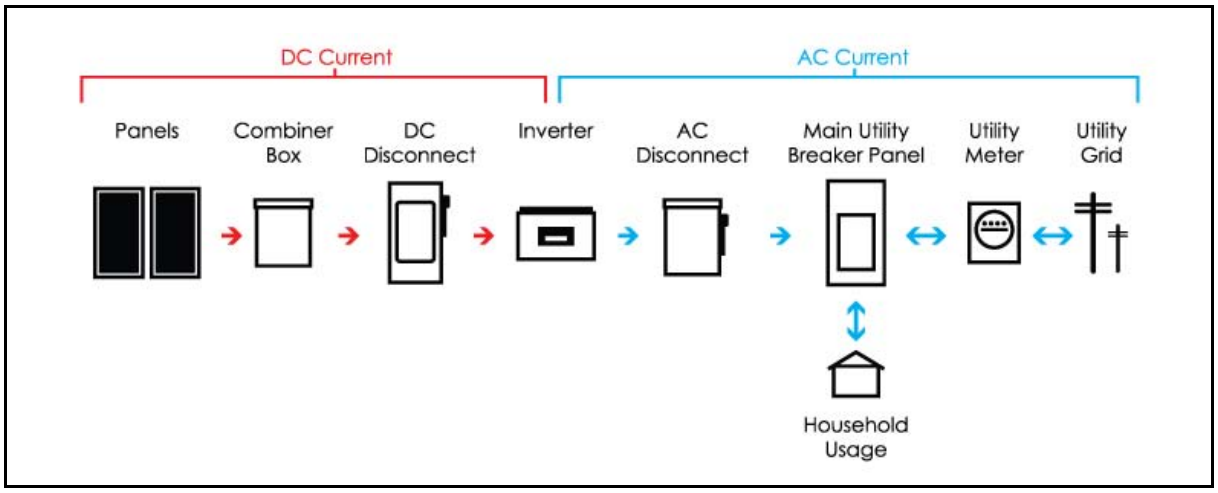
1.2 Solar PV Basics

A solar PV system is made up of multiple components that collect the sun's radiated energy, convert it to electricity and transmit the electricity in a usable form. A schematic diagram of such a system is shown in Figure 1 below.

The main component is the solar panel, which is comprised of a group of individual solar cells that convert sunlight energy to electricity. The panels are held in place by a frame which is either fastened to an existing structure or is placed atop a stand that is mounted on the ground. Panels are typically comprised of 40 individual solar cells. Several panels connected together in series are identified as a "string" and often operate as a single generating unit, meaning if one panel becomes inoperable, it shuts down the entire string. Multiple strings assembled together into one solar facility are referred to as an "array."

The electricity produced by individual panels is direct current (DC) which is brought together in a combiner box and fed as a single DC flow to an inverter. The inverter converts the electricity that is produced by the PV cells from DC to alternating current (AC), a form that can be tapped by users of the electrical grid (grid-connected systems are also referred to as a grid-tie system).[2] Disconnects are located in both the DC and AC lines to allow the utility company to interrupt electrical current during repair and maintenance.[3] A breaker panel is necessary for protecting the system from short circuits and voltage surges. A utility meter accounts for the amount of electricity transfer between on-site service and the utility grid.

Figure 1: Schematic Diagram of a Typical Grid-Connected Solar PV System



Source: http://www.affordable-solar.com/grid.tie.htm

1.2.1 Types of Solar PV Technologies

The primary types of PV technologies applicable to airports are those associated with crystalline silicon panels. Solar cells assembled in panels are made of silicon and are the most efficient technology for

[2] Stand alone systems that are not grid-connected utilize a charge regulator or a controller. They also require a battery to store electricity and make it useful during times when the sun is not shining.
[3] The fire department should be consulted on disconnects to allow access to the system in the event of an emergency.

converting light energy to electricity. Monocrystalline panels are made of large silicon crystals which are less common and therefore more expensive but also operate more efficiently. Polycrystalline panels are made of many small silicon crystals and are the most common type of solar panel. Crystalline silicon is cut into disks, polished and connected together with metal conductors, and assembled on a panel. The panels are covered by a thin layer of protective glass and the panel is attached to a substrate of thermally conductive cement which traps waste heat produced by the panel and prevents it from overheating.

Other types of PV technologies include thin film and multi-junction versions. Thin-film solar is made from amorphous silicon or other materials such as cadmium telluride. While less efficient than traditional solar cells, thin-film can be deployed less expensively on flat building surfaces such as building rooftops and facades to generate electricity. Multi-junction systems consist of multiple thin-film layers that increase efficiency. Newer solar technologies are being developed using inks and dyes produced through traditional printing techniques to decrease costs and expand deployment opportunities[4].

The U.S. Department of Energy's National Center for Photovoltaics is the central location for research and development utilizing the expertise of the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories.

1.2.2 Energy Conversion Process and Efficiency

Photovoltaic devices convert light energy to electricity. When semiconducting materials are exposed to light, they absorb some of the sun's energy in the form of photons and emit electrons in the form of electricity. However, the amount of electricity that can be generated is only a percentage of the total amount of the sun's energy available. Physical limitations of converting photons to electricity have been established in the laboratory -- some photons reflect away from the panels and some pass through the panels, so that the electricity conversion efficiency for today's photovoltaic panels is between 6 and 20% of the total energy available. In comparison, the burning of fossil fuels is about 28% efficient. Also, as operating panels age and degrade, their efficiency goes down (on average about 0.5% each year).

Solar electricity performance is affected on-site by geographic, meteorological, and technical conditions. Electricity production is dependent on the amount of solar irradiance (i.e., sunshine intensity) at any one location, cloud cover, and other environmental factors such as smog and dust. The amount of energy available also changes daily and seasonally depending on the position of the sun in the sky. For any location, the maximum solar irradiance will occur at 12:00 noon on the summer solstice. Solar irradiance is typically measured in "peak sun hours" which defines the number of hours (on average) where a location can produce 1 kWh/m^2 (kilowatt-hour per meter squared). Information on solar irradiance for specific locations in the U.S. can be found on the NREL website.[5]

Panel capacity is the amount of electricity that can be generated by the panel at maximum output. The capacity is determined by standardized testing in laboratory conditions. Solar panels vary in rated production capacity. Denver International Airport is utilizing 216-watt panels at its Pena Boulevard installation; Albuquerque International Sunport is utilizing 305-watt panels. The panel capacity proposed for any new system will be determined based on many factors including available space and project budget.

[4] National Renewable Energy Research Laboratory. 2010. Solar Research. http://www.nrel.gov/solar/
[5] http://www.nrel.gov/gis/solar.html

Power production from a solar panel is calculated based on (1) the panel's rated power, (2) the solar energy availability (monthly average), and (3) efficiency loss due to elevated operating temperatures. For example, a 315-watt panel in Phoenix Arizona in June with a 3% average efficiency loss for panel heating would be determined as follows:

[315 watts] x [7.13 hours] x [97%] = 2.179 kWh

Regardless of panel rating, electricity production of solar panels increases as the sun rises and the panels warm up. While one might think that maximum electricity production would occur on the summer solstice (June 21) when the sun is highest in the sky (~12 noon), this is often not the case. Production levels off at the ideal design temperature of 25º C (77º F) then begins to decrease as the ambient air temperature increases. Power production decreases by 5% for every 10º C (18º F) increase over the design temperature[6].

1.3 Other Solar Power Generating Systems

Though often less suitable to airports, other types of solar power generating systems exist and are described below.

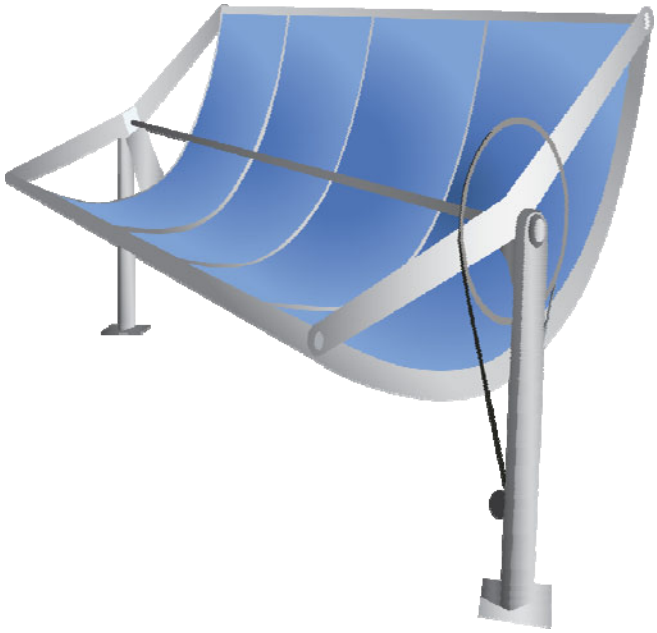
1.3.1 Concentrated Solar

Concentrated Solar Power (CSP) systems use large reflective surfaces in massive arrays to focus the sun's energy on a fixed point to produce intense heat, which is then converted to electricity. The most common means for producing electricity in these systems is to heat water and produce steam, which drives a turbine, usually for the purpose of supplying commercial power to the grid. The two most common CSP designs are parabolic troughs and power towers shown in Figures 2 and 3 below.

Parabolic troughs continually track the sun and concentrate the sun's heat onto receiver tubes filled with a heat transfer fluid. The fluid is heated up to 750º F then pumped to heat exchangers that transfer the heat to boil water and run a conventional steam turbine producing electricity.

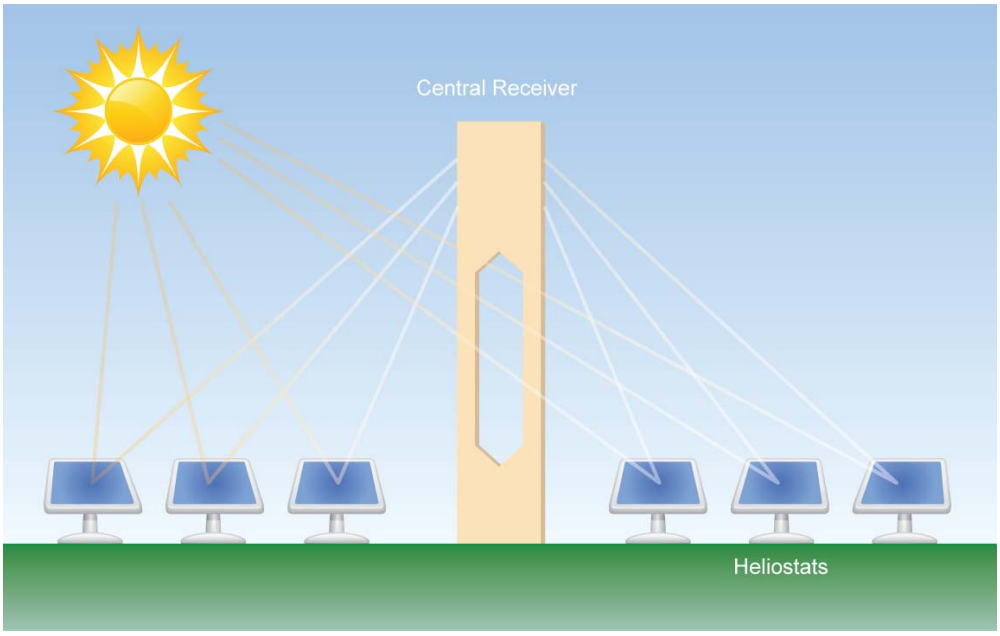
[6] Zauscher, M. 2006. Solar Photovoltaics Panels from a Hear Transfer Perspective. Department of Mechanical and Aerospace Engineering. University of California, San Diego. http://courses.ucsd.edu/rherz/mae221a/reports/Zauscher_221A_F06.pdf

Figure 2: Typical Parabolic Trough Collector



Whereas parabolic troughs focus sunlight to receivers located on each individual unit, power towers focus all the facility's sunlight to a single receiver. The power plant is comprised of individual heliostats (mirrors) arranged in a circular array that track with the sun. Each heliostat reflects sunlight onto the central receiver at the top of a tower. Just like the parabolic trough, a heating fluid transfers heat to create steam to drive a turbine and produce electricity.

Figure 3: Typical Power Tower Collector



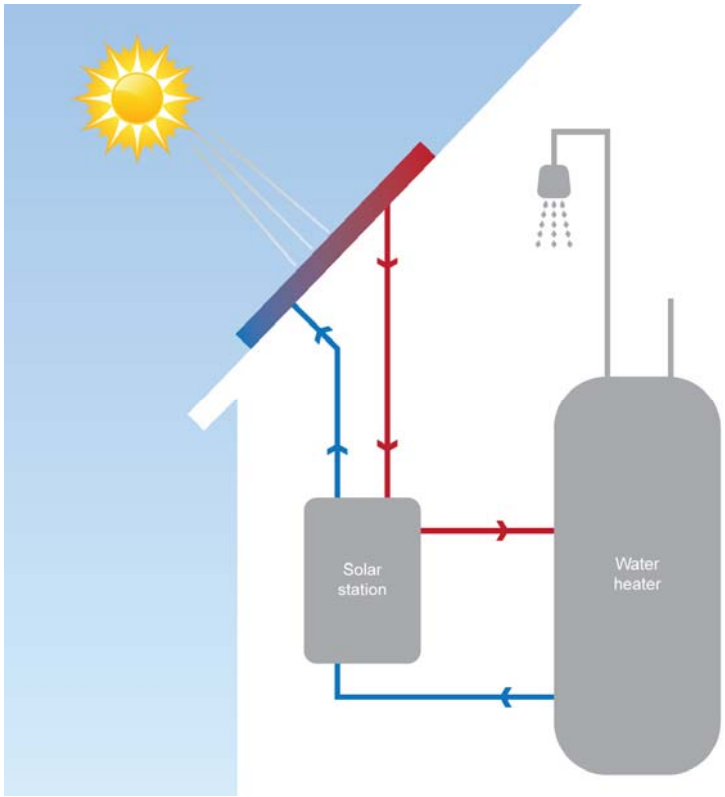
One of the benefits of either form of CSP over PV is that the heated fluids can be used to store energy and delivery electricity even when the sun is not shining.

Concentrated Solar Power projects require enhanced coordination with the FAA due to unique issues with reflectivity, thermal plumes, radar interference, and airspace penetration.

1.3.2 Solar Thermal Hot Water

Solar thermal refers to conventional systems used to produce hot water by exposing water to the sun's energy either directly or by heating a fluid in a closed loop that heats the water, as illustrated in Figure 4. The concentrated solar power systems described above are an advanced form of solar thermal employed to produce electricity in large amounts to feed the electrical grid. Conventional solar thermal systems are deployed as panels that contain coils filled with the heating fluid or water. These systems can be used to serve a single household or a larger residential, commercial, or airport application. Their greatest benefit to areas already served by the electric grid is to minimize the electricity demand on domestic or commercial water heaters to keep water constantly hot.

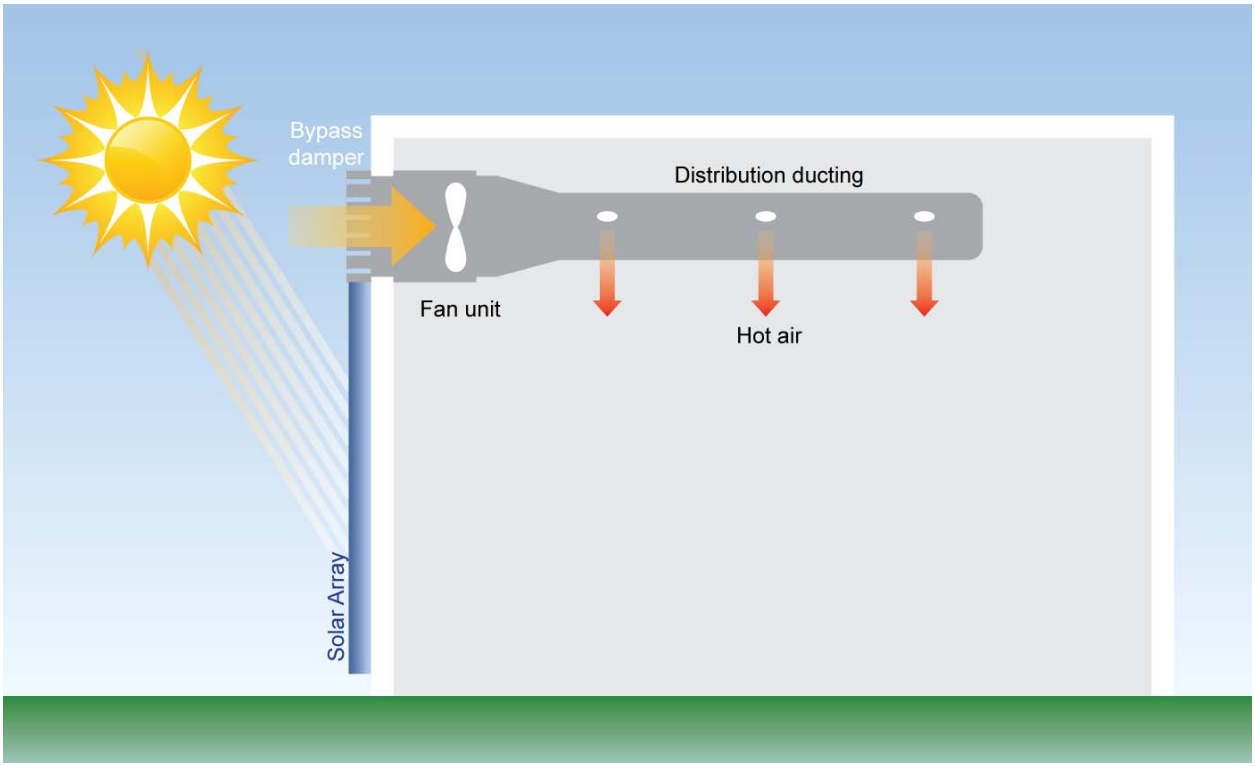
Figure 4: Typical Solar Hot Water Collector



1.3.3 Transpired Solar Collectors

Transpired solar collectors, also referred to as "solar walls," are placed on the sides of buildings to pre-heat ventilation air inside the building, an illustration of which is shown in Figure 5 The design is relatively simple: employ a heat-absorbing metal panel typically on an outer south-facing wall of a building. Air located between the panel and the wall is heated and drawn into the building's ventilation system by circulating fans. Through this process, fresh air is constantly drawn into the solar heated space and then into the building making the system particularly good for building activities that require constant ventilation. The systems are especially effective in sunny climates with long heating seasons.

Figure 5: Typical Solar Wall Collector



1.3.4 Compatibility of Solar Generating Systems with Airports

Given the constraints of some solar energy systems, solar PV tends to be the technology that provides the best opportunity for airports today. Based on available information, solar PV for an airport application has the best cost-benefit ratio of the solar power alternatives. In comparison with CSP systems, solar PV is more compatible with airport land use because it:

1. Is most cost-effective when serving a smaller on-site electricity demand as opposed to large-scale generation for the electricity grid;

2. Has a low profile and modular design, which is compatible with low-demand airport property such as rooftops and airfields; and

3. Is designed to absorb sunlight (rather than reflect it), minimizing potential impacts of glare.

4. Doesn't attract wildlife, which is a critical aviation hazard.

In addition, many airports are currently employing solar PV and reporting reliable and safe performance. In contrast, CSP is typically not compatible with airports. One reason is because CSP requires more space than is usually available on airport property. More importantly, CSP projects in general have raised concerns about hazards to safe air navigation from:

1. Potential glare and glint caused by parabolic troughs and heliostats that might cause temporary loss of vision to pilots on arrival or departure, or to Air Traffic Control personnel in the control tower.

2. Electromagnetic interference with on- and off-airport radar systems that may pick up a false signal from the metal components of the mirrors with impacts that can vary based on solar tracking activity.

3. Physical penetrations of navigable airspace from power towers that extend into Part 77 imaginary surfaces, terminal instrument procedures (TERPS) surfaces, or the path of radio emitting navigational aids.

4. Thermal plumes emitted by the power tower that produce unexpected upward moving air columns into navigable air space.

Conventional solar thermal hot water units can be physically compatible with airport land uses and activities because their design is similar to that of solar PV panels. However, solar thermal has been best demonstrated as a supplementary source for domestic uses based on frequency of hot water use and level of demand. Airports may want to explore the opportunity of conventional solar thermal hot water at the same time they are looking at solar PV depending on specific hot water use conditions at the airport.

Transpired solar collectors are also potentially compatible with certain airport buildings such as hangars or garages. These solar collectors, like conventional solar thermal hot water units, have an advantage over PV and CSP installations in terms of local air quality because they directly offset the airport's consumption of conventional fuels and emissions.

All solar projects are subject to FAA review for compatibility with a safe and efficient air navigation system. The FAA will review solar PV project to ensure that potential issues such as approach slope penetration, reflectivity, and communication system interference are avoided. See Section 3.1 for more information on the review process and standards.

1.4 Photovoltaic Designs for Airports

Solar PV is a technology that can readily be designed into an existing landscape without major modifications due to its relatively simple, modular construction. For the airport environment, this means that PV can be placed in locations that are not used for aviation activities and therefore have little value to the airport or for alternative developments. However, because solar panels are made of expensive materials that keep the cost of solar electricity comparatively high, it is important to minimize the amount of engineering and construction necessary to secure the panels to keep solar electricity cost competitive.

1.4.1 Roof-mountings

Roofs are an optimal location for solar panels because they commonly receive unobstructed sun exposure, as seen in Figure 6. Roofs may also provide a ready-made support structure for a solar installation, obviating the need for costly engineering and materials. Mountings will depend on the type, design, and structural characteristics of the roof and wind-loading requirements of the panels. South facing angled roofs require less support structure than flat roofs or those facing a direction other than south. Special mountings will need to be considered in areas prone to hurricanes and other seasonal weather events. Local building codes provide wind-loading design requirements. Airport buildings often have both flat roofs (e.g., terminal buildings) requiring a generic support structure and angled roofs (e.g., hangers) which may need little in the way of support. An analysis of the existing roof loading capacity must be conducted to determine if structural reinforcement is required which will impact project cost. Project size is also a cost consideration as roof-mounted systems are typically more cost-effective for "smaller" projects whereas ground-mounted projects provide better pricing for larger projects.

Figure 6: Example of a Roof-Mounted Solar PV System

1.4.2 Ground Mountings

Installation of solar panels at ground level, an example of which is seen in Figure 7, requires flat or gently rolling terrain with unobstructed views to the south. Ground-mounted systems also require geotechnical analysis to confirm the long-term stability of the soils that support them, particularly when deploying tracking systems whose efficiency will decrease if the soils destabilize the panel alignment. To avoid destabilization, ground-based panel mountings typically consist of poles and steel beams for extra support. This increases panel-for-panel costs of ground-based systems, though economies of scale can make larger systems more economical when space is not a limiting financial consideration. In addition, while engineering and materials can increase costs, the technical difficulty of the engineering and construction is typically low.

Figure 7: Example of a Ground-Mounted Solar PV Installation

1.4.3 Tracking

Tracking systems employ hydraulic or motor driven mechanisms to move the panels such that they are continuously perpendicular to the sun, maximizing their electric generation potential. An example of a tracking system is seen in Figure 8. Panels can move in two directions to optimize contact with the sun. One direction adjusts vertically to the sun's seasonal position in the sky whereby the panel angle relative to the ground increases or decreases. The second direction is a horizontal movement tracking the sun's daily path from sunrise to sunset. If the system employs one of these tracking systems it is referred to as a "single-axis" system. If it employs both, it utilizes "dual- axis" tracking. Tracking systems introduce a considerable amount of additional technology and complexity to solar systems, which increase capital and maintenance costs. The efficacy of a tracking system depends on a cost-benefit comparison of the increase in electricity production versus the increase in expense. Where maintenance issues are greater, for example in snow or dusty conditions, financial returns decrease.

Figure 8: Example of a Tracking Solar PV Installation

1.4.4 Remote Systems

Solar has become a preferred method to electrify many remote systems. The most visible examples are highway signs and monitoring devices seen along roadways. The advantage of solar for these applications is that they do not require connection to the grid. However, even with a back-up battery, there is the potential risk that power can become interrupted.

Airports, too, have recognized the advantages of remote lighting systems. In January 2008, the FAA issued Engineering Brief No. 76, "Using Solar Power for Airport Obstruction Lighting"[7] to provide guidance on this application. The Brief provides specific design guidance on using solar for remote power applications, and conditions that can make them more cost-effective than connecting to the grid. The guidance in the Brief is applicable to obstruction lights located on- and off-airport property. FAA Advisory Circular (AC) 150-5345-50B, Specifications for Portable Runway and Taxiway Lights, provides additional guidelines on portable airfield lighting for temporary use and solar applications which may include solar charging of batteries. Airports with solar-powered LED obstruction lights include Chicago O'Hare, Los Angeles International, and False River (near Baton Rouge) Louisiana.

1.5 Solar PV Supply and Demand

The feasibility of a solar PV system depends first and foremost on good solar exposure and efficient utilization. Without those features, a solar project is unlikely to be cost-effective even with available tax credits and other financial incentives. The basic factors that affect solar PV electricity supply and demand are (1) the strength of the solar resource, (2) other weather factors influencing project design, and (3) airport-specific practical considerations like amount of electricity used and available space for a project.

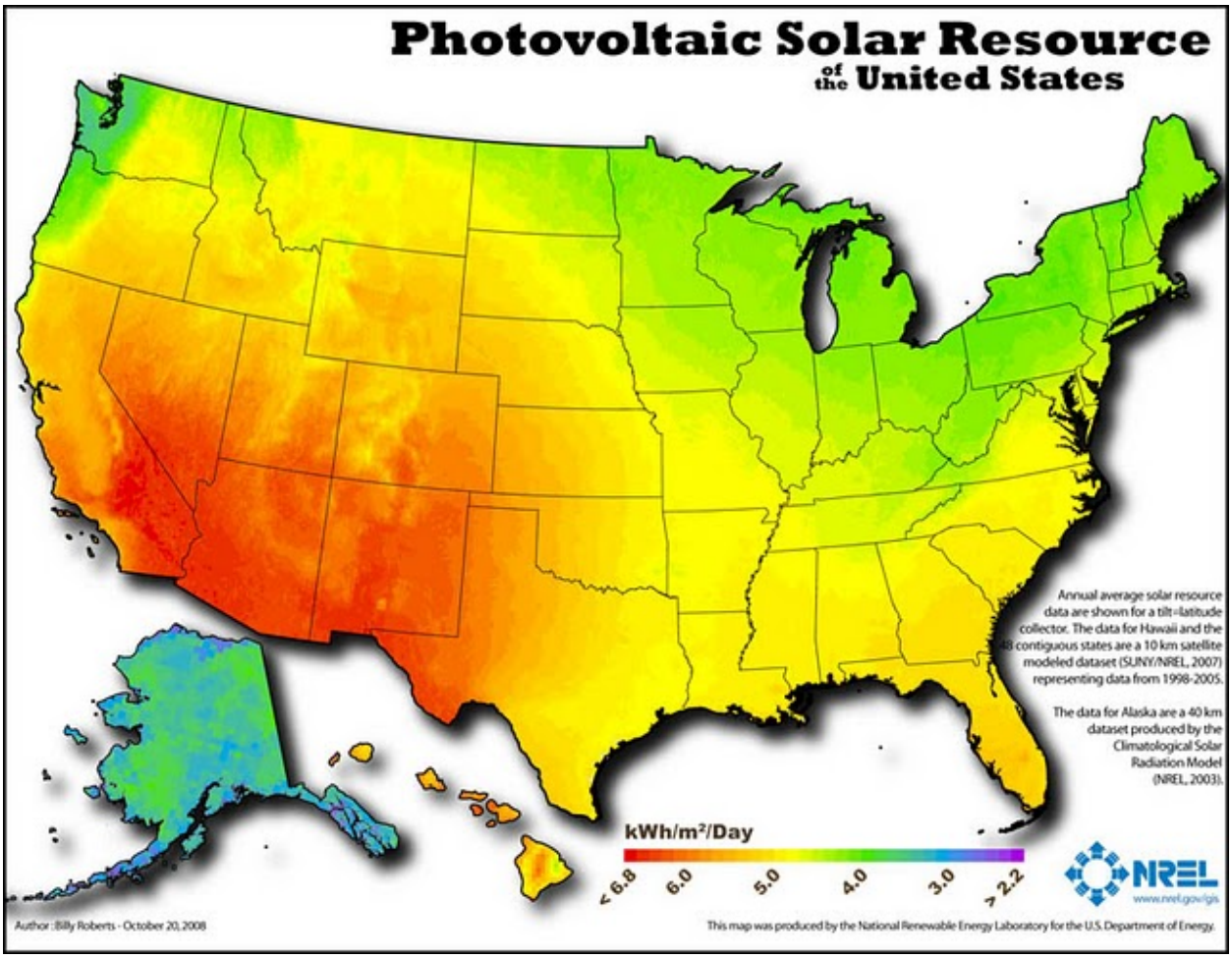
1.5.1 Supply – Solar Resource and Other Weather Factors

For a site that is essentially free of shade, the amount of solar energy available for capture is dependent upon climate and geography. The southwestern U.S. is the sunniest and driest part of the country, while the northwest and east are cloudier and more humid. The southern U.S. also receives more solar energy per unit area than does the north by virtue of its closer proximity to the equator.

Figure 9 illustrates the comparative solar resource across the U.S. The warm colors (reds, oranges, and yellow) depict the areas with the strongest solar resources; the cooler colors (greens and blues) are less desirable areas. Arizona and New Mexico comprise the majority of this optimum area. Adjacent lands extending west to the Pacific (and Hawaii), north into Oregon and Wyoming, and east into Nebraska, Kansas, and west Texas provide the next best tier of solar resource areas, followed by the Gulf States and southeastern U.S. The upper Midwest, New England, and the Pacific Northwest are less optimal, while Alaska represents the poorest resource, largely the result of its high latitude and short days.

[7] FAA. 2008. Using Solar Power for Airport Obstruction Lighting. http://www.faa.gov/airports/engineering/engineering_briefs/

Figure 9: Photovoltaic Solar Resource



Source : http ://www.nrel.gov/gis/solar.html

Other weather factors affecting the solar resource include snow, hail, lightning, hurricanes, and dust. All of these factors should be considered during project design and may have a modest impact on project costs, but none is likely to represent such a severe limitation that it would prohibit proceeding with a solar project.

Solar production benefits from the rarified atmosphere that exists at higher elevations; however a corresponding increase in snow potential may inhibit efficiency if panels remain buried for any substantive period of time. In such areas, some production efficiency loss should be factored into the analysis, though elevating the panels and increasing their orientation with the ground (i.e., tilting them appropriately) will mitigate the loss by allowing the panels to shed the snow more rapidly. In areas where large hail storms are common, damage to the panels from falling hailstones is possible, but would be a very site-specific consideration. However, all solar projects are designed with lightning protection to make sure that the system is not damaged by lightning strikes. Should a site have extenuating factors, additional protection beyond convention may be warranted. Solar projects proposed in areas of the U.S. subject to hurricane force winds must meet enhanced building code standards to withstand hurricane-force wind loads.

Dust, like snow, will be a design and operations and maintenance issue. Dust that collects on the panel surface will negatively impact the panel's electricity production efficiency. Because many projects are located in dry climates with little rain, owners will often conduct a panel rinse twice per year. Fixed (non-tracking) panels will also be designed with some tilt (rather than just flat) so that when it does rain, the water and residue slide easily from the panel rather than collecting on the panel surface.

1.5.2 Electricity Demand

The amount of electricity consumed at the airport is an important factor to consider when developing a solar PV design concept. Solar PV works best where the electricity can be generated and consumed on-site. This is one of the central reasons why airports are good locations for solar PV because airports are a high energy consumption land use. A secondary factor often correlated with electricity demand is available space.

There are economic benefits to serving an on-site electricity load with a solar project. Connecting to the electricity grid adds costs to the project in the form of additional infrastructure and utility interconnection fees. Solar is also physically easier to integrate into an existing land use either on rooftops or available lands making it compatible with existing building electrical systems.

A good example of an on-site use is a rooftop PV installation on a parking garage that powers the garage lights. A ground-mounted facility with greater generation capacity can provide electricity to a nearby terminal or maintenance building with larger electricity consumption needs. Alternatively, a general aviation airport with minimal electricity demand may only be able to justify a solar project if it benefits from state electricity generation and distribution laws (See Chapter 4, Net Metering).

It is also important to note the relationship between electricity demand and property availability in assessing the feasibility of solar projects. Urban airports, on one hand, tend to be space constrained but have a high demand for electricity on-site. Project designers may need to first look at rooftop availability, and secondarily creative locations on the airfield that meet FAA airport design standards. Rural airports, on the other hand, likely have plenty of space to site a solar project, but no on-site electricity demand requiring a grid connection and increased costs. Due to these siting and economic factors, solar projects should be designed to balance electricity demand and available space. See Chapter 2 for more detail on airport planning for solar projects.

1.6 The Electrical Grid

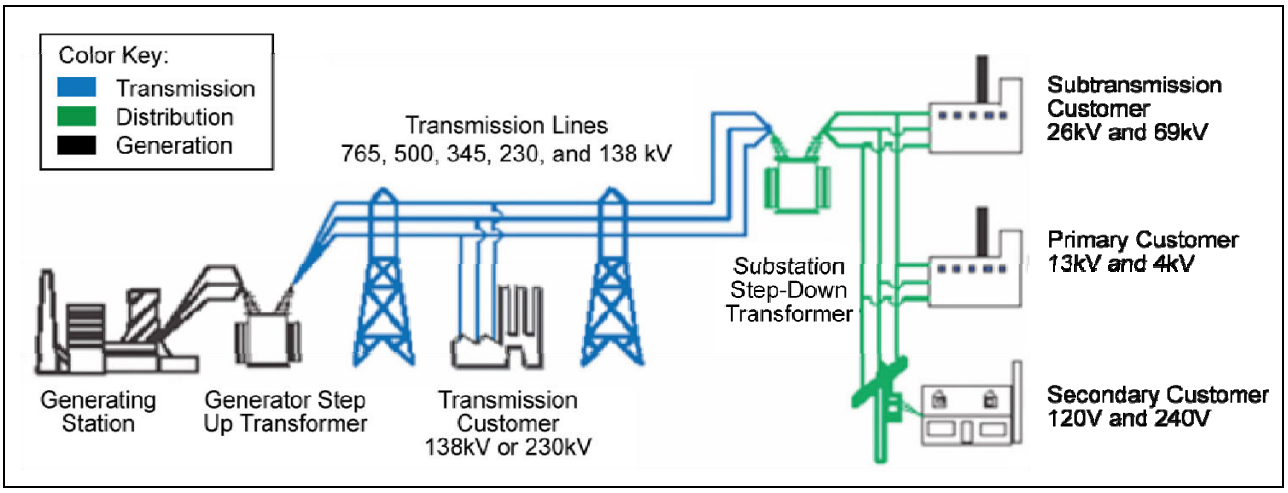
The electrical grid is a complex wired system that provides the country with access to electricity. It has developed as a patchwork of some 4,000 separate systems, that have been consolidated into just three primary systems -- Eastern, Western, and Texas -- each operating as a service provider. Distributed generation facilities, like solar and wind, dispersed throughout the grid are an important new tool used by utilities to provide electricity locally as an alternative to increasing capacity at central power plants and to upgrading transmission lines.

1.6.1 System Infrastructure

As indicated in Figure 10 below, the electrical grid is divided up between generation, transmission, and distribution. Power generation systems include fossil fuel plants, nuclear plants, hydroelectric dams, biomass plants, wind farms, and solar farms. The electricity is converted by a step-up transformer to a transmission voltage and fed out on high-voltage transmission lines that are efficient at transmitting electricity over long distances with the least amount of electricity loss. The largest of these lines – the

backbone of the grid – have a capacity of 765 kV. As electricity is moved closer to a demand center, the transmission voltage is stepped-down. Very large electricity users may receive electricity at the lowest transmission voltages of 230 or 138 kV. All other users (e.g., industrial, commercial, and residential) are served by electricity that is further stepped-down to a distribution voltage of various capacities suited to serve the different types of customers.

Figure 10: Schematic of the U.S. Electrical Grid System



Source : http ://www.oe.energy.gov/information_center/electricity101.htm

1.6.2 Electricity Transactions

Electricity commerce proceeds along two parallel systems: physical and financial. These different transactions are illustrated in Figure 11.

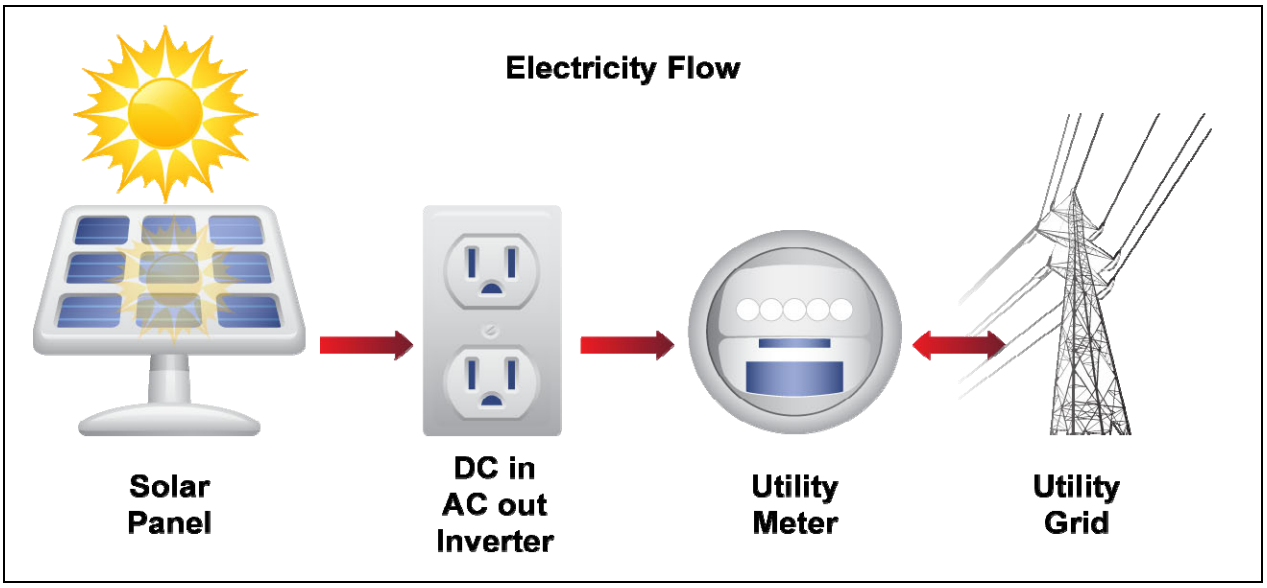
Physically, electricity is produced at a generating source and pumped into the grid, from which customers tap their own electrical needs. An independent system operator is responsible for managing the electrical grid in a manner that ensures stability of the voltage and sufficient supply to meet the common demand. When you turn on a light in your house, you are tapping the grid for electricity; however, the source of that electricity may not be easy to distinguish. Physically, electricity moves through the electrical system from source to user, where the closest users to a source are likely obtaining electricity from that source. As users are located farther away from a generation source, it becomes more difficult to determine which source is providing supply. In the U.S., where large regional power plants provide electricity supply as opposed to smaller "distributed" sources, there is greater distance between the electricity generator and the electricity consumer. However, the independent system operator is primarily focused on making sure that the entire grid is stable and electricity is available, rather than accounting for who is using electricity from which generator.

Financially, the utility company acts as the middle manager between electricity producers and consumers. It buys electricity on the spot market in quantities to match the total demand of its service territory. Market prices vary based on day and time of transaction, and are reflected in peak and non-peak prices. The electricity a utility buys is not a specific commodity produced by a generator and delivered to the utility; rather it is a paper transaction allowing producers to be paid for loading electricity into the grid and customers to tap power from the grid. A comparable illustration is the electricity grid as a bathtub, where generators fill the tub at one end and users withdraw water from various locations around the

edges. The utility company bills customers for electricity use based on the amounts they paid on the spot market plus their associated business fees (e.g., distribution charges, system maintenance charges, and management fees). Many states have instituted an additional surcharge for renewable energy that has been collected in a fund to support in-state renewable energy developments.

Utility companies also manage the local utility infrastructure in their service territory. Utilities make sure that the electrical distribution network is functioning effectively. They also manage the infrastructure by performing regular maintenance and constructing upgrades to ensure that future electrical demand can be supplied.

Figure 11: Schematic Flow of Electricity Transactions Over the Grid



Another factor is that many States are passing so-called Renewable Portfolio Standards (RPS), which require utilities to purchase a portion of their total electricity from renewable energy generators. RPS programs create a local market for renewable energy that has a value greater than conventional energy. To validate that the utility is "purchasing" renewable energy and that renewable energy generators are specifically compensated for their unique commodity, paper transactions in the form of Renewable Energy Credits (RECs) are used. Utilities pay an added price for the REC to verify their purchase of renewable energy under the RPS mandate. That added price goes directly to the renewable energy generator which contributes to making the generation of renewable energy profitable. In a physical sense, the "green" electricity flows from the generator into the grid and mixes with all other electricity sources. No user can claim to tap only "green" electricity if it is utilizing the grid[8].

[8] U.S. Department of Energy. 2010. Renewable Energy Certificates. http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=0

Renewable Energy Credits (RECs), like soybeans, are commodities that are bought and sold in an open trading market. A REC represents the difference between the price of conventional electricity and the price of the renewable electricity (also known as the price premium). Some entities, like companies and universities, are willing to pay this premium for renewable source credits to satisfy their customers or members. In other cases, utilities may be required by state law to buy renewable electricity and pursue RECs, driving up their value. The extra price for RECs makes the renewable electricity product

1.6.3 Solar Grid-Tie System

Solar systems are often times designed to serve on-site electricity demand only. This condition may be referred to as distributed generation. Grid-tie solar refers to those systems that feed electricity to the utility grid. Because many airports have a substantial electricity load on-site, the electricity they generate may never reach the grid. For others, seasonal variations in on-site demand (e.g., high load for summer cooling, lower in winter) and electricity production (more in summer than in winter) may determine if the airport is importing or exporting electricity from the grid.

State law determines how much the on-site generator (e.g., the airport) will be compensated for the electricity it produces and exports. These laws are collectively termed "net metering." States that require utilities to compensate generators at the retail electricity price as opposed to the wholesale price provide additional economic incentives for renewable generation. This is another important factor to consider in evaluating project economics (see Chapter 3). Regardless of the amount of electricity produced, the utility must approve the interconnection of the system because it will interface with the grid on-site and therefore must meet technical specifications and provide for safety considerations.

1.6.4 Distributed Generation and Its Benefits to the Grid

Energy generation projects provide electricity to a user. Central power plants push the electricity onto the electrical grid where it can be tapped by consumers. Smaller generation projects can be located anywhere on the grid to serve local users. These facilities are referred to as "distributed generation" and they include facilities like solar and wind.

Distributed generation projects benefit both the utility and the generator. By supporting a distributed generation project, utilities can avoid more costly upgrades to grid infrastructure that may be capacity constrained and require substantial investments. Utilities may offer their own rebate programs to customers that make localized upgrades to minimize their electricity demand either through energy efficiency or on-site generation. Typically, these are small investments but in some instances might be a source for small-scale solar projects. Generators benefit by producing electricity at a cheaper cost near the electricity users and avoiding transmission charges applied by the utility. Net metering programs authorized by Federal legislation and incentivized by individual states require that the utility buy-back excess electricity produced on-site.

Depending on the size of a project, locating the generation source close to the user can minimize electricity loss (over distance) and obviate the need to compensate the local utility. These conditions are particularly important for solar projects whose economics are tight. Building a long electrical interconnection cable, particularly on an airport where all such lines must be buried, can be a costly expense. This illustrates one of the fundamental advantages of rooftop solar which can be built right at the electricity load with interconnection lines made internal to the building.

Case Study #1 – Deploying Different PV Designs

Denver International Airport – Pena Boulevard and Fuel Farm Projects – Colorado

Denver International Airport (DIA) has been at the forefront of airport solar energy development projects. Currently, DIA has constructed two projects in partnership with private developers. The Pena Boulevard Project, located adjacent to the entrance road to the Jeppesen Terminal, was commissioned in July 2008. It is a 2 MW ground-mounted project consisting of 9,250 Sharp 216-watt solar panels on a single axis tracking system. A second project located at the fuel farm went online in December 2009. That project is a 1.6 MW ground-mounted project consisting of 7,400 Sharp fixed solar panels. DIA is presently exploring additional projects.

Tracking system at the Pena Boulevard Solar Farm

DIA has been first in-line, and its experiences have been very helpful to future solar projects, including its own. One significant change between its first two projects was switching from a single axis tracking system to a fixed system with no moving parts. Tracking is employed to maximize contact of the photovoltaic panels with the sun and increase electricity generation efficiency. The private developer of the first project determined that tracking was appropriate for the Pena Boulevard Project and had such a system designed. The tracking system experienced operational difficulties exacerbated by the drastic extremes in weather conditions which compromised the lubricating fluids. As a result, the cost of system maintenance was higher than budgeted and downtime was necessary for repairs which reduced electricity production. While the financial impact of these difficulties were borne by the private developer who designed, built, and owns the facility, DIA received less solar electricity in its first year of operation than expected. To avoid potential complications with tracking systems, the developer of the second solar project at the fuel farm decided to deploy a fixed mounted system with no moving parts. While the fixed system does not generate the same amount of solar electricity as a fully operational tracking system, it provides a certain minimum electricity production level and minimizes risks associated with unexpected maintenance costs.

Fixed System at the Fuel Farm Solar Farm

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2 DESIGN CONSIDERATIONS: PLANNING AND SITING SOLAR FACILITIES

Solar PV projects are generally a compatible land use at airports because of their low profile and ease of integration with existing facilities. The economics of projects are favorable because of the large on-site energy demand and good solar exposure. However, projects must meets standards to protect air navigation and existing aviation activities, as well as supporting national environmental policies. Sponsors need to consider several factors to determine the feasibility of a solar project, including the consistency of a project with aviation activities and approved airport master plans, potential environmental issues associated with project siting alternatives, and the need to obtain approvals from the FAA including an update to the Airport Layout Plan. Sponsors should consult with the FAA early and throughout the process to ensure that a proposed project meets all FAA requirements.

This chapter starts with an overview of a typical solar project life cycle and is followed by a description of likely project participants, airport planning design considerations, and the FAA approval process.

2.1 Solar PV Project Life Cycle

A solar system that is designed and installed properly will operate for more than 20 years. The PV panel itself has no moving parts and can last more than 30 years[9]. The following is a brief description of the stages of a solar PV project.

2.1.1 Siting and Feasibility

The siting and feasibility stage is the first step from idea to project development. Whether completed internally by the airport, a prospective development partner, or an energy consultant, the siting and feasibility study includes an assessment of the different locations for a project including compatibility with aviation, central design issues such as size and architecture, and a cost/benefit analysis of alternative scenarios. These elements are brought together to form a coherent analysis of the options with recommendations for next steps. An important outcome of this study is to determine if the airport will seek to own the system or lease property to a third-party private developer.

2.1.2 Design and Permitting

Once a project has been defined, it must go through a more detailed design and the permit approval process. The airport operator or its representatives should initiate early coordination with the FAA as the design is developed to ensure that the project complies with FAR Part 77, NEPA, and FAA requirements for land leases and funding as applicable. Detailed design information may be needed to look at whether a solar tracking system makes sense and to investigate issues such as roof load and geotechnical factors. Once the design has been finalized, applications are filed for all Federal and state permit approvals.

2.1.3 Installation

Depending on project size and installation platform (building or ground), solar projects are relatively simple to install with construction occurring in days, weeks, or months. Like any construction project,

[9] U.S. Department of Energy. 2008. Solar FAQs – Photovoltaics – The Basics. http://apps1.eere.energy.gov/solar/cfm/faqs/third_level.cfm/name=Photovoltaics/cat=The%20Basics

the solar installation involves mobilization, preparation, building and connecting the system, testing, and finishing. The construction manager is the critical point person to make sure all is accomplished as designed on time and on budget. A construction safety plan must be prepared and approved prior to the issuance of a notice to proceed.[10]

2.1.4 Operations and Maintenance

When the solar facility is operating, regular operations and maintenance (O&M) activity is minimal. However, the system must be constantly monitored to ensure that its electricity production is maximized. Should system production fall drastically, the owner will likely call in a local technical firm contracted to perform O&M to look at the problem and make component changes as needed. This same firm may also conduct periodic cleaning of the panels and vegetation management to ensure that the panels are optimizing their electricity production potential. Typically, cleaning will occur twice each year and vegetation management will depend on the setting.

2.1.5 Decommissioning/Re-commissioning

The end of a solar project's life cycle will trigger either decommissioning (dismantling) of the system or re-commissioning or repowering (installation of a new system). While solar panels have a manufacturer's expected life of 20-25 years, the industry does not have much experience with decommissioning and re-commissioning of solar facilities because systems built more than 20-25 years ago are rare, and those systems came with no such warranty and are quite different from the panels with warranties today. In addition, useful life will vary among owners and will be dependent upon a particular system's production, an individual assessment of O&M costs, and costs and benefits of repowering the system. As an example, a system constructed on a school in Massachusetts is still producing about 90% of its original design output 29 years after being installed.

2.2 Project Participants

The following is a brief description of each of the participants in a solar project. Generally, these participants are the same regardless of owner or business structure. However, their level of involvement may differ given the business structure and project details.

2.2.1 FAA Airports

There are 9 FAA Regions and 21 FAA Airport District Offices (ADOs) that manage the FAA's day-to-day operations with the nation's airports. These operations include airport safety and standards, grant management, and compliance. Regional FAA and ADO engineering, planning, compliance, and environmental specialists are responsible for reviewing proposed airport projects and determining if they comply with Federal airspace, airport, and environmental regulations, as well as airport sponsor's obligations under Federal grant agreements and surplus property deeds of conveyance.

The FAA Office of Airports in Washington DC (Headquarters) develops national policies, standards, regulations, and guidance for the national system of airports and oversees Federal funding, compliance, and airport environmental reviews. Generally, solar projects are reviewed at the regional level with

[10] FAA Order 5100.38C (Airport Improvement Program) states: All Safety Phasing Plans must be received, reviewed, and coordinated with other FAA operating administrations, approved for airspace review, and approved for use prior to the start of all construction projects.

Headquarters becoming involved only if a project requires additional resources or presents a complex problem. Indeed, this guidance is intended to clarify FAA policy on solar projects in order to support regional decision-making.

Early coordination with the FAA on solar projects is essential to obtain FAA input and to address all of the issues so that timely approvals are possible.

The FAA role in solar energy is multi-faceted. First, the FAA ensures that solar projects are sited properly and do not cause safety problems for aviation or otherwise interfere with aeronautical and airport activities. Regional personnel coordinate the airspace reviews of all construction projects with other FAA organizations, including the Air Traffic Office of Obstruction Evaluation. FAA also reviews solar project agreements for consistency with an airport sponsor's Federal obligations for its financial self-sustainability, its preservation of legal rights and powers, and its retention of airport revenue. In addition, the FAA is an operator of solar technology, generally PV solar, in remote areas or at facilities where the construction of electrical lines is more expensive (e.g., LED runway lights, remote communications, etc.). And finally, the FAA provides information and, in limited circumstances, funding incentives to sponsors for solar installations. In this regard, the FAA seeks to support the modernization and improved efficiency that solar technology can provide to airports.

2.2.2 Airport Sponsor

The airport sponsor, whether the owner or just the host of a solar facility, must act as the project's lead applicant and main contact with the FAA. This responsibility extends to projects where a private solar developer is leasing land from the airport to construct, own, and/or operate the facility. In this case, all private entities involved in the project must be named on the required applications and forms. The sponsor must be familiar with the regulatory review process and communicate on a regular basis with the FAA to ensure that adequate information is developed for the project and that the approval process is proceeding correctly. For solar projects on-airport, the airport sponsor is generally the applicant for all permits and approvals. For off-airport projects, the developer will be the sole applicant.

The sponsor will be the day-to-day "eyes and ears" over the facility but will rely on other technical experts for installation, operations, and maintenance. The airport will use the electricity produced and either deduct that use from its regular utility bill (and realize cost savings) or pay the private owner a set price for the electricity. The facility owner must work with the utility company (and installer) to ensure that the facility is designed and built to conform to the electrical grid. Regardless of ownership structure, the airport also coordinates with the FAA regional office on siting, design, and procurement to ensure that the facility conforms to FAA regulatory and funding standards.

Prior to submitting any applications for FAA approval, the sponsor should contact the regional airport planning staff to discuss the components of a proposed project. Using this *Guide*, the region or ADO and the airport can consider the issues associated with locating solar projects on airports and draw on expertise acquired by the sponsor to assess the potential for a project.

2.2.3 Utility

Regardless of whether the utility is a private investor-owned utility or a division of municipal or state government (or quasi-public authority), the primary role of the utility is as protector of the electrical grid. It must ensure that any generation system with a connection to the electric grid will not negatively impact the grid. It must also ensure that it can access the system and shut it down for emergency operations and scheduled system maintenance and repairs. The utility is also responsible for understanding the impact of renewable energy systems on their state regulatory mandates and on company/agency revenue. Many states have enacted renewable energy standards, which require utilities to generate or purchase a specified

amount of renewable energy per year. When purchasing renewable energy, utilities can accomplish their mandates by acquiring renewable energy credits from eligible electricity producers. In addition, utilities also need to be aware of when distributed energy projects go on-line so that they can forecast drops in demand for grid-produced electricity and potential impacts on company revenue.

2.2.4 Private Developer

Private developers may act as a party contracted by the airport operator to build a solar facility, or they may act as a turn-key contractor to design, finance, build, own, and operate a facility that supplies electricity to the airport as a customer. In either case, the private developer brings to the airport a central contact for the technical and financial aspects of solar development. Airports may seek to hire their own experts as a check on the information provided by the developer.

2.2.5 Installer

The installer is the company with experience designing and installing solar systems. The developer may also be the installer or the installer may be contracted to design and build the system.

2.2.6 Financier

Financiers can take a variety of forms depending on the business structure and ownership. Banks may provide financing regardless of ownership. Private investors can take a diversity of forms but could include individuals, companies, money fund managers, and venture capitalists. If the airport looks to raise its own funds from borrowing, it may due so through municipal bonds or a project-specific fee/charge/tax. Airports may also obtain funding through enterprise accounts, funding from other municipal entities (like the municipal utility), and from grants. Private entities will take advantage of tax credits from the Federal government (through the Internal Revenue Service) and from state taxes where tax incentive programs have been enacted. Private entities can also use the power purchase agreement (contract between the Airport and Developer for long-term electricity purchase), net-metering revenue, and value of renewable energy credits to help secure bank and private investor financing. All of these factors are discussed in greater detail in Chapter 4.

2.2.7 Other

Other entities that might be involved in an airport solar project include state and municipal governments, interest groups, communities, and individuals. Government entities will provide supporting and coordination roles to the airport. For example, fire departments may need to disconnect system infrastructure in the event of an emergency. Local groups may offer technical assistance for development of projects and community groups may want to know about the airport's solar activities and how they benefit or potentially impact the community.

2.3 Airport Land Use and Safety Planning

Every airport sponsor has accepted an obligation to protect the airport from incompatible land uses. As such, the airport owner must take care to know of potential land uses near the airport that may impact aviation or expose the airport to liability. At the very least, sponsors that have legal or proprietary control of land near its airport (cities and counties, for example) must prevent uses that are incompatible with aeronautical uses of the airport, even if these uses are beneficial to the sponsor for non-aeronautical reasons. Failure to take prudent steps and to exercise appropriate rights and powers to preserve the aeronautical utility of the airport may lead to a loss of future Federal funding. In many cases, a sponsor

may not have the authority to prevent incompatible land uses near the airport. In such cases, the sponsor should raise its concerns during public hearings and comment periods associated with project approvals.

Active project planning starts with a review of airport land use and safety criteria and approvals. Figure 12 below presents a flow chart of the FAA's review process for solar projects. The following section addresses airport land uses and safety factors that must be considered prior to proceeding with airspace and environmental reviews.

2.3.1 Lands and Buildings

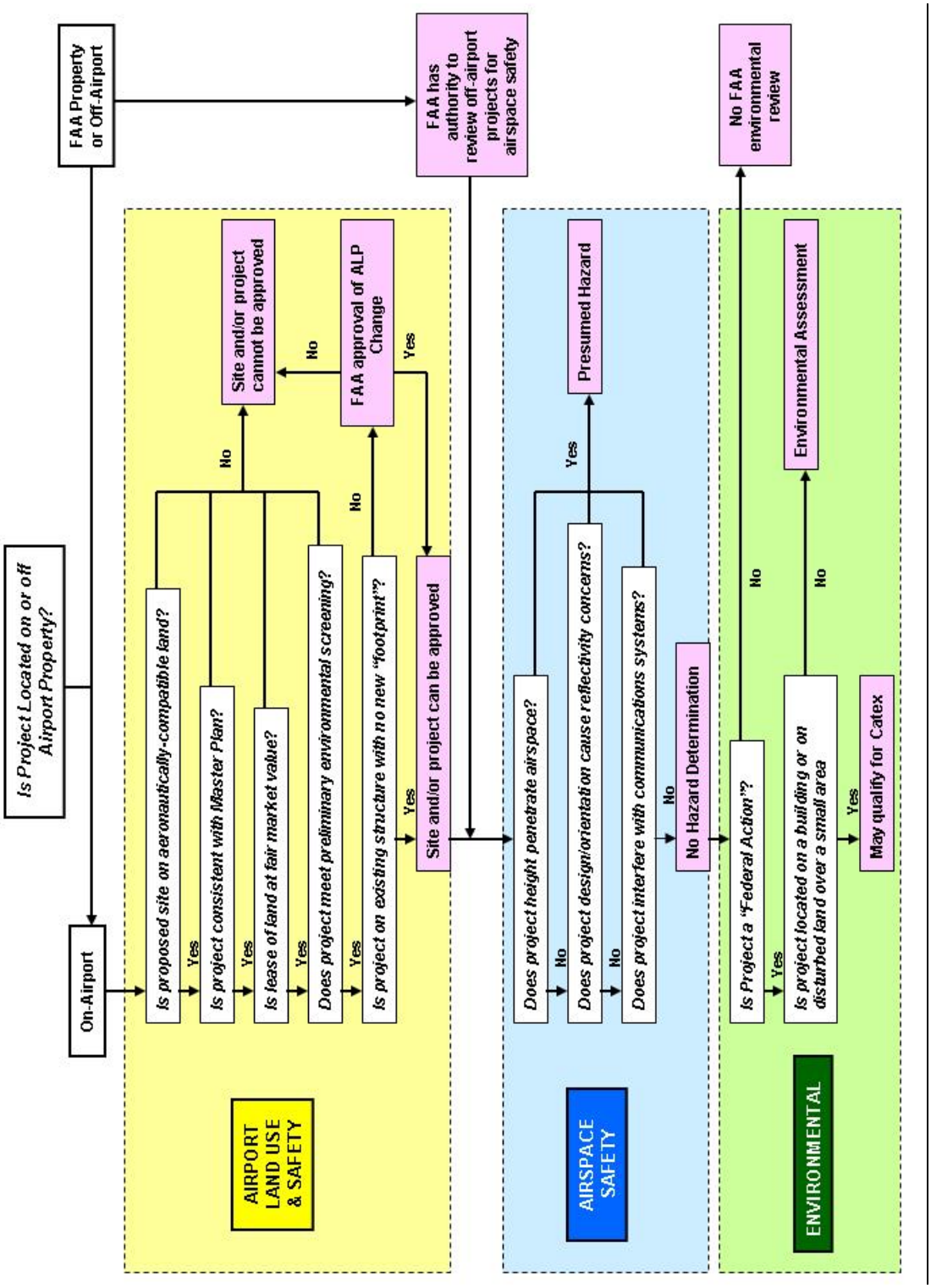
In the process of exploring the technical viability of solar generation, the next stage is to evaluate the specific aspects of project siting on the airport. One important consideration is available space. Many airports have large open areas that may remain unused unless converted to an application like solar. Available spaces might include noise buffers, flat areas near runways where other uses would infringe on 14 CFR Part 77 surfaces, or tops of hangars (though concerns for reflectivity and safety could still limit the application of solar energy systems in some of these spaces). Because land-constrained urban airports have fewer siting options than airports in more rural settings, rooftop installations on terminals, hangers, and parking garages can sometimes be their only practical option. The FAA requirement that the airport sponsor secure fair rental value from non-aeronautical lessees could impact the financial structure of a solar proposal at a land constrained airport.

Ground-mounted solar projects have been successful at airports where the airport sponsor either (1) has land that can be used for solar without affecting aeronautical planning or competition with other potential uses, or (2) has identified unique compatible airport parcels to safely site solar on land that serves an aeronautical purpose but may not be used for more intensive development. Ground-mounted projects are only cost-effective when built at a larger scale occupying an area of multiple acres too large to be sited on rooftops. Larger projects can offset the added cost of mounting structures by providing more electricity revenue (or savings) relative to fixed costs of equipment and land prices.

Roof-mounted solar projects are constrained in size by available roof space. They are particularly suitable at airports that either (1) do not have a large on-site electricity demand, or (2) have little open land available for the safe placement of a ground-mounted system. Because roof-mounted projects are collocated with a building electrical system, the cost of infrastructure from the panels to the existing network tends to be smaller.

Under either option, the project must evaluate existing aviation and airport activities and ensure that the project will not have a negative effect.

Figure 12: FAA Review of Solar Projects



2.3.2 Airport Design Standards

The design of airports and their facilities is strictly regulated to ensure that airports operate in a safe and efficient manner. Airport design guidelines are provided in FAA Advisory Circular (AC) 150/5300-13, Airport Design[11]. Some of the relevant zones near runways and taxiways where placement of structures and activities are restricted include:

Building Restriction Line: a line that identifies suitable building area locations on airports. The BRL should encompass runway protection zones, runway object free areas, the runway visibility zone, NAVAID critical areas, areas required for terminal instrument procedures, and airport traffic control tower line of sight.

Clearway: area connected to and extending beyond the runway ends. It has a slope from the runway end of not greater than 1.25 percent and extends from 500 to 1,000 feet from the runway end.

Object Free Area: an area that must be free of objects except those necessary for air navigation or ground maneuvering purposes (see Figure 12).

Obstacle Free Zone: an area adjacent to the runway that precludes taxiing or parked airplanes, and obstacle penetrations except for frangible visual NAVAIDs.

Runway Protection Zone (RPZ): an area off the runway end to enhance the protection of people and property on the ground. While it is desirable to keep all objects clear in the RPZ, some objects are permitted as long as they do not attract wildlife, are outside the OFA, and do not interfere with navigational aids. For example, automobile parking facilities, although discouraged, may be permitted. Residences and places of assembly are prohibited from the RPZ (see Figure 12).

Runway Safety Area (RSA): a defined surface surrounding the runway prepared to reduce the damage to aircraft that overshoot/undershoot the runway. No objects can be sited in an RSA unless they are required to be there because of their function.

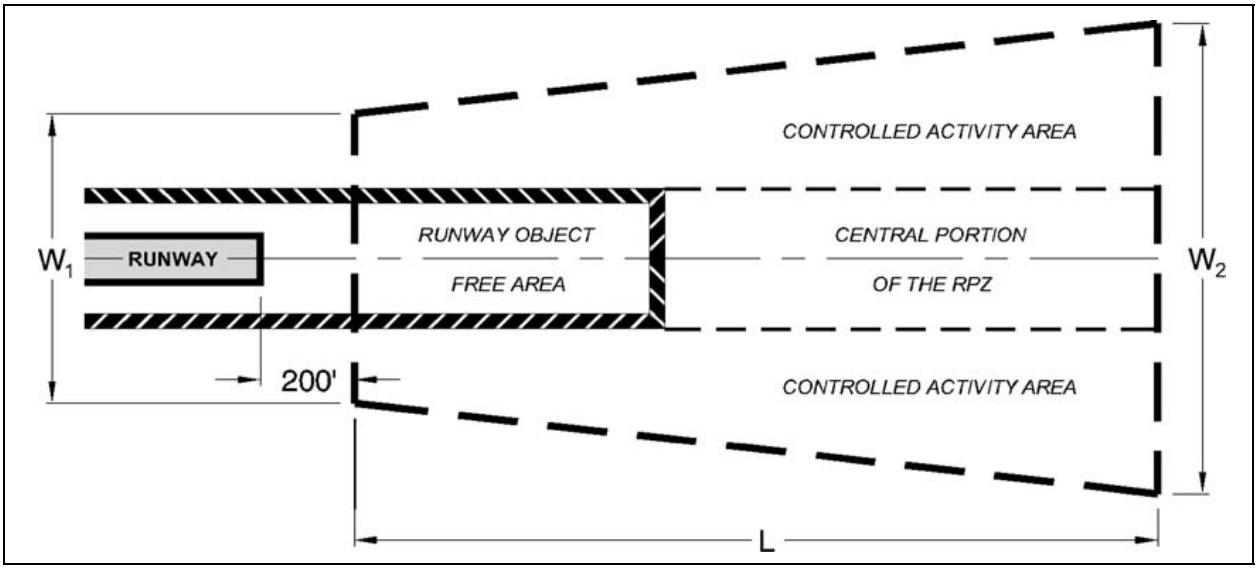
Taxiway Safety Area: a defined surface alongside the taxiway prepared to reduce damage to aircraft. No objects can be sited unless they are necessary because of their function.

Taxiway Object Free Area: are areas adjacent to taxiways that prohibit service vehicle roads, parked airplanes, and above ground objects except those located in the OFA because they are needed for air navigation and ground maneuvering.

The FAA has broad authority to approve the placement of specific structures and activities relative to their potential impact on aviation. Sponsors should review the FAA's *Airport Design* AC guidelines when evaluating siting. Sponsors should also be aware of specific locations that may comply in principal with the design AC but may be subject to discretionary FAA review for potential issues such as glare.

[11] FAA. 1989. Airport Design. FAA Advisory Circular 150/5300-13. Most recently amended in 2009; http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5300-13

Figure 13: Restricted Areas Near a Runway End



Source: Advisory Circular 150/5300-13, Airport Design

In general, the FAA does not recommend that sponsors locate solar facilities in the RPZ. However, the FAA will consult on specific proposals like the one presented by Fresno on a case-by-case basis (see Case Study #2, Solar Project Siting at Fresno Yosemite International Airport). Working with the FAA in advance of site selection to confirm the appropriate siting relative to any discretionary criteria is important whether conducted as part of a larger master planning process or as a stand-alone project.

2.3.3 Consistency with Aviation and Airport Activities

Airports have a primary mission to serve the flying public and facilitate safe and convenient air travel. All other activities occurring at airports must support this primary mission and therefore must be consistent with those fundamental activities.

In assuring compatibility, airport sponsors should use guidance provided in the *Airport Design* AC (150/5300-13) when siting PV installations and work with the FAA, State Aeronautics Divisions, and stakeholders on master planning activities. While the *Airport Design* AC provides clear information about areas critical to the protection of people and property, other planning activities like those associated with solar facilities are discretionary. Working through the issues to understand the basic implications of siting decisions will require information gathering, consultation, and education. In determining whether a proposed solar project is compatible with aeronautical activities, sponsors should consider the following.

1. The project cannot be located in a Runway Object Free Area, Obstacle Free Zone, Runway Safety Area, Taxiway Object Free Area or a Taxiway Safety Area.

2. The project cannot penetrate imaginary surfaces that define the lower limits of airspace including the clearway.

3. The project must demonstrate that glare will not impact airspace safety. (Recommendations for meeting this standard are described in Section 3.1.2.)

4. The project must consider construction period impacts on aviation. Airside projects may result in modifications to typical flight procedures if contractors and equipment produce a temporary impact on airspace. This may result from the need to access the project site by passing vehicles and equipment close to runways. It may also occur if a large crane is necessary for installation and the crane penetrates airspace due to its height.

5. The project must use airport property that is not designated for aeronautical activities or request a formal land release or change in land use.

The evaluation of a project's consistency with aviation and airport activities is best conducted in partnership with the FAA, using the Airport Layout Plan (ALP) as a starting point. Once the compatibility assessment steps listed above have been taken, the sponsor will need to file a Form 7460 and obtain a formal airspace review from the FAA (see Section 3.1).

2.3.4 Consistency with the Master Plan and Airport Layout Plan

The FAA works with airports on a variety of planning processes. Those most relevant to solar projects are Airport Master Plans and ALPs.

An Airport Master Plan is a comprehensive study of an airport which describes the short-, medium-, and long-term development plans to meet future aviation demand. In accordance with AC 150/5070-6B, *Airport Master Plans* [12], Master Plans are developed through a collaborative process to engage the airport, agencies, businesses, and stakeholders in planning for the airport's future. The purpose of the Master Plan is to identify critical issues related to the airport's infrastructure and direct financial resources to address those issues. The ALP is then modified to include future infrastructure improvement projects identified in the Master Plan.

Airports are beginning to recognize the potential for solar and may wish to identify possible future project locations in the Master Plan and potentially the ALP. Most airports today have not included solar projects as part of their future planning because the opportunity to develop on-site solar has only recently become economical and foreseeable. Oftentimes, airports respond to an immediate opportunity presented by a private party to partner on a solar project without extensive forecasting or planning. Referring to the ALP is critical for both aviation compatibility and future success of solar generation. Airport sponsors should review the ALP to determine if future projects are planned that might interfere with solar access.

As specified in AC 150/5070-6B, an ALP depicts both existing and planned land uses and facilities at an airport. Projects proposed for FAA funding must be identified on the ALP. To fulfill this requirement, the ALP typically needs to depict the features of the existing and planned built environment on the airport. For example, the built environment typically shown on the ALP includes the outline of a building footprint or the limits of pavement. Facilities collocated with existing structures, such as an elevator shaft on the roof of a terminal building, are usually not depicted on the ALP as they are located within the footprint of the collocated structure. Without changing the footprint outline of the structure, the collocated facility does not constitute a change to the ALP and subsequently a Federal action. While the need for plan updates will vary depending on the number and type of projects completed by airports, the airport is required to update the ALP if one has not been completed in several years. Grant assurances state that the sponsor must maintain an up-to-date ALP. In general, solar installations at airports are either collocated with existing facilities or installed independently on the ground.

[12] FAA Advisory Circular AC 150/5070-6B, *Airport Master Plans*, May 01, 2007 http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5070-6

2.3.5 Airport Layout Plan Approval

The ALP must be approved by the FAA prior to authorization of Federal funds for airport improvement projects. The importance of the ALP is as a consensus document illustrating existing conditions and future development plans at the airport. Some small-scale development activities may not be specified on the ALP. However, it is important to distinguish areas available for future aviation and non-aviation purposes in lieu of specific development projects.

Solar projects have typically not been depicted on the ALP prior to project approval by FAA due to the relatively quick planning and construction period. With the broader recognition that solar generation might become part of an airport's development plans, sponsors are advised to include solar projects on ALPs currently under revision or update. Ground-mounted solar projects trigger a Federal action and are subject to NEPA review, which must be completed prior to construction.

As part of this *Guide*, the FAA is providing recommendations on what types of solar projects should be depicted on an ALP. In summary, solar installations of any size, located on the airport, that are not collocated on an existing structure (i.e., roof of an existing building) and require a new footprint, need to be shown on an Airport Layout Plan (ALP). Collocated solar installations need to be shown on the ALP only if these installations substantially change the footprint of the collocated building or structure. Sponsors need to revise the top elevation of buildings or structures on the ALP when solar installations increase the building or structure height.

2.3.6 Land Release Approval

Land releases are often necessary for solar projects where land is leased to a private entity for a 15-25 year period to own and operate a solar facility.[13] Several airports have developed solar facilities through a public-private partnership whereby land is leased to a private developer who owns and operates the facility and provides the electricity to the airport. In order for the sponsor to lease land for a non-aeronautical purpose (such as electricity generation), it must consult with FAA. Solar projects in Bakersfield, Denver, Fresno, and Oakland where land was leased for the solar facility, followed the procedures summarized below.

Airport property is dedicated for airport purposes, including non-aeronautical, but aviation-compatible uses to generate airport revenue. As airport property, however, there are certain obligations covering the use of this property, which must be addressed before the land can be used or disposed of for non-aeronautical uses. The FAA must ensure solar power use agreements for airport property for sale or lease demonstrate that such use provides prudent financial benefit to the airport.

In some cases, extensive solar power uses of airport property will require FAA approval of a land release request. If so, the sponsor must submit documentation which describes, among other items, the airport's obligations to the land based on how it was acquired, the type of land release request, justification for the release, demonstration that the airport will obtain fair market value in return for the release, and what will be done with the revenue that is generated by the release. The proposed action subsequent to the release must be shown to be in compliance with the ALP.

In most cases, the FAA prefers that airport land not needed for aeronautical use be leased rather than sold so that it provides continuous income for airport purposes and preserves the property for future aviation usage so long as the future use is compatible with airport operations. Solar projects where land is leased to a private developer for a 15-25 year period provides the airport with the right to reclaim the property

[13] http://www.faa.gov/airports/eastern/aip/sponsor_guide/media/SGSect3.doc

for future use after the lease period has ended. Land acquired with AIP noise compatibility grant funds must, generally, be sold after the airport sponsor converts the land to compatible uses.

The sponsor must submit to the ADO the request to change the ALP and update Exhibit A to show that the property will be used for non-aeronautical purposes. As stated in Section 4.2.2, the FAA's approval either to release property for use as a solar electricity facility or to concur with an appropriate lease of suitable airport property may constitute a Federal action triggering a NEPA review which must be completed prior to FAA issuing a land release.

2.3.7 Environmental Screening

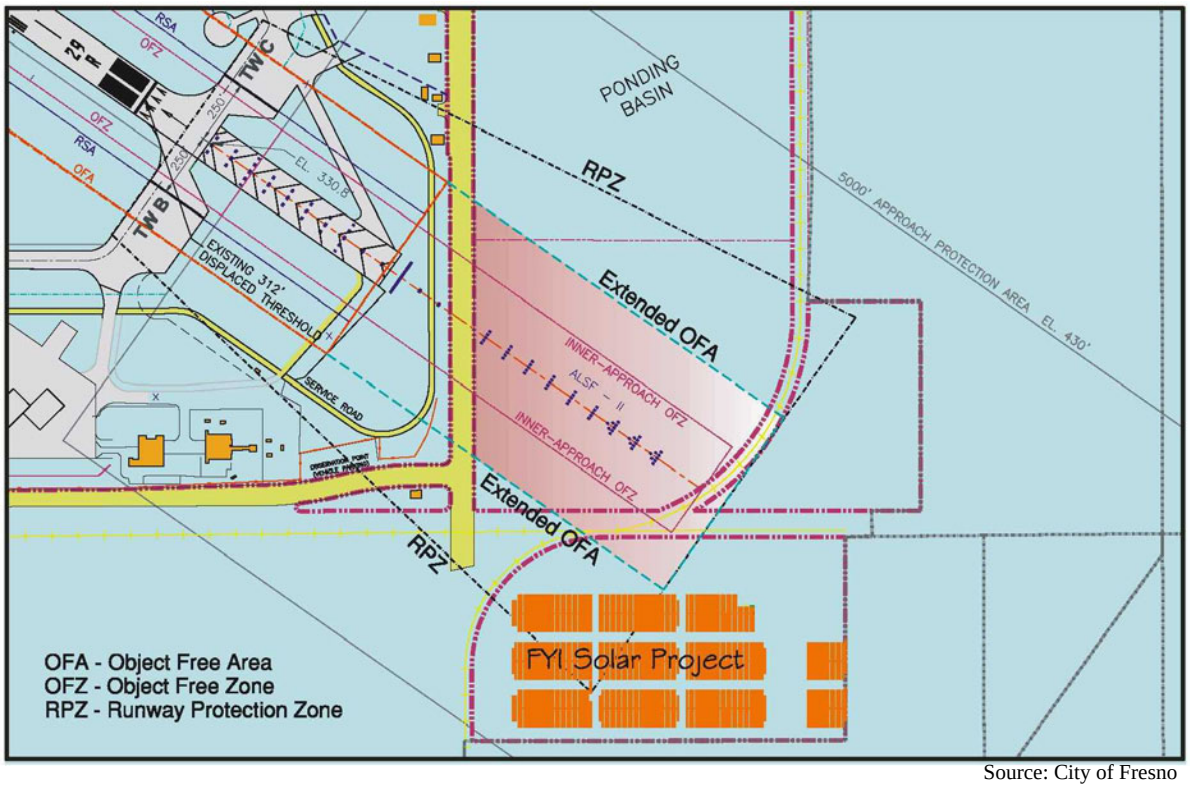
In addition to its statutory responsibility to protect air navigation and facilitate efficient air travel, which are accomplished in part through effective airport planning and design, the FAA must also ensure that approved projects and funds are consistent with national environmental laws and policies. Many solar projects may be subject to review under the NEPA, as well as be required to obtain environmental permits from Federal, state, and local agencies. Therefore, it is important that project proponents conduct an initial environmental screening of their project to identify as potential environmental fatal flaws early on before the project proceeds too far into siting and design.

Environmental issues that might arise in the NEPA review and individual permit review include endangered species, wetland disturbance, water quality degradation from erosion and sedimentation, hazardous materials, and historic and archaeological resource impacts. While existing solar facilities on airport property do not appear to be wildlife attractants, the environmental screening process should look carefully at potential wildlife impacts.[14] The environmental screening process should collect information on existing and historic habitats and land uses in the proposed construction area using such means as statewide geographic information system databases, file searchers, and consultation with municipal planners and agency personnel. Should a unique environmental resource be identified for a proposed site, alternative sites or mitigation of adverse impact options should be evaluated before proceeding (see Section 3.2 for discussion of the environmental review process).

[14] Example: the County of Sacramento CA is addressing concerns about the potential impacts of proposed airport solar development on hawk foraging habitat (Letter from the Airport Manager to the County Planning and Community Development Department, September 29, 2010).

Case Study #2 – A Unique Siting Example

Fresno Yosemite International Airport (FYI) – California



Source: City of Fresno

The City of Fresno constructed a 2.4 MW ground-mounted solar generation system in June 2008. The project consists of 11,700 Sharp solar panels on a single axis tracking system. The project was financed through a Power Purchase Agreement (PPA) with a private developer, and received state support in the form of rebates and utility long-term contract purchase requirements. The panels produce enough electricity to serve approximately 58% of the airport's annual average electricity load.

The airport discussed several different sites with the private developer and ultimately agreed to locate the project near the end of Runway 29 and adjacent to the Object Free Area but inside a portion of the Runway Protection Zone. This area, due to its location relative to air traffic, was unusable for any land uses requiring regular presence by people. In addition, unmanned structures were constrained to only low profile ones that did not penetrate into the approach zone. For those reasons, the land had little value which made it a very suitable location for a solar project.

Because leases must be reviewed by the FAA and the price of the lease must reflect a fair market value standard, leases of land potentially valuable for other development results in higher solar electricity prices. Locating solar on land with less value keeps the solar electricity price down making PPA prices both cost competitive for the airports and profitable for the private developer. As a result, land that would otherwise provide no value becomes a new revenue source to the airport. In general, the FAA does not recommend that airports locate solar projects in the RPZ. However, the FAA will review specific airport proposals like the one presented by Fresno on a case-by-case basis.

3 REGULATORY AND SAFETY REQUIREMENTS FOR SOLAR PROJECTS: MEETING AIRPSACE AND ENVIRONMENTAL STANDARDS

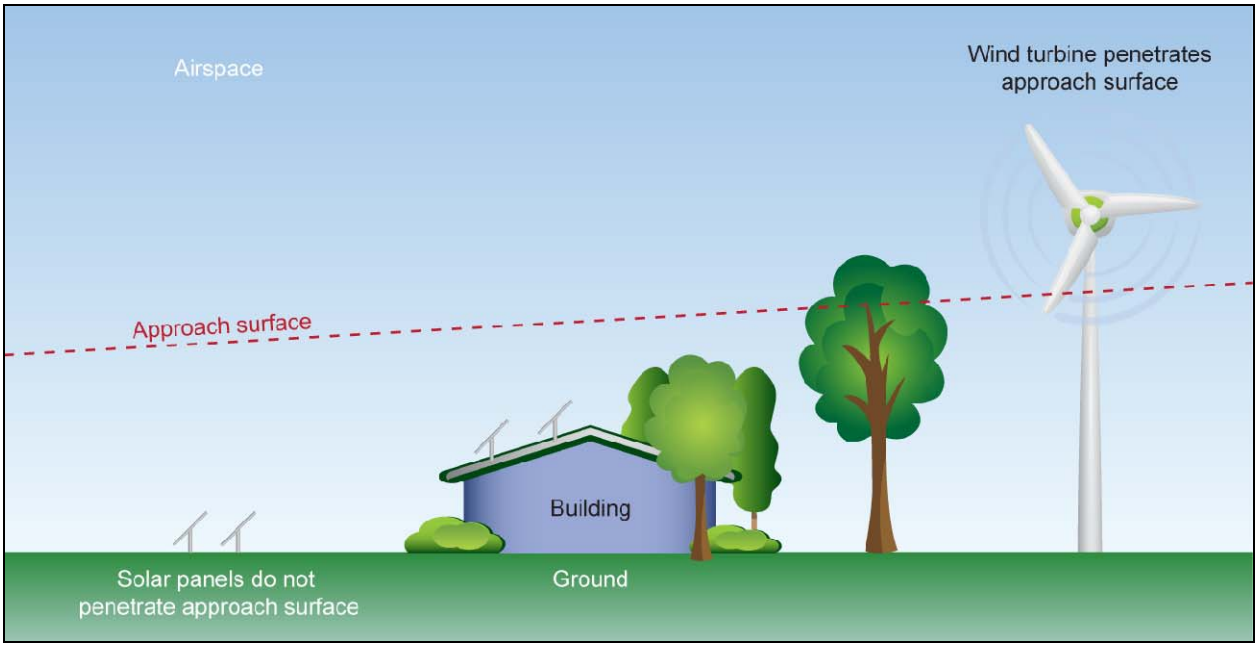
Solar development proponents must plan their projects to avoid impacts on aviation and the environment. As part of an Airspace Review, Airport Sponsors should assess airspace penetration, reflectivity, and communication systems interference for all airport solar projects whether ground or building-mounted. The FAA is also authorized to review all projects for compliance with national environmental laws. This chapter provides guidance to the FAA and sponsors on FAA procedures for reviewing proposals to construct solar PV projects on airport property or in the vicinity of the airport. Because solar projects have opened up new issues that are not familiar to FAA technical reviewers and sponsors, past FAA project reviews were performed on a case-by-case basis. This chapter provides FAA regional personnel with needed information and tools to conduct more consistent and timely reviews of solar projects. Please refer back to Figure 12, FAA Review of Solar Projects.

The following section summarizes FAA Airspace Reviews under Part 77, which provides the FAA with broad authority for protecting the nation's airspace. The discussion of Part 77 requirements includes the triggers for FAA review of solar projects at or in the vicinity of the airport.

3.1 Airspace Review

The FAA's foremost mission is to ensure a safe national air navigation system. To meet this objective, the FAA conducts aeronautical studies of proposed activities that could impact airspace. These studies review physical incursions of proposed structures into airspace, interference with radar communications, and any other conditions that might negatively impact air traffic. Figure 14 illustrates potential airspace conflicts. **Due to its broad authority to protect airspace, the FAA must be given data to review any construction or alteration on a public use airport regardless of height or location.** For projects proposed on airport property, sponsors must file documentation with the FAA so that it can complete an airspace review and assess the potential impact of the project on air navigation. For off-airport projects, local governments, solar developers, and other stakeholders in the vicinity of an airport have the responsibility to inform the FAA about proposed projects so that the agency can determine if the project, especially if large, presents any safety or navigational problems.

Figure 14: Physical Penetration of Airspace



All solar projects at airports must submit to FAA a Notice of Proposed Construction Form 7460 under Part 77 to ensure the project does not penetrate the imaginary surfaces around the airport or cause radar interference or glare.[15] Even if a project will be roof mounted and the height will be below an existing structure such as a building or light fixture, the sponsor must still submit a case for analysis to ensure that the project does not cause glare or interfere with radar installations.[16] The FAA will conduct an aeronautical study of the project and will issue a determination of hazard or no hazard. The timeline for these approvals is typically 30-45 days.

Due to its broad authority to protect aviation safety, the FAA may need to review any major solar project regardless of height or location.

FAA's regional or ADO offices will process the 7460 data and conduct the aeronautical studies to ensure the project will not penetrate the imaginary surfaces or interfere with radar or create a potential glare hazard. The aeronautical studies will be conducted by the following offices:

- Air Traffic Obstruction Evaluation Office (AT OES) – Responsible for evaluating Part 77 requirements.
- Air Traffic Operation Service Group (AT OSG) – Responsible for coordinating with air traffic control to identify any operation impacts.

[15] FAA authority to review non-physical penetrating impacts such as communications interference and reflectivity is stated in Section 6.3.2 of "Procedures for Handling Airspace Matters", FAA Order JO 7400.2G, April 10, 2008.
[16] The 7460 case data can be completed as a hard copy or online at https://oeaaa.faa.gov/oeaaa/external/portal.jsp.

- Technical Operations (Tech Ops) – Responsible for evaluating the case for impacts to NAVAIDs, conducting electromagnetic and line-of-sight shadow studies, and highlighting frequency problems.
- Flight Standards (FS) Responsible for reviewing proposals to determine the safety of aeronautical operations, and of persons and property on the ground.
- Flight Procedures (FP) - Responsible for evaluating proposals to determine impacts on instrument procedures and whether aircraft instrument operations can be conducted safely.
- Airports (ARP) – Identify the structure's effect on existing airports and planned improvements based on airport design criteria including assessing potential impacts on airport operations, capacity, efficiency, and development, and making recommendations for eliminating adverse effect.

The Form 7460 should be accompanied by a discussion of consistency with the ALP, and address airspace issues of physical penetration, communications systems interference, and reflectivity. It should include the following information:

- Location of panels
- Location of radar facilities
- Location of Control Tower
- Verification that panels are located outside of airport design prohibited areas
- Verification that panels will not physical penetrate airport imaginary surfaces
- Verification that solar facilities will not block radar communications
- Assessment of reflectivity including time periods when reflection may contact Control Tower and aircraft

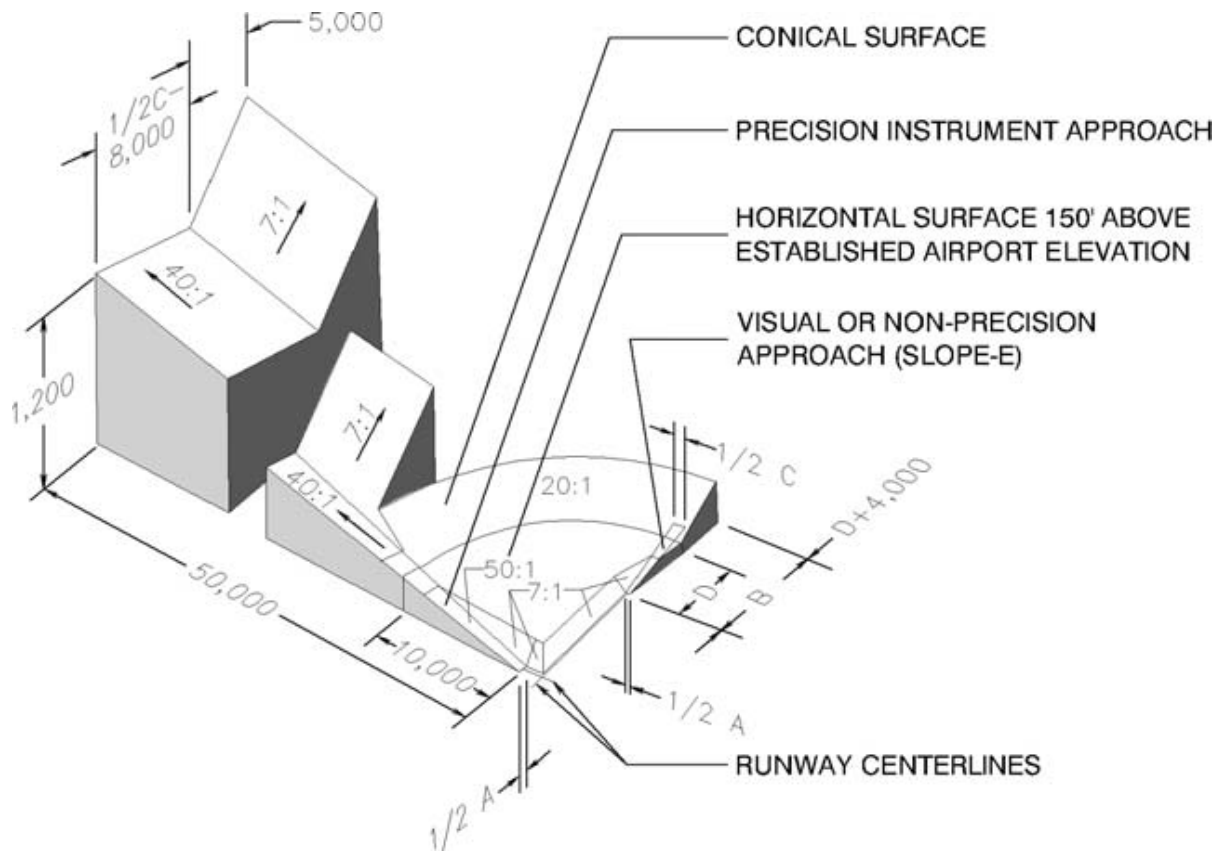
Once the FAA completes the aeronautical study, a determination will be made regarding the impact to air navigation. The determination will be one of the following: a No Hazard Determination, a Conditional Hazard Determination, or a Final Hazard Determination. Airport sponsors for currently operating solar PV projects that have submitted Form 7460 to the FAA for an airspace review have obtained a "No Hazard Determination."

3.1.1 Airspace Penetration

14 CFR Part 77 imaginary surfaces establish standards for determining obstructions in navigable airspace. These imaginary surfaces extend out from the runway in a manner that reflects where aircraft are likely to fly while also accommodating unforeseen aircraft maneuvers. The height above the ground of the imaginary surface is lowest near the runway and increases at distance from the runway. Away from airports, airspace begins at 200 feet above ground level.

Airports must maintain vegetation, prevent building, and manage any temporary construction activity to conform with Part 77 analysis determinations. A figure depicting the imaginary surfaces extending out from the airport is presented below.

Figure 15: Imaginary Surfaces that Define Navigable Airspace



Large structures, like communication towers and wind turbines, often exceed 200 feet in height and therefore are required to submit a Form 7460, Notice of Proposed Construction or Alteration. Structures shorter than 200 feet but located within 20,000 feet of a runway may also penetrate navigable airspace. Solar panels, when tilted properly to the south-facing sun, extend to a height of as little as three feet above the ground making it possible for siting close to runways without penetrating an imaginary surface. The low profile of solar panels allows for greater flexibility in finding the most appropriate location on the airport for electricity generation. Projects that have located solar panels in close proximity to runways and taxiways have conducted analyses to ensure that the solar panels do not penetrate the imaginary surface.

NOTE: As of June 26, 2012, the FAA is reviewing Section 3.1.2 ("Reflectivity") of the "Technical Guidance for Evaluating Selected Solar Technologies on Airports" based on new information and field experience. All users of this guidance are hereby notified that significant content in this section may be subject to change, and the FAA cautions users against relying solely on this section at this time.

3.1.2 Reflectivity

Reflectivity refers to light that is reflected off of surfaces. The potential impacts of reflectivity are glint and glare (referred to henceforth just as glare) [17] which can cause a brief loss of vision (also known as flash blindness)[18]. The amount of reflectivity varies greatly among solar technologies with concentrated solar power technologies being highly reflective and PV being primarily absorptive. Because solar energy projects introduce new visual surfaces to the airport setting where reflectivity could result in glare that causes flash blindness episodes on pilots or air traffic controllers, reflectivity requires study during project siting and design. The amount of analysis will depend on site-specific issues. The following section summarizes the issue of reflectivity followed by a range of strategies to assess its potential impact.

Reflectivity Basics

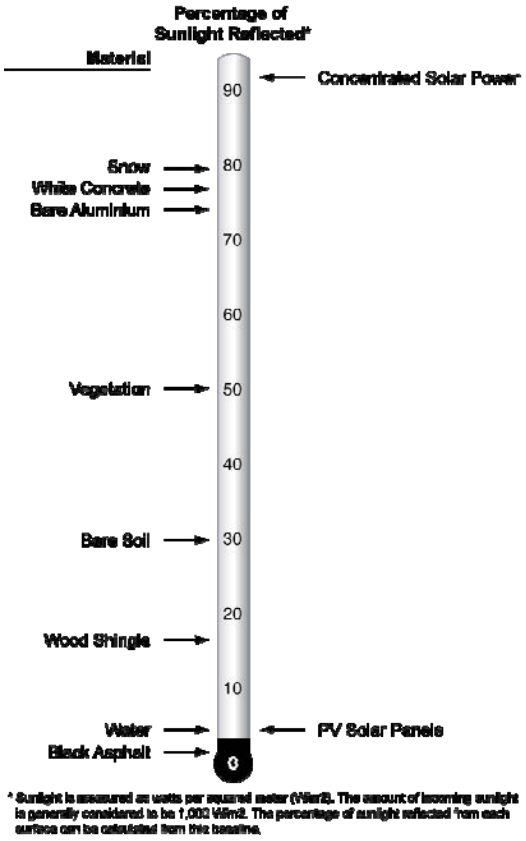
Understanding how reflectivity is measured requires a review of some basic optical concepts.

The amount of light reflected off of a solar panel surface depends on the amount of sunlight hitting the surface as well as the surface reflectivity. The amount of sunlight interacting with the solar panel will vary based on geographic location, time of year, cloud cover, and solar panel orientation. Often 1000W/m^2 is used in calculations as an estimate of the solar energy interacting with a panel when no other information is available. According to researchers at Sandia National Lab, flash blindness for a period of 4-12 seconds (i.e., time to recovery of vision) occurs when 7-11 W/m^2 (or 650-1,100 lumens/m^2) reaches the eye[19].

Once the amount of sunlight interacting with the panels is known, reflectivity from solar projects will vary based on the type of solar power system and its materials and design. Solar PV employs glass panels that are designed to maximize absorption and minimize reflection to increase electricity production efficiency. To limit reflection, solar PV panels are constructed of dark, light-absorbing materials and covered with an anti-reflective coating. Today's panels reflect as little as 2% of the incoming sunlight depending on the angle of the sun and assuming use of anti-reflective coatings[20]. Using the previously mentioned value for solar irradiance, this would mean roughly 20 W/m^2 are reflected off of a typical PV panel. CSP systems, on the other hand, utilize mirrors to maximize reflection and focus the reflected sunlight and associated heat on a design point to produce steam which generates electricity. The percent of sunlight reflected is about 90% translating to 900 W/m^2 reflected from a CSP system. Figure 16 presents a scale of percent sunlight reflected from a variety of surfaces including PV and CSP solar generating systems. Different analyses are necessary to understand the potential for glare impacts for each of these systems.

[17] Glint is a momentary flash of bright light, whereas glare is a continuous source of bright light.
[18] FAA Order 7400.2f defines flash blindness as "Generally, a temporary visual interference effect that persists after the source of illumination has ceased."
[19] Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.
[20] Evergreen Solar. 2010. Evergreen Solar; More Electricity. Fact Sheet.

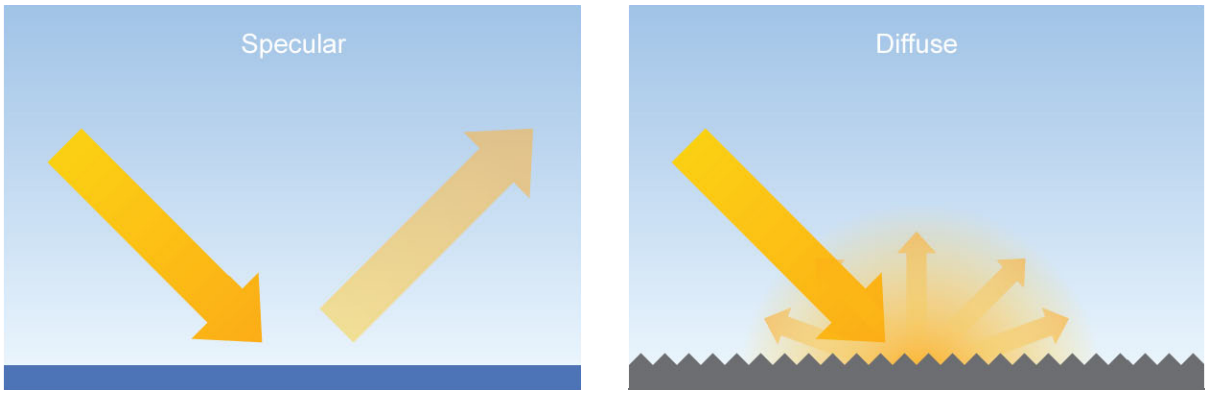
Figure 16: Reflectivity Produced by Different Surfaces[21]



While the amount of light reflected off a surface is important, the nature of the reflected light is even more important when assessing the potential for flash blindness. One important characteristic of light to consider is whether the reflected light is "specular" or "diffuse". Specular reflection reflects a more concentrated type of light and occurs when the surface in question is smooth and polished. Examples of surfaces that produce specular reflection include mirrors and still water. Diffuse reflection produces a less concentrated light and occurs from rough surfaces such as pavement, vegetation, and choppy water. Figure 17 graphically illustrates specular and diffuse reflections. All surfaces in reality produce a mixture of both types of reflections, but the surfaces listed above are dominated by one type.[22] Outside of very unusual circumstances, flash blindness can only occur from specular reflections. The exact percentage of light that is specularly reflected from PV panels is currently unknown. However, because the panels are a flat, polished surface, it is a reasonable assumption that most of the light is reflected in a specular way and thus is fundamentally different from that reflected off a rougher surface.

[21] http://spacemath.gsfc.nasa.gov
Newton, C. 2007. A Concentrated Solar Thermal Energy System. Florida State University College of Engineering. Master's Thesis.
[22] Ho et al

Figure 17: Different Types of Reflection



Completing an Individual Glare Analysis

Evaluating glare for a specific project should be an iterative process that looks at one or more of the methodologies described below. The sponsor should coordinate closely with the FAA Regional Environmental Specialist to collect the data necessary for a particular project review. These data should include a review of existing airport conditions and a comparison with existing sources of glare as well as related information obtained from other airports with experience operating solar projects.

Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis that is needed may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

(1) A qualitative analysis of potential impact in consultation with the Control Tower, pilots, and airport officials
(2) A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel
(3) A geometric analysis to determine days and times when an impact is predicted.

The level of assessments should be followed step-by-step and, at the conclusion of each step, the FAA will determine if potential reflectivity issues have been addressed adequately.

The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.

1. Assessing Baseline Reflectivity Conditions

Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. Figure 16 shows the percent of incoming sunlight that is reflected off of a variety of surfaces. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing and operators will wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.

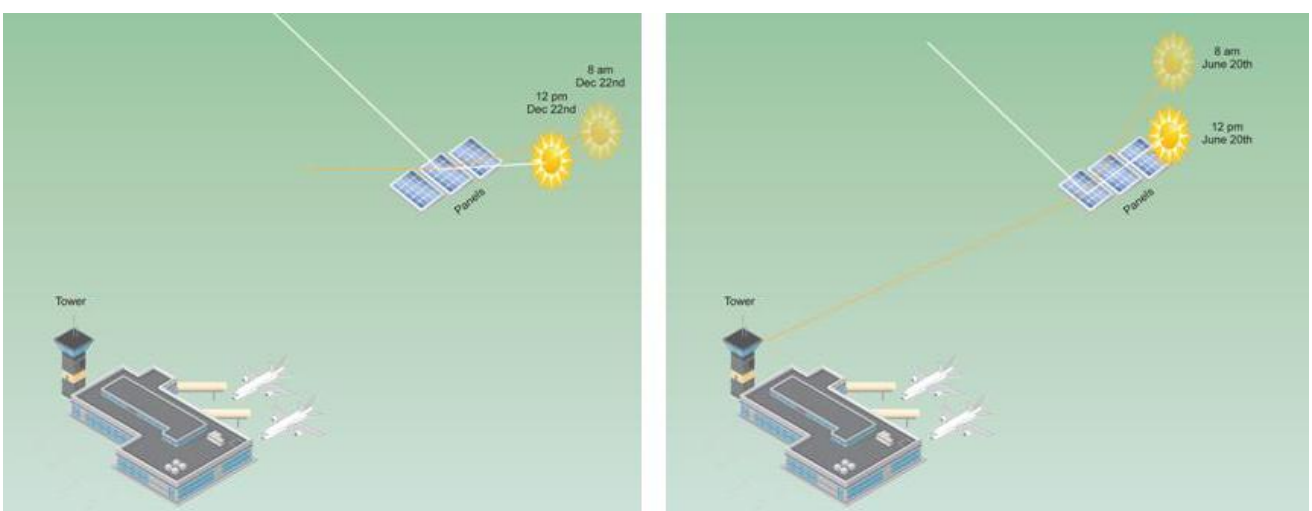
2. Tests in the Field

Potential glare from solar panels can pretty easily be viewed at the airport through a field test. A few airports have coordinated such field tests with the FAA Air Traffic Control Personnel to assess the significance of glare impacts. It is simply done by taking a solar panel out to the proposed location of the solar project and tilting the panel in different directions to generate various levels of glare onto the air traffic control tower. For the two known cases where such a field test was conducted, the tower personnel determined that the effect of the glare produced by the solar panels was not significant.

3. Geometric Analysis

Geometric studies are the most technical approach for reflectivity issues that are difficult to assess. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun not only moves across the sky every day, but its path in the sky changes during various times of year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts. Figure 18 provides an example of such a geometric analysis.

Figure 18: Simple Example of a Geometric Analysis



Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limits to aircraft passing by. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far do you need to be from a solar reflected surface to avoid flash blindness? It is known that this distance is directly proportional to the size of the array in question[23] but still requires further research to answer completely. An aviation-specific dynamic model that could evaluate potential impacts on fixed (Control Tower) and moving (aircraft) sensitive receptors would be a beneficial tool.

The FAA ***Airport Facilities Terminal Integration Laboratory (AFTIL)***, located at the William J. Hughes Technical Center at Atlantic City International Airport, provides system capabilities to evaluate control tower interior design and layout, site selection and orientation, height determination studies, and the transition of equipment into the airport traffic control tower environment. AFTIL regularly conducts computer assessments of potential penetrations of airspace for proposed airport design projects and has modeled the potential characteristics of glare sources, though not for solar projects. AFTIL may be a resource for regional FAA officials and sponsors who seek to evaluate the potential effects of glare from proposed solar projects. See http://aftil.tc.faa.gov/ for more information.

Experiences of Existing Airport Solar Projects

Solar installations are presently operating at a number of airports including megawatt-sized solar facilities covering multiple acres. Project managers from six airports where solar has been operational for one to three years were asked about glare complaints. Air traffic controllers were contacted from three of those airports and asked to comment on the effect of glare on their daily operations. To date, there have been no serious complaints from pilots or air traffic control due to glare impacts from existing airport solar PV installations. Any potential problems in this area have apparently been resolved prior to construction through one or a combination of the strategies described above. The anecdotal evidence suggests that either significant glare is not occurring during times of operation or if glare is occurring, it is not a negative effect and a minor is part of the landscape to which pilots and tower personnel are exposed.

3.1.3 Communication Systems Interference

Communication systems interference includes negative impacts on radar, NAVAIDS, and infrared instruments. Radar interference occurs when objects are placed too close to a radar sail (or antenna) and reflect or block the transmission of signals between the radar antenna and the receiver (either a plane or a remote location). Though it is possible for interference to be caused by other communication signals, more commonly, it is caused by a physical structure placed between the transmitter and receiver. However, similar concerns have been raised for airport-based navigational aids and communication facilities. NAVAIDS can be impacted similarly to radar, but they include passive systems with no transmitting signals. Impacts on infrared communications can occur because the solar panels continue to retain heat into the first part of dusk and the heat they release can be picked up by infrared communications in aircraft causing an unexpected signal.

Studies conducted during project siting should identify the location of radar transmission and receiving facilities and other NAVAIDS, and determine locations that would not be suitable for structures based on their potential to either block, reflect, or disrupt radar signals. Due to their low profiles, however, solar PV systems typically represent little risk of interfering with radar transmissions. In addition, solar panels

[23] Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

do not emit electromagnetic waves over distances that could interfere with radar signal transmissions, and any electrical facilities that do carry concentrated current are buried beneath the ground and away from any signal transmission.

To ensure such systems are further isolated, past solar projects have also been required to be set back from major on-airport radar equipment as a protected buffer. The solar fields at Oakland and Bakersfield were required to meet setbacks from transmitters of 500 and 250 feet, respectively.

Off-airport solar projects are even more unlikely to cause radar interference unless located close to airport property and within the vicinity of a radar equipment and transmission pathways. However, when located near radar installation, CSP projects can cause reflection of radar transmission due to their metallic components. Some reflections can be mitigated with Ram (radar absorbing material) coatings but these can be cost prohibitive. One project located just outside the fence at the Phoenix Airport was reviewed by FAA and conditions were placed on the Airspace Review approval to address potential concerns with radar interference. In many cases, communication and coordination with the proper FAA officials can mitigate the issues and concerns regarding solar power installations in and around airports.

3.2 Environmental Review

Like other development projects, solar facilities are subject to Federal, state and local environmental laws. This section reviews the NEPA process which is applicable to Federally-funded projects and environmental issues that might be reviewed under NEPA or by individual permitting agencies.

3.2.1 NEPA

The National Environmental Policy Act (NEPA) requires Federal agencies to evaluate the environmental impacts of their actions and consider alternatives to mitigate potential impacts. For all new projects at airports which require a Federal action, a NEPA review must be conducted. Federal actions can include a change to the ALP, the issuance of a Federal permit or approval, or the granting of Federal funds. For example, a ground-mounted solar project would trigger an update to the ALP and therefore require environmental review under NEPA. However, a determination issued by the FAA under an airspace review is not considered a Federal action and alone does not trigger a NEPA review. Roof-mounted projects must be reviewed by NEPA if (1) the airport receives Federal funding or (2) the roof is leased to a private third-party. Solar PV projects previously reviewed under NEPA have received a Catex (CSP facilities such as parabolic troughs and power towers may have different environmental issues as determined under NEPA). After consulting with the Region or ADO about the project and environmental issues, the sponsor will provide the FAA with environmental information to support a Catex or an Environmental Assessment (EA). Past solar PV projects have received a Catex from the Region or ADO, supported by background documentation on the purpose and need for the project and any potential environmental impacts.[24] The FAA will review the sponsor's documentation for the project and issue a determination that the project qualifies for a Catex, or if not, requires an EA. As with all categorically excluded actions, FAA environmental specialists must evaluate extraordinary circumstances to ensure that the FAA complies with its responsibility to minimize environmental impacts to specially protected resources.

Several solar projects constructed at airports in recent years have been formally reviewed by the FAA for NEPA compliance. These projects include the two solar facilities at Denver International Airport, and

[24] The FAA is considering the development of a new Categorical Exclusion (Catex) for small solar energy projects.

facilities at Fresno and Bakersfield.[25] Table 1 lists airports that have constructed solar projects and the types of Airspace and NEPA reviews.

Table 1: Examples of FAA Regulatory Reviews for Existing Airport Solar Projects

Airport	Project Type	Airspace	NEPA
San Francisco	Roof	None	None
DIA – Pena	Ground	No Hazard	Catex
DIA – Fuel Farm	Ground	No Hazard	Catex
Fresno	Ground	No Hazard	Catex
Bakersfield	Ground	No Hazard	Catex
Albuquerque[26]	Roof	None	None
Boston	Roof	None	None
San Jose	Roof	None	None

Sponsors for any solar projects proposed at an airport must submit a 7460 form under Part 77 and either appropriate documentation to support a Catex or an environmental assessment depending on the size and potential environmental impact of the project. In both cases, the FAA strongly urges proponents to work with the FAA early in the development process to facilitate a comprehensive and effective review. Once the appropriate NEPA documentation is provided, the FAA will either issue a Finding of No Significant Impacts (FONSI) or require the preparation of an Environmental Impact Statement (EIS).

3.2.2 Examples of Potential Environmental Issues

Because solar energy systems do not release any emissions or store any hazardous materials, potential environmental damage is limited to impacts associated with land development. Even then, many projects can be located on the roofs of existing structures that are already developed, thereby avoiding land disturbance. Previously disturbed sites are also good candidates for solar installations because they will

[25] Each sponsor applied for a Catex under Order 1050.1E 310 "Categorical Exclusions For Facility Siting, Construction, and Maintenance" and provided supplemental information on site specific environmental issues to support the Catex determination. Solar projects constructed on rooftops at Albuquerque (Phase I), San Francisco and Boston did not submit a NEPA application to the FAA because no federal action was anticipated. A Catex was approved for the ground-mounted solar projects by citing the following categories[25]:

> 310n – Minor expansion of facilities including the addition of equipment on an existing facility where no additional land is required, or when expansion is due to remodeling of space in current quarters or existing buildings. Additions may include antennae, concrete pad and minor trenching for a cable.
>
> 310r – Purchase , lease, or acquisition of three acres or less of land with associated easements and rights-of-way for new facilities. (ATO)
>
> 310aa – Upgrading of building electrical systems or maintenance of existing systems, such as painting, replacement of siding, roof rehabilitation, resurfacing or reconstruction of paved areas, and replacement of underground facilities.

[26] The first Project at Albuquerque was completed with no Federal money and therefore there was no Federal action. Phase two of the project has received funding from the FAA and will be subject to NEPA review.

not produce an increased impact. In fact, one of the advantages of constructing solar at airports is that often much of the on-airport open space has been previously disturbed or is actively managed in accordance with formal vegetative and wildlife management plans to keep it from penetrating airspace or becoming a wildlife habitat. Still, such areas may provide environmental benefits that are subject to regulatory review (see FAA Order 5050.4). The following environmental impacts are among the areas that should be considered during a NEPA review and that may require Federal, state, or local permits.

Wildlife Habitat / Endangered Species

Wildlife habitat on airports typically includes habitats for species that prefer a grassland environment. While the airfield environment is managed to be free of natural groundcover, shrubs, trees, and water bodies that provide structure for shelter, foraging, and reproduction of wildlife, it can attract a specific group of animals. Species that had to be considered during siting and design of past projects include burrowing owl, kit fox, and grassland birds. Some of these species may be listed for protection under Federal or state endangered species laws. Should the airport decide to proceed with a project at a site where wildlife habitat may be impacted, the sponsor will need to characterize the extent of the habitat, demonstrate how the project will minimize impacts, and mitigate for any unavoidable damage.

Water Quality Impacts from Erosion and Sedimentation

Construction projects disturb vegetation and soil and make it available to erosion causes by rain events. The footprint of land disturbance for solar projects is limited to posts that hold up the ground-mounted panels. However, construction vehicles needed to bring the panels and other materials to the site and install the equipment can cause temporary impacts on the land that must be managed to avoid erosion and sedimentation. The potential environmental impacts of erosion will vary considerably by region depending on the time necessary to re-vegetate and stabilize disturbed areas. As an example, two years after construction of its Pena Boulevard Solar Project, Denver International continues to maintain erosion control and actively re-vegetate lands disturbed by construction.

Wetlands Disturbance

Wetlands are protected by Federal and state environmental laws due to their broad benefits to wildlife and water quality. Projects that disturb wetlands or are proposed near wetlands may require the issuance of a wetland permit. The permit may require land stabilization to prevent against erosion and sedimentation. It may also require an assessment of alternatives to avoid and minimize impacts, and measures to mitigate unavoidable impacts. For Denver's Pena Boulevard Project, the developer connected two sections of the project by drilling and installing a cable underneath a wetland to avoid a physical impact from traditional trenching.

Hazardous Materials

Hazardous materials are regulated by Federal and state laws. Because solar panels do not employ hazardous materials, the use of them does not trigger an environmental review. However, if a project is proposing to disturb land to construct a solar facility, the applicant may need to test the soil prior to any work to ensure that historic contamination is not released from the soil. Should preliminary testing suggest that soils may be contaminated with a regulated waste, it may be wise to avoid construction in that area for both environmental and economic reasons.

Historic/Archaeological

Federal activities must comply with the National Historic Preservation Act. Many states also have historic preservation programs that may encompass additional areas. Solar projects proposed for the roofs

of historic airport buildings may require approval to ensure that the solar panels do not adversely impact the historic value of the structure. Ground-mounted projects that disturb soils may need to conduct an archaeological study to ensure that below-ground historic resources are not impacted.

3.3 Off-Airport

Solar projects constructed off-airport are proposed and managed by private developers and public agencies. They include a wide variety of technologies (PV, solar thermal, and concentrated solar power) and sizes (residential, commercial, and utility-scale or grid-fed). While projects proposed on-airport have a direct link with FAA authority and agency NEPA responsibilities, the need for FAA airspace review is less clear the farther away projects are from the airport fence. The FAA has broad authority for airspace review and the evaluation of any solar project that could pose a potential hazard to air navigation.

The clearest trigger for FAA review is a physical penetration of airspace. It is well-established that structures rising 200 feet or greater above the land surface must be reviewed by the FAA. Tall structures, such as wind turbines, cell towers, and communication antennae customarily rise above 200 feet and proponents know that an airspace review is required. The FAA will review the location of structures and, depending on their proximity to existing airports, will either limit their height to remain out of flight paths or condition their approval to day and night obstruction lighting. Concentrated solar power projects with power towers may rise to a height of 200 feet or greater, triggering an airspace review. Many other solar projects including parabolic trough and PV farms will not and therefore the need to file a notice with the FAA may not be clear.

Currently, no defined thresholds for project size, type, or distance from the airport are available that automatically trigger FAA airspace review. However, proximity to the airport and CSP technology are two indicators of likely FAA interest in a solar project.

Some utility-scale solar projects have been sited on Federal lands subsequent to a bid to lease land from a Federal agency such as the Bureau of Land Management (BLM). Due to their location, these projects are subject to NEPA review with the land holder (e.g., BLM, Air Force) acting as the lead Federal agency coordinating the NEPA review. For these projects, mechanisms including Federal register notices and inter-agency communications should be sufficient to alert the FAA that the project is proposed. It would then be incumbent upon the FAA to inform the applicant that it requires an airspace review.

How the FAA is notified about potential impacts to airspace, or how it hears about pending solar projects, varies. However, it is the responsibility of local governments, solar developers, and other stakeholders in the vicinity of an airport to check with the airport sponsor and the FAA to ensure there are no potential safety or navigational problems with a proposed solar facility, especially if it is a large facility. Likewise, sponsors must be aware of nearby off-airport activities that could have a negative effect on the safe and efficient operation of the airport. Sponsors should notify the FAA when such activities are proposed and FAA needs to participate in public meetings or permitting processes.

Case Study #3 – Evaluating Airspace Issues

Metropolitan Oakland International Airport – California

Oakland International's General Aviation Airport is host to a 756 kW ground-mounted system owned and operated by a private company, which sells power back to the Port of Oakland at a discount. The project consists of 4,000 fixed solar panels.

While the private developer was responsible as project applicant to file a 7460 Notice of Construction or Alteration with the FAA for airspace review, it was critical that airport personnel play an active role in assessing siting issues to ensure that the project would not produce a negative impact on airspace or aviation activities. The airport is knowledgeable about FAA airport design standards and flight operations, and works on a daily basis with FAA personnel in the Air Traffic Control Tower and ADO.

The three issues that Oakland evaluated during project siting were airspace penetration, radar interference, and glare. Because it was exploring a location along a service road near the GA runway, consideration of the imaginary surface extending out from the edge of Runway 6/27 was a critical consideration even with low profile panels. As a result, the panels were located approximately 400 feet from the runway avoiding any penetration of the imaginary surface of airspace. Second, the siting had to consider the location of the panels relative to Navaids. A radar system is located to the west of the proposed site. After consultation with the FAA, it was decided to preserve a 500-foot buffer from the radar to protect against any interference. Third, the airport discussed the potential for glare to impact the air traffic control tower. The FAA determined that, based on the available information, that glare would not cause a negative impact. However, to ensure that it could address any unforeseen problem, the FAA indicated that it would preserve the right to remove the project if a significant impact were to occur.

The project has been operational since November 2007 and there have been no reports of airspace impacts from radar or glare on the air traffic control tower or on pilots. One of the keys to a smooth approval process was close coordination between the airport, the solar developer, and the FAA from the earliest phases of the project.

4 AIRPORT SOLAR ECONOMICS: UNDERSTANDING THE FINANCIAL INCENTIVES THAT MAKE SOLAR COST-EFFECTIVE

Even with the free power of the sun, it has been a challenge for solar energy to compete with conventional energy sources. Two factors that make solar electricity more costly are the efficiency of solar panels and the cost of panel materials. Advances in technology have improved both, yet solar electricity can still cost about three to four times more than its fossil fuel competitors. Other related factors influencing solar economics are the intensity of the site's solar resource (see Section 1.5) and site design, although the cost to install a solar project is relatively uniform regardless of location. The viability of solar is also determined by the existing cost of electricity and available financial incentives. This chapter reviews electricity cost considerations and financial factors that can help airports determine project cost-effectiveness and identify the best financing option(s).

For those seeking short-term returns, solar energy is probably not the right investment because equipment costs are high and annual revenues (or cost savings) are low. The solar option is more attractive for those looking at long-term financial benefits. In the future, solar pays back its costs and then provides "free" electricity with little operations and maintenance expense. Solar also represents a form of insurance which guarantees a long-term, predictable electricity price and avoids potential fluctuations in conventional fossil fuel prices that are pinned to commodity prices influenced by supply and availability. These factors make solar a good investment for long-term land uses, like airports. A checklist is provided at the end of this chapter for doing a simple screening assessment of feasibility and solar potential.

4.1 Cost of Electricity

When existing electricity prices are low, it is difficult for solar to compete, but when existing electricity prices are high, solar may be a viable option. However, the analysis is complicated by the variability of conventional electricity costs over time.

4.1.1 Conventional Electricity

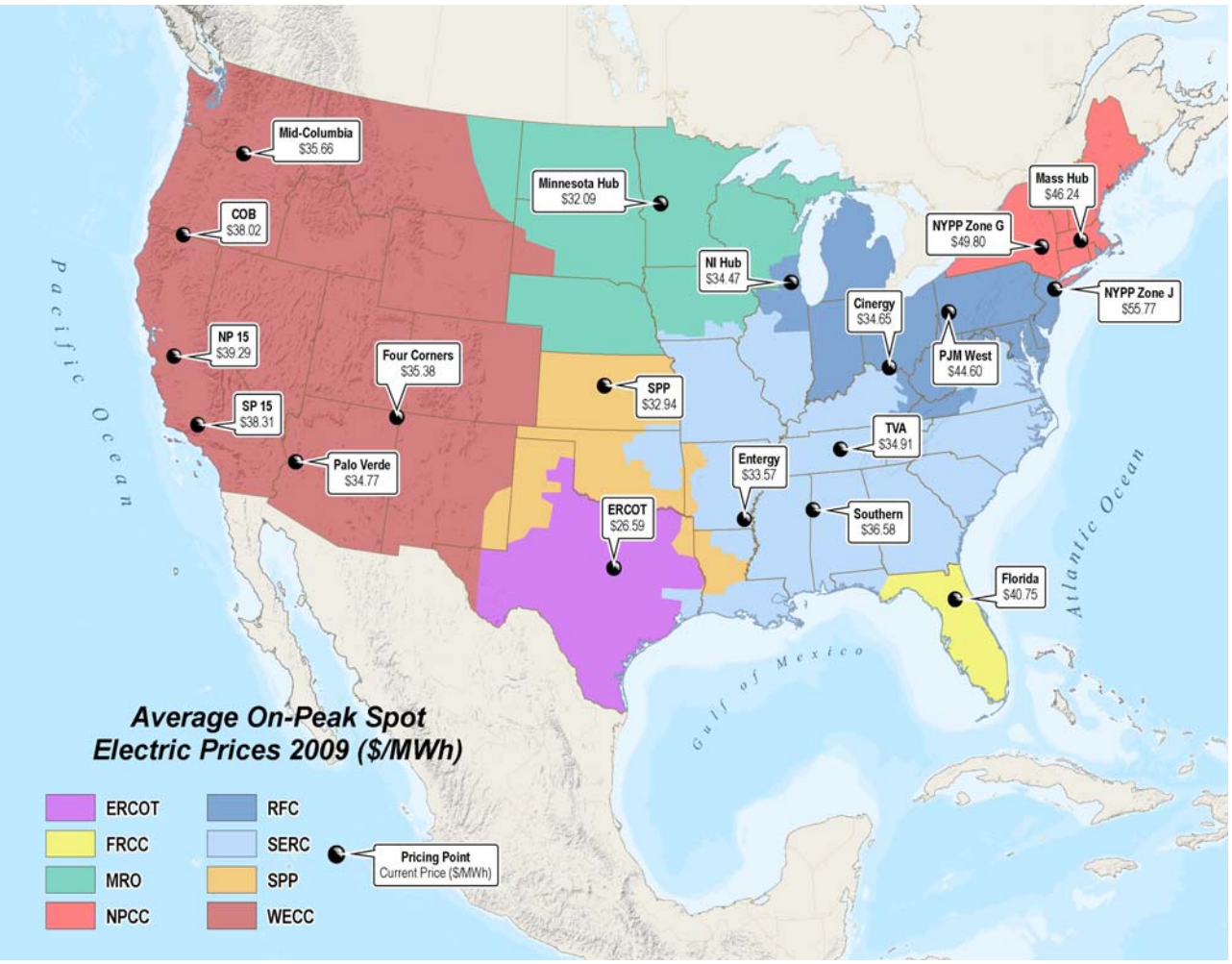
While we don't know exactly what energy prices will be tomorrow, we do know where prices have been historically, and where they are today. Based on national averages, conventional electricity prices have increased by 38% in the past fifteen years.[27]

Prices also vary widely among individual states and regions of the country. Figure 19 provides information on regional electricity prices in 2009. In that year, the northeast had the highest electricity prices while Texas had the lowest. Updated monthly data for April 2010, shown in Table 1, indicates that, even within the northeast, conventional electricity prices varied by as much as 35% from one New England state to another. A simple conclusion might be that solar projects will be most cost-competitive in Connecticut, not in Texas. However, the present-day cost of electricity is only one of three fundamental project factors that must be considered along with the solar resource and financial incentives.

[27] Electricity prices in creased from 6.86 cents per kilowatt-hour (kWh) in 1996 to 9.5 cents per kWh in 2010. During that same period, prices peaked at 10.65 cents per kWh in July 2008. U.S. Energy Information Administration. http://www.eia.doe.gov/

Determining the cost effectiveness of solar electricity primarily involves three local factors:
1) Existing cost of electricity – where electricity prices are relatively high, solar is more economical
2) Strength of solar resource – the more sun, the more solar electricity produced, and the more revenue
3) State government incentives – state tax rebates or RPSs can make the difference

Figure 19: Average On-Peak Spot Electric Prices 2009 from Regional Transmission Organizations



http://www.ferc.gov/market-oversight/mkt-electric/overview.asp

The top 10 states in terms of the cost of electricity (all sectors) for April 2010 are listed in Table 2 below.

Table 2: Highest Electricity Prices in April 2010

State	Price (cents per kWh)
Hawaii	24.23
Connecticut	17.55
New York	15.95
Alaska	15.13
Massachusetts	14.84
New Hampshire	14.59
Rhode Island	14.10
New Jersey	13.69
District of Columbia	13.42
Vermont	13.04

Predicting future prices for conventional electricity presents other uncertainties. Recent price trends offer some guide but energy forecasters have a difficult time predicting economic cycles, fossil fuel shortages, or international political instability, all of which can have a major impact on the availability of fossil fuels and the related price of electricity.

4.1.2 Solar Electricity

Unlike conventional electricity, the future cost of electricity from a solar facility is highly predictable throughout the life of the project. While there will be small variations annually in the amount of sun available for electricity production, other factors that influence the price of solar are known thus making the margin of error small for predicting future electricity prices from solar.

The National Renewable Energy Laboratory has developed a solar energy calculator known as PVWatts to help project developers predict expected solar production from a particular project site.[28] Of the total cost of a solar project over a 25-year period, for example, 99% of costs can be incurred in the initial investment.[29] These costs include securing property rights, designing and permitting the system, materials, construction, and commissioning.

Solar electricity has a high initial investment, but few costs during operations and maintenance. The key to solar financing is to find a long-term customer for the electricity and to spread the payback of the initial investment over a long-term contract.

Future costs are limited to operations and maintenance, equipment replacement, and decommissioning. Annual operating costs are about 0.02% of the total project cost. The only major expense during the operational life occurs when the inverter fails, which is commonly planned for in the business model in year 11. (The inverter converts the electricity from DC to AC – see Section 1.2.) Panel failure and replacement is relatively uncommon, however the business model will factor in some panel replacements as an anticipated cost.

[28] http://www.pvwatts.org/
[29] http://www.pvresources.com/en/economics.php

Long-term trends in the installed cost of solar PV have been decreasing, making solar electricity more cost competitive. The price of solar has decreased by about 4% per year and is expected to continue to decrease as a result of decreasing material costs and an increase in manufacturing efficiency.[30]

Electricity produced by solar panels (and therefore revenue generated) annually for a project's 25-year life can also be calculated accurately. Therefore, the financial key to a solar energy system is finding a means for spreading the high initial project costs over the life of the project.

4.1.3 The Power Purchase Agreement

A Power Purchase Agreement (PPA) is a contract for electricity between a buyer and a seller. A PPA is a key milestone in any renewable energy project because the PPA locks in a long-term revenue source for the proposed power generation.

A PPA may be signed between a producer and a consumer who are physically connected, or it might be executed between distant entities (requiring certification and issuance of RECs). In either case, with the PPA, the developer can approach a financial institution (or private investors) that will lend money to the project with assurances that they will be paid back over time from the revenues generated from electricity production.

PPAs are generally executed between a private developer who sells the electricity and a consumer, who could be public or private. Airports, which are public entities that may own and generate electricity, typically do not execute PPAs because they are also the customer (though there may be a need for certain interagency agreements as in the case of San Francisco's agreement with a municipal utility). Utilities, on the other hand, may be buyers of renewable energy through a PPA in order to satisfy state-mandated renewable energy purchasing requirements under an RPS program.

Because airports are a large and reliable long-term electricity consumer, PPAs have been a successful tool used by airports to develop renewable energy projects. Airports are often constrained from raising fees on its customers to finance investments, particularly when the improvements are not fundamental components of airport infrastructure. In addition, airports are not in the energy business and are more suitable to serving as a host and long-term customer for the electricity as opposed to a developer of power generation. By executing a PPA, the airport can avoid costs associated with project investment while locking in a long-term price for the electricity source and budget for those utility costs, as appropriate.

[30] http://www.solarbuzz.com/solarprices.htm

In 2007, DIA was approached by a private solar developer about constructing a solar project on airport property. The project concept made sense to the private developer because the airport had good solar exposure for creating electricity, lots of space to site a project, and a long-term demand for electricity. DIA was interested because the project could provide them with electricity at a rate cheaper that it pays today and at a fixed price for 15 years. The developer and airport memorialized their agreement through a PPA. But in order for the parties to agree to a price that achieved both the profit objectives of the private developer and the price reduction objectives of DIA, funding was required from the local utility, Xcel. Why would the Xcel contribute to the project when it pays lower prices for electricity produced by fossil fuels? Because the Colorado legislature passed a law requiring utilities to purchase a specific amount of renewable energy generated electricity annually, or pay a fine larger than what it would pay for the "green" electricity. So Xcel issued an RFP requesting bids to supply renewable energy generated electricity. The private developer offered to sell electricity at a competitive rate when compared to other renewable energy alternatives. When Xcel selected the project at DIA, it agreed to pay for the price premium of the renewables (in the form of RECs), completing the financing and allowing all parties to achieve their financial objectives. The standard ground lease and PPA used by DIA are provided in Appendix C and D, respectively.

4.2 Financial Incentive Programs to Lower the Cost of Solar

Governments have established a number of financial programs with the aim of incentivizing the production of solar electricity. Those incentives take the form of tax credits, grants, rebates, loans, and production payments. Public policies such as Renewable Portfolio Standards, Feed-in Tariffs, and net metering may require the purchase of solar power. The DOE database of state incentives for renewables and efficiency (DSIRE)[31] provides a comprehensive and updated listing and description of Federal, state, and local programs. The Solar Alliance *Four Pillars* Report describes how incentives, interconnection policies, net metering policies, and utility rate and revenue policies represent the four most important components of a robust state solar market.[32] Direct cash incentives like rebates and production payments have been central to sparking solar investment while interconnection and net metering policies that restrict solar expansion act to dampen solar development. Installed capacity of solar projects is the best measure of state incentive success. Table 3 lists the top ten States in terms to solar installations in 2009.

[31] DSIRE database is managed by the North Carolina Solar Center and Interstate Renewable Energy Council. 2010.
[32] http://www.solaralliance.org/downloads/four_pillars.pdf

Table 3: Top Ten States in Solar Installations for 2009[33]

State	MW_{DC}
California	212.1
New Jersey	57.3
Florida	35.7
Colorado	23.4
Arizona	21.1
Hawaii	12.7
New York	12.1
Massachusetts	9.5
Connecticut	8.7
North Carolina	7.8

These data represent all solar installations (e.g., residential, commercial) and do not directly translate into the states with the best incentives for airport solar projects. For example, Florida's 2009 installed capacity is weighted by the 25 MW solar farm constructed by Florida Power and Light in DeSoto County as well as by the localized incentives offered by the municipal utility in City of Gainesville. Otherwise, Florida at this time does not offer highly favorable incentives for commercial-scale projects at airports.

The following section summarizes policies and programs available for airport solar projects.

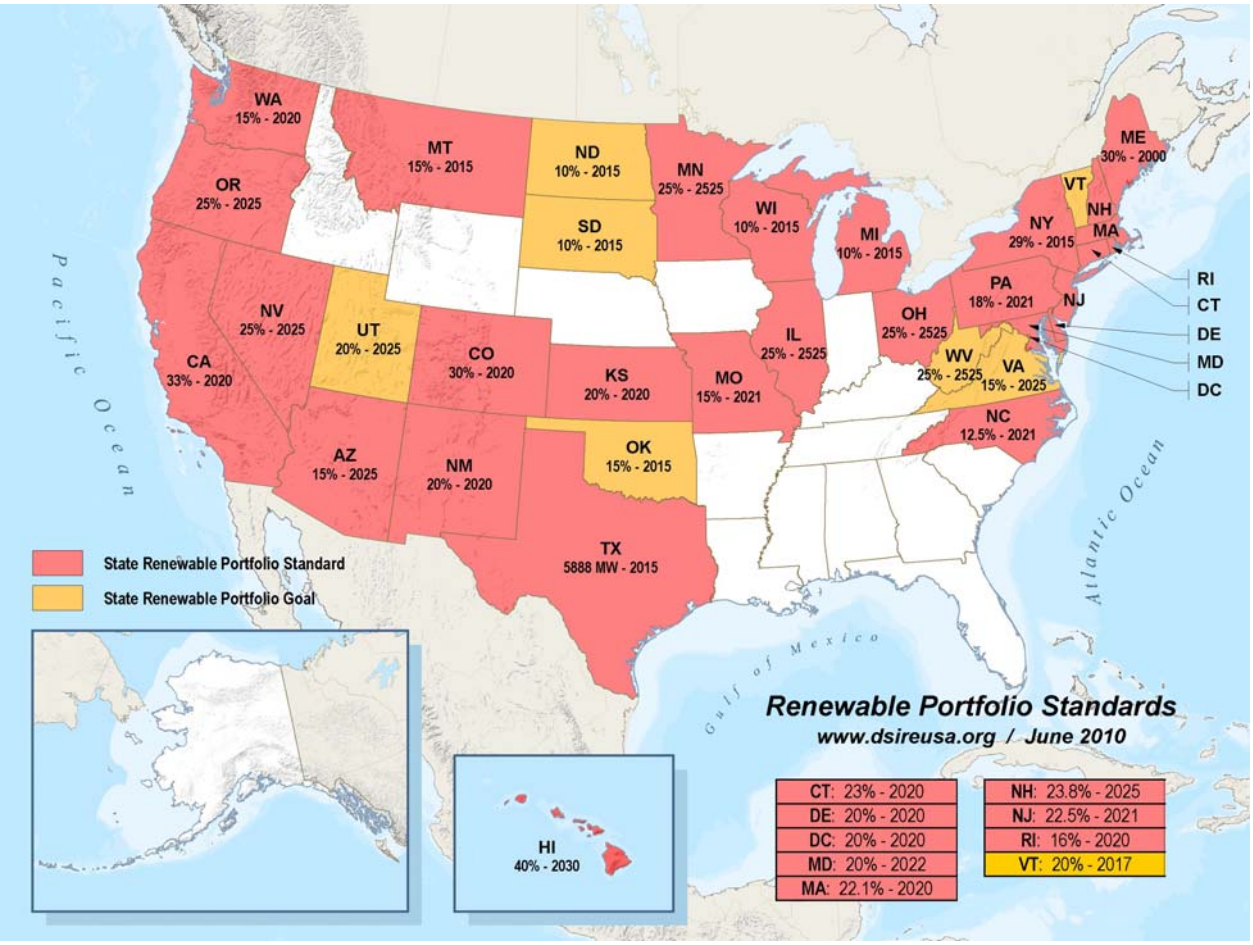
4.2.1 Renewable Portfolio Standards

An RPS, also referred to more recently as a Renewable Electricity Standard (RES), is a government law or policy that requires purchasing of renewable energy. Iowa was the first state to adopt an RPS in 1991, followed by three other states in 1997. As of June 2010, 36 states and the District of Columbia had adopted an RPS or renewable purchasing goal (see Figure 20). Congress is also considering proposals to amend national energy policy to include a Federal RES mandate for renewable energy purchasing.

By enacting an RPS and requiring that some percentage of the electricity sold in a state come from a renewable source, states have expanded the market for renewable energy. Under the program, electricity purchasers, typically the electric utilities, must now find renewable energy generators and purchase their electricity from such generators or be subject to penalty (referred to as a "Compliance Payment") under state law. Because the compliance payment is set at a price higher than the renewable price, purchasers are incentivized to find renewable energy to purchase. Should the purchase of renewable energy result in an increase in overall electricity costs to the purchaser, it will adjust its customers' rates accordingly to pay for the shortfall.

[33] http://irecusa.org/wp-content/uploads/2010/07/IREC-Solar-Market-Trends-Report-2010_7-27-10_web1.pdf

Figure 20: Renewable Portfolio Standards in the U.S.



http://www.dsireusa.org/summarymaps/index.cfm?ee=1&RE=1 [click on renewable portfolio standards]

4.2.2 Renewable Energy Credits

The most complex aspect of managing the RPS program is accounting for buying and selling of the renewable energy. RECs have become the common "currency" for verifying that renewable energy has been purchased and RECs are typically part of any renewable energy transaction accomplished under an RPS/RES program. RECs are like a stock certificate issued by an independent organization that certifies that a generator meets the definition of "renewable" and is generating renewable energy. The purchaser (again, oftentimes the utility) acquires the RECs as part of its transaction for purchasing the renewable energy. The purchaser then holds the RECs as verification of its purchase and presents them to state regulators as necessary.

4.2.3 Tax Credits

Federal, state, and local governments which levy taxes to pay for government services may seek to promote private investment in solar development by offering tax relief. The offer is to decrease the amount of taxes owed based on the amount invested in renewable energy manufacturing or development projects. Because the incentive is associated with a reduction in tax payments, only private (taxpaying) entities can take advantage of this opportunity.

There are two primary programs that have been created at the Federal level through the Internal Revenue Service (IRS) to apply renewable energy investments to a reduction in tax payments: (1) investment or production tax credit, and (2) accelerated depreciation.

The investment tax credit (ITC) and production tax credit (PTC) both provide tax relief to a renewable energy developer in an amount depending on the program available, which for solar projects has been the ITC. Under the ITC, the IRS approves a tax credit equal to 30% of the total project cost amount invested to develop the project. The tax credit can be claimed when filing Federal income taxes subsequent to the project going into service. The value of the tax credit may be sold to other private entities, which have a tax interest and see an economic advantage to partnering on the project. With the tax credit, the private entity never receives cash to help pay for a project, but rather receives a credit on payments due, thereby producing a net positive on the company's balance sheet.

Another mechanism used to reduce project costs through tax relief is referred to as accelerated depreciation. Future taxes must be paid on the value of installed equipment including investments in renewable energy projects. As the equipment gets older, its value depreciates and tax payments based on value will also depreciate. The IRS program called Modified Accelerated Cost Relief System (MACRS) establishes a five-year period after which the equipment depreciation cycle is complete and taxes on value no longer need to be paid. All of these measures are meant to provide tax relief to renewable energy projects, including solar, to decrease expenses during operation and thereby produce electricity at a lower cost.

Some states have enacted tax legislation where revenue departments offer similar tax credit programs on state tax liability. Oregon, for example, offers businesses a 50% tax credit up to a maximum of $10 million. Developers must submit an application for preliminary certification where minimum technical criteria are reviewed and approved prior to commencing construction.

4.2.4 Government Grants and Rebates

Tax incentives have been instrumental to catalyzing renewable energy projects. However, if given the choice, energy developers would prefer to receive a grant or rebate payable in cash because cash is more fungible than credit. Grants and rebates are less popular from a public policy perspective due to the need for enhanced oversight, but have been used to speed the pace of renewable energy development projects.

Cash has also been provided to projects in the form of rebates. Rebates can be inter-changeable with grants and may differ only in when they are approved and issued. In both cases, the generator will apply for approval of the funding application in advance. A rebate is typically paid out after the project is constructed and may be based on the unit of electricity produced. A grant may be paid before or after construction.

The Massachusetts Port Authority (Massport), which operates Boston Logan International Airport, is using both public and private incentives to decrease the cost of electricity to be produced from a solar array on the roof of Terminal A. Massport initially earmarked Federal stimulus money awarded to the State's Energy Program and allocated to Massport to pay down the upfront capital investment of a solar project on Terminal A. Then it solicited public bids from solar companies interested in owning and operating the facility. Following bid selection, Massport executed a PPA with the private developer to buy the electricity produced by the system. The private developer was able to provide a cost-effective bid for electricity price due to the reduced capital investment from a Federal stimulus grant and its ability to monetize the tax credits. This will be Logan's second solar project. The first is shown in Figure 21.

Figure 21: Solar Trees on Parking Garage at Boston's Logan Airport

4.2.5 Feed-In Tariff

Feed-in Tariff (FiT) programs have been popular in Europe but less so in the United States until recently because a FiT fixes the price of the electricity produced rather than allowing markets to establish the price (with or without subsidies). Additional components of the FiT include guaranteed access to interconnect with the utility grid and a long-term contract (i.e., PPA) with the utility. The FiT program requires utilities to buy renewable energy from all eligible participants, and establishes different prices for each technology based on expected market costs. These programs encourage the development of a diversity of energy projects because the cost of development is amortized.

Germany enacted a FiT in 2000 and rapidly became the world leader in wind and solar manufacturing and development. Today, Germany remains the leader in solar but dropped to second in wind behind the U.S. after 2009[34]. California was the first U.S. state to enact a FiT in 2008.

4.2.6 Bonds

Bonds allow government to raise money through borrowing. There are some examples of state and local governments establishing bond authority for renewable energy projects. The government raises the money to borrow by selling bonds with the intention of using money saved from the project in the long-term to pay back bond buyers plus interest without additional tax or fee hikes.

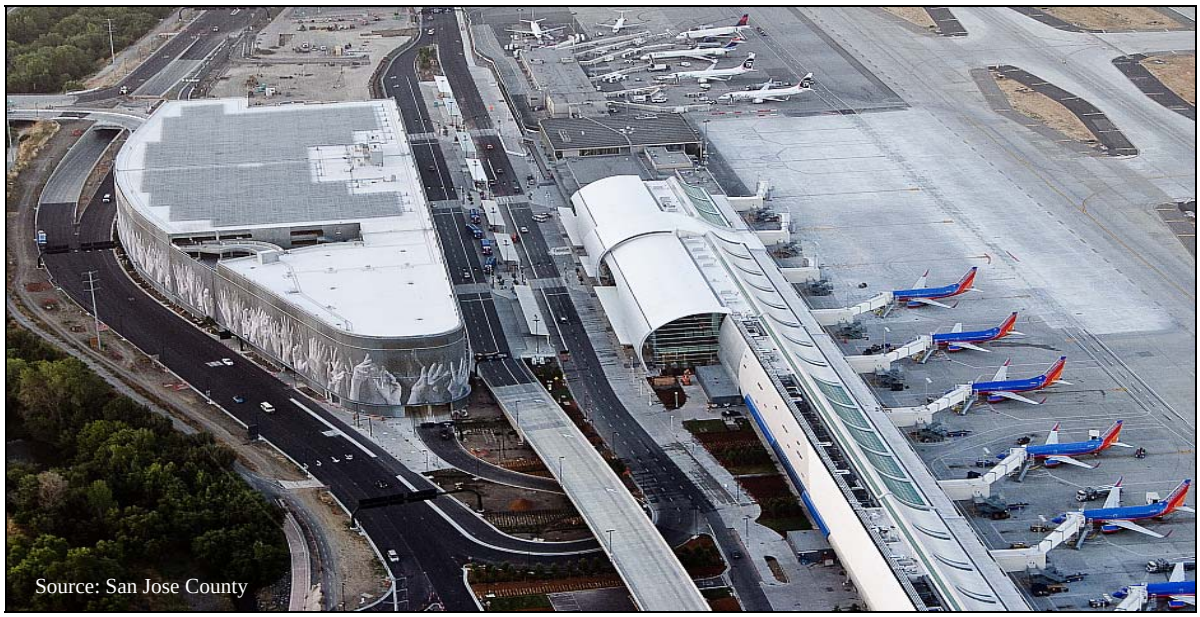
Clean Renewable Energy Bonds (CREBs) were authorized by the Energy Tax Incentive Act of 2005. The legislation permits state and local governments, cooperative electric companies, Native American tribal governments, and public power providers to issue CREBs to finance clean energy projects. Under CREBs, the bond issuer (e.g., local government) issues the bond and raises money. After the project is constructed, the bond is repaid overtime with interest; however, the Federal government pays the interest portion in the form of a tax credit. This allows the issuer to raise the money interest-free.

Funding for CREBs is authorized annually. While funding amounts have been notable, the reduction in tax paying businesses during the economic recession has left the program underutilized over the past two years, though a new provision in March 2010 allowed for a direct subsidy payment in lieu of the tax credit. CREBs can only be utilized for projects owned by the borrowing entity (i.e., are not for privately-owned, third party projects).

The County of San Jose 1.2 MW rooftop solar installation at Mineta San Jose International Airport (see Figure 22) was built under the Terminal Area Improvement Program through project bonds. The rental car companies are the County's partners on the project and they needed to be comfortable with the business case for the project on a long-term Return on Investment (ROI) basis. The economics of the project greatly benefitted from an approximately $2 million solar incentive grant from the State of California through the California Solar Initiative. Without the grant, the 20-year ROI would not have been positive. Rental car companies and their customers are paying for 90% of the structure, as 90% is dedicated for rental car operations. The other 10% is for public parking and is paid through the airport. The companies pay via their long-term lease agreements with the airport, which is a "residual" agreement meaning the cost and debt service for the structure, including solar, along with operating costs, are secured through their lease payments. Customers also pay a "customer facility charge" of $10 per transaction (a standard amount among California airports) that is also part of our revenue stream that secures the rental car center costs. Thus, having a reasonable ROI on the solar installation was essential. The overall capital cost of the rental car center (both for public parking and rental cars, and including solar) is approximately $270 million.

[34] REN21, (2009). "Renewables Global Status Report: 2009 Update," Paris: REN21 Secretariat. Available at: http://www.unep.fr/shared/docs/publications/RE_GSR_2009_Update.pdf

Figure 22: Solar on New Rental Car Parking Facility at Mineta San Jose Airport



4.2.7 Net Metering

Net metering is a form of performance incentive whereby the utility pays an energy generator for electricity that is exported to the grid. Oftentimes, there is a requirement that some percentage of the electricity generated be consumed on-site (by a factory, hospital, school) with the excess exported. The utility then either purchases the exported electricity or credits the generator's electricity account. When the electricity is sent out to the grid, this is often referred to as "spinning the meter backwards" meaning that the amount of electricity consumed on-site (and measured by the electrical meter) decreases (and the amount paid for electricity also decreases).

Federal law requires utilities to purchase back exported electricity; however, the specific payments associated with net metering programs vary among states. Factors that are considered in determining if net metering is a cost-effective solution include: project caps for individual sites and annual allotments within a utility's service area; the price at which the utility must compensate the generator (wholesale or retail price); and whether off-site bills can be credited by the exported energy (e.g., if municipality is the generator, they can credit other electricity consumption accounts).[35] Because net metering only helps electricity exporters, many large and medium size airports cannot benefit because they will always use more electricity on-site than is generated by a solar facility. However, small general aviation airports might be able to capitalize on net metering programs.

[35] Federal law and FAA policy regarding airport revenues and financially self-sustaining business practices for airport sponsors require that airport operators preserve the value of airport assets. Airport sponsors may grant the right to produce electricity on the airport to other parties that construct commercial improvements. These agreements and net metering should align with the responsibility to pay for electricity consumed in an autonomous relationship with the utility or electricity broker. Airport operators can provide lighting and other electrical utilities in-common, under lease and use agreements, or to public areas of the airport not subject to lease or use agreements. In this case, the airport operator must retain the revenue of electricity it produces. Also, generally speaking, airport operators should retain the financial benefits of electricity generated on airport property for airport purposes and not allow those financial benefits to be used for the non-airport interests of the broader municipal sponsor.

4.3 Ownership Models

Public policy incentives provide different opportunities for different owners of solar energy projects. Identifying the appropriate ownership model will vary depending on a combination of economic and public policy factors specific to the project site.

The airport has two primary options when considering solar project development. The first is a solar facility owned by the airport. The second is a facility owned by a private company - the model most widely used by airports today. Regardless of who owns the solar facility, the same groups will be involved in project development with the airport in the lead as property owner. Which ownership model the airport selects will determine which financial incentives can be utilized and who owns the environmental attributes of the project. An early-stage determination of ownership should consider the following:

- Are tax incentives a significant portion of how the project will be paid for? Because there is a 30% tax credit available for all solar projects through the IRS, the answer to this question is "yes." Therefore all airport solar projects should consider the financial benefits of partnering with a private company that can take advantage of the tax credits and pass those savings on to the airport in the form of cheaper electricity. The counterbalance to this will be if government funding (either from a municipal utility or from state or Federal energy programs) produces greater benefits than the tax incentives. Bonds might also be a consideration.

- Is ownership of the environmental attributes important to the airport or city? Solar power has value beyond just electricity because it is produced from clean, renewable sources. That value can be realized either through a voluntary market (driven by customer demand for green power) or a mandatory market (driven by a state RPS). In either case, the airport or municipality may wish to own the value of the renewable energy (RECs). This benefit should be considered in the ownership model because the owner of the facility owns the RECs.

This section describes the two primary ownership models and the advantages and disadvantages of each option. Both models have proven to be successful and there are examples of airports that have done each.

4.3.1 Private Ownership – Airport as Host

The private ownership model offers the best approach for airports to develop solar especially in states with attractive tax credits. In the private ownership model, the airport leases property to a private developer granting them the right to construct, own, and operate a solar facility. The basic contract is a land (or roof) lease with a $ per unit rental fee, annual escalators, and term of lease. To make the project worthwhile, the developer will likely seek a long-term lease of 10-30 years. The land lease agreement will often include options for the airport to buy the facility back from the developer and terms and conditions of such an option. Figure 23 illustrates the fundamental transactions of this model.

The developer owns the solar facility, the electricity it produces, and the green benefits associated with it. Typically, the airport will also execute a PPA with the developer to purchase the electricity produced by the solar facility for a specific price over a long-term period. It is possible that the developer could execute a PPA with another entity (other department of government, nearby business), however, it is easier to have one contract with the airport for both land lease authority and electricity purchase. The utility may acquire the RECs if it has a mandate to purchase renewable energy under a state RPS program. At a minimum, it will review the technical specifications of the electrical interconnection and issue an interconnection permit.

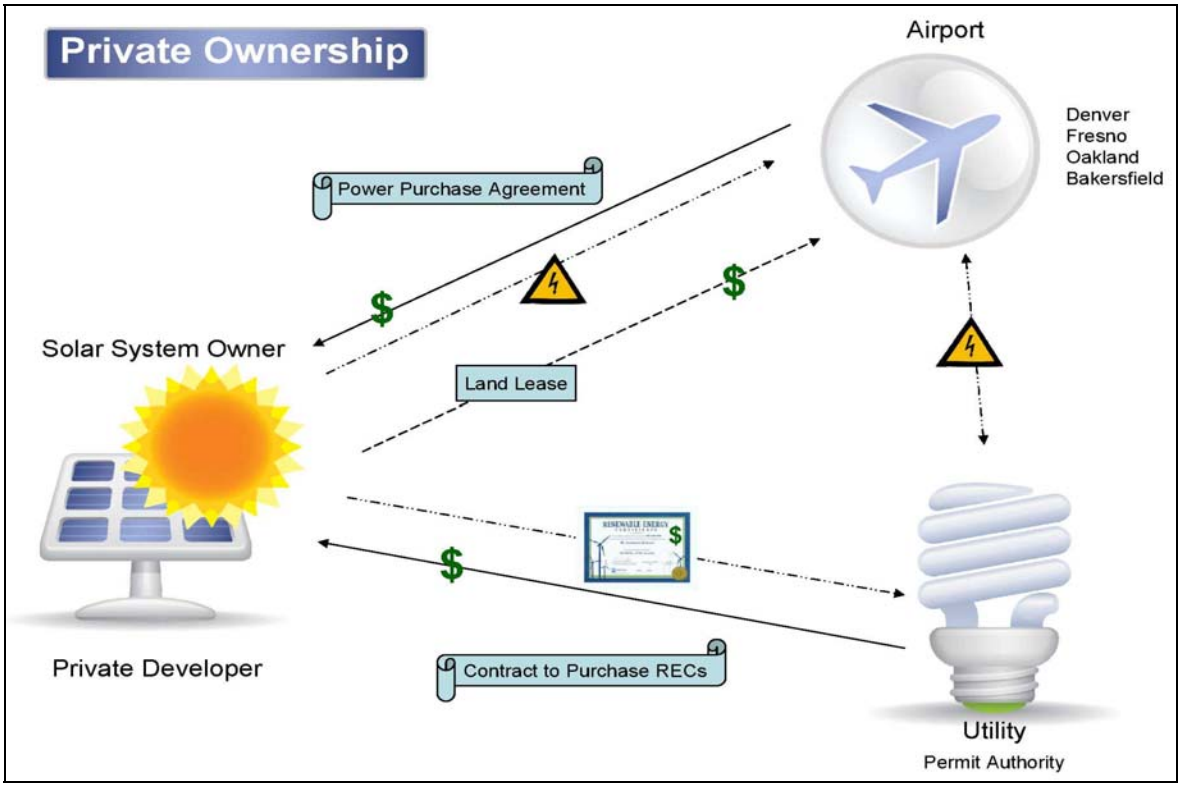
The developer permits, constructs, owns, operates, and maintains the facility for the life of the project. Because profitability is entirely dependent upon the efficient operation of the facility, the developer is sure to take good care of their investment.

Advantages: The private ownership model is fundamentally a simpler proposition for the airport if not more economical in the long-term. It requires no capital investment from the airport. It requires no specialized expertise on solar energy from the airport. The sponsor is seen as being proactive on environmental and energy issues and responding to the concerns of the community without taking on the risks associated with owning and operating the solar facility.

Disadvantages: The primary disadvantage to the private ownership model is that the sponsor releases control of the project and the associated project. A secondary drawback is that the airport will not achieve a payback point and begin receiving free electricity. Instead, the sponsor is locked into paying for the electricity (assuming a lower than market rate) for the life of the contract unless it exercises an option.

Funding: Engaging a private partner to develop a solar project allows the project to take advantage of the tax credits with those savings being passed on to the airport through a lower cost in the PPA. The tax credits are a more certain subsidy than competing for government grants. The Federal tax credit alone, however, has not been enough to attract private investment which has focused on states that provide supplementary tax credits. It is possible that projects can be structured with both a Federal grant to pay down the cost of the initial capital investment, and by executing a lease with a private partner who can capitalize on the tax credits.

Figure 23: Private or Third-Party Owned Business Model



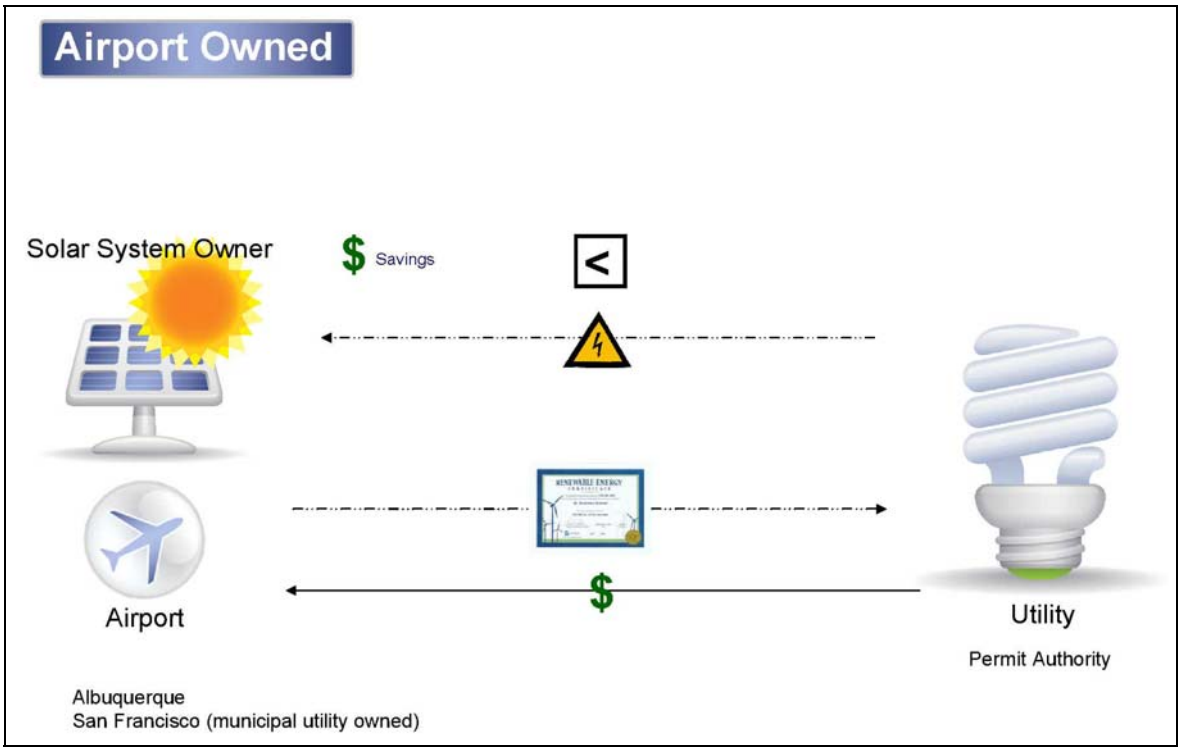
4.3.2 Public Ownership – Airport as Owner

In the public ownership scenario, the airport owns the solar facility and utilizes the electricity and associated "green" benefits on-site. The sponsor contracts with a design-build firm to construct and commission the project. It executes a separate contract for operations and maintenance. The utility's primary role is to conduct a technical review of the facility to ensure its compatibility with the electric grid, and issue an interconnection permit approving the project. It is possible that the utility could also purchase the renewable energy credits from the sponsor to satisfy RPS requirements which will also further reduce the cost of the electricity produced. Electricity generated by the project is used by the airport to offset future purchases from the grid. The project pay-back period is reached when the savings from electricity that otherwise would have been purchased from the grid equals the cost of the project investment. Figure 24 displays a more simple bilateral business relationship of the public model.

Advantages: As owner of the solar project, the sponsor provides no rights to its property to a private energy company. Assuming all factors are equal, the cost of the project is less over the life of the project (e.g., 25 years) than private ownership where long-term airport electricity payments also pay for the private company's return on investment. This leads to a point in the future where the solar facility is entirely paid off and is providing free electricity to the airport for the cost of maintenance.

Disadvantages: Owning a solar project could also mean owning any responsibilities associated with project management, working with contractors, and overseeing performance guarantees and warranties. While these issues are no different (or riskier) than any other construction project on airport land, the technical issues associated with solar energy development may present some challenges beyond those associated with typical building systems and airport support structure. While public ownership results in a less costly project over the project life, it also requires funding the capital investment.

Figure 24: Airport Owned Business Model



Funding: The subsidies for solar projects and other renewables have been weighted towards tax credits that spur private investment. Because airports as non-taxpaying entities are not eligible for the tax credits, private developers have been more successful in proposing cost-effective solar projects than public entities. However, those opportunities have been most competitive in States that offer their own tax credit programs in addition to the Federal investment tax credit (ITC). State variations in public policy have created regional imbalances where solar projects are concentrated in certain States.

Ownership structure for existing airport solar projects is summarized in Table 4.

Table 4: Examples of Ownership Structure for Existing Airport Solar Projects

Airport	Business Model	Owner/ Operator	Electricity Purchase	RECs
Denver #1	Private Third Party	Renewable Ventures	PPA – Airport purchase from owner	Developer sells to Utility
Denver #2	Private Third Party	Oak Leaf Partners	PPA – Airport purchase from owner	Developer sells to Utility
Albuquerque	Airport Owned	City of Albuquerque, Aviation Dept	No purchase – direct use on airport; offsets grid	Owned by City
Fresno	Private Third Party	Solar Power Partners	PPA – Airport purchase from owner	Developer sells to open market
San Francisco	Public Utility Owned	SF Public Utility	Airport purchases at set commercial retail rate	Owned by City
Oakland	Private Third Party	Sun Edison	PPA – Airport purchase from owner	Developer sells to open market
Bakersfield	Private Third Party	Regenesis	PPA – Airport purchase from owner	Developer sells to open market

* No Federal funds were directed to the airports for any of these projects.

The City of San Francisco has ambitious greenhouse gas reduction goals and has appropriated resources to achieve those goals. As part of this program, the City has been identifying municipal buildings to be retrofitted with solar PV. The San Francisco Public Utility Company (PUC) approached the airport about hosting a solar facility as part of this program and in 2007 the PUC funded the construction of a 450 kW solar PV system on the roof of Terminal 3 at San Francisco International Airport. Under the contractual arrangement, the airport buys the electricity that is produced by the solar panels at the typical commercial electricity rate so that there is no cost impact of the solar on the airport budget. The project is shown as Figure 25.

Figure 25: Rooftop Solar Project on San Francisco's Terminal 3

Case Study #4 – Partnering with a Private Developer

Meadows Field – Bakersfield, California

Meadows Field in Bakersfield, California is host to a 744 kW AC ground-mounted solar generation system owned and operated under a lease contract with a private developer. The project consists of 4,704 185-kW solar panels on a single axis tracking system.

The developer and Kern County, which operates the airport, signed a PPA under which the county agrees to purchase all of the electricity produced by the solar facility at a pre-determined price over a 20 year contract period. The panels produce enough electricity to serve approximately 75% of the airports annual average electricity load. However, because the electricity use of the airport is not always in-sync with the electricity output of the solar facility, the airport both receives electricity from the electric grid (e.g., in the evening), and exports electricity (during maximum output). In the middle of the afternoon when exporting occurs, the airport is selling electricity back to the utility company under a net metering agreement. This is also referred to as "spinning the electric meter backwards." This is a good time for the airport to be paid for electricity because it is valued at peak rates when demand for electricity on the overall grid is high. Conversely, when the airport is purchasing electricity from the grid, it is during off-peak hours when electricity rates are lower.

The benefits to the airport are a 20-year fixed price for electricity, which when compared to long-term averages in market rate electricity, will amount to a 16% savings in electricity payments; a lease payment from the developer over the 20 year contract of $0.01/s.f./year for the 6 acre project area; and half of the value of the RECs produced by the project. RECs will soon be sold by renewable energy producers to others who want to offset carbon emission taxes. Renewable Energy Certificates, which are publicly traded environmental commodities, are not monetized yet. Once a market price has been established, the RECs, which are split 50/50 between the sponsor and developer, should be worth between $0.01 to $0.08/kWh of energy produced over the life of the system. A 50% share at $0.01/kWh should be worth around $150,000 annually.

The private developer can take advantage of accelerated depreciation and investment tax credits and split those savings with the airport as part of the PPA electricity price. By securing a long-term customer for its electricity, the developer can operate a profitable solar project.

Table 5: Feasibility Checklist for Airport Sponsors

Issue	***Consideration***	***Yes or No***
Initial Screening		
Solar Resource	Is there enough solar resource? (See Figure 9)	
Extreme Weather	Are there extreme weather events or conditions that should be considered that might increase installation costs?	
Electricity Demand	Can the electrical output be used on-airport to enhance economics?	
State Incentives / Electricity Price	Is there a combination of robust state incentives and high existing electricity prices that will make solar cost-competitive?	
Space Constraints	Are there space constraints that will limit project size and impact economics?	
Site Selection		
Land vs. Building	Does the airport have non-aeronautical airfield land available for solar?	
Competing Uses	Has a fair market value been determined?	
ALP Designation	Are ALP changes needed and have they been approved by the FAA?	
Glare	Has the Form 7460 been filed and has a glare analysis been reviewed by the FAA?	
Environmental	Is the project located on undisturbed land requiring consultation with Federal and state environmental agencies?	
Proximity to Electrical Load	Can the project be sited close to existing electrical meters to minimize the costs associated with interconnecting cables?	
Financing		
Airport Revenue Retention	Are project revenues being kept for aviation uses?	
Tax Incentives	Are there enough state incentives to benefit the project cost?	
Grants/Rebates	Are there any grants or rebates available?	
Loans/Bonds	Are loans and bonds an option and are the rates beneficial?	
Production Payments (RECs)	Is there a state RPS?	
Private or Public	Do the financial instruments available clearly favor private or public ownership?	

5 THE FEDERAL ROLE IN AIRPORT SOLAR DEVELOPMENT

The Federal government encourages, through a variety of policies and programs, the development of technologies that take advantage of the clean abundant energy of the sun and provide a secure and reliable source of domestic energy production. The benefits of solar energy extend to important national goals of greater energy independence, clean air, and the control of greenhouse gases affecting climate change that ultimately affect the quality of life for all citizens.

Federal assistance for solar energy is provided through several means, including tax credits (see Chapter 3), research and demonstration programs, funding initiatives, technical assistance, and public information services. The lead Federal agency in the solar arena is the U.S. Department of Energy (DOE). The DOE directs national energy policy and balances Federal priorities for energy development and efficiency including the management of solar energy programs.

DOE programs for solar energy are located under the Assistant Secretary for Energy Efficiency and Renewable Energy (EERE). The DOE State Energy Program (SEP) provides grants and technical assistance to states for renewable energy and sustainability projects. The SEP Program is the only program in EERE that provides substantial outreach and funding for local solar projects. The Solar Energy Technologies Program (SETP) supports solar research and development, systems integration, and market transformation initiatives for high-profile partnership projects. SETP also provides technical assistance to local, state and Federal government entities on technical and policy/regulatory issues. More information on SEP and SETP programs can be found at the DOE web site.[36]

5.1 Executive Orders for Energy Management and Sustainability

Executive Order 13423, *Strengthening Environmental, Energy, and Transportation Management of Federal Agencies*, is a major impetus for new Federal agency energy management and sustainable energy policies including encouraging the development of renewable energy projects.[37] EO 13423 requires Federal agencies to lead by example in advancing the nation's energy security and environmental performance targets. Among the directives to Federal agencies, EO 13423 includes the following energy goals:

- Improve energy efficiency and reduce greenhouse gas emissions from the agency by reducing energy consumption by 3 percent annually through 2015 or by a total of 15% by the end of fiscal year 2015 (relative to fiscal year 2003).
- Ensure that at least half of the agency's renewable energy consumption in a fiscal year is from new renewable sources, and the agency should implement renewable energy generation projects on agency property to the extent feasible.

[36] www.doe.gov
[37] Initiated by President Clinton, re-signed by President Bush in 2007 and codified into law with the passage by Congress of the Omnibus Act of 2009, which was signed by President Obama in February 2009.

- Ensure that, if the agency operates a fleet of more than 20 motor vehicles, it (i) reduce the fleets total consumption of petroleum products by 2% annually through the end of fiscal year 2015 (compared to the 2005 baseline), (ii) increase fuel consumption of non-petroleum-based fuels by 10 percent annually, and (iii) use plug-in hybrid vehicles where cost-effective based on a life cycle analysis.

Based on EO 13423, the FAA issued Order 1050.21 in 2007, mandating the development of an internal FAA Environmental Management System (EMS).[38] The EMS is designed to identify potential environmental impacts from FAA activities and to improve agency environmental performance on a continual basis. In addition, the Office of Airports is proposing an Advisory Circular to sponsors on how to develop and implement an airport EMS, which several airports around the country have already accomplished to standard.

Executive Order 13514 of 2009, *Federal Leadership in Environmental, Energy, and Economic Performance* requires Federal agencies to develop an inventory of their greenhouse gas emissions and to quantify long-range targets for greenhouse gas reduction.[39] When establishing targets, Federal agencies must consider reductions of energy intensity in Federal buildings and increased use of renewable energy sources in all Federal facilities and vehicle fleets. Federal agencies are also encouraged to coordinate with the private sector to develop incentives for vendors and contractors that use green technologies.

5.2 FAA Policy and Planning

The FAA is incorporating energy management and sustainability goals into many of the agency's policy and planning documents. For example, energy management is cited in the 2010 *FAA Business Plan* as a core objective:

> "*provide guidance and coordinate [FAA] efforts to plan, implement, and document agency energy management activities to address national mandates without adverse effects on the national aviation system.*"[40]

In addition, the Office of Airports has included sustainability in its proposed 10-year strategic plan as one of the five major organizational goals along with safety, mobility, workforce, and international subject areas.

Most importantly perhaps, the FAA is exploring a variety of environmental and sustainability initiatives as part of the agency's major planning initiative for the future *the Next Generation Air Transportation System* (NextGen). NextGen provides the agency's long-term blueprint for bringing promising research on alternative aircraft fuels to commercialization and implementing new navigational systems that greatly improve flight track and procedural efficiencies to reduce fuel burn and emissions. NextGen initiatives for airports will include funding to critical areas of airport infrastructure expansion, including environmental improvements that reduce airport carbon footprints.

[38] Order 1050.21 was issued on October 30, 2007 by Robert Sturgell, Acting Administrator for the FAA.
[39] Signed by President Obama on October 9, 2009.
[40] *Aviation Policy, Planning, and Environment: Fiscal Year 2010 Business Plan*, November 2009.

5.2.1 Possible Strategies for Solar Development

Underlying FAA's general support of sustainable airport development is the agency's primary interest in ensuring that solar projects do not interfere with safe and efficient air transportation. The FAA exercises its safety responsibilities regarding solar development under Part 77 authority (see Chapter 3).

Provided aviation safety is insured, the FAA may be able to facilitate solar development in several ways that help sponsors design and build modern and efficient solar facilities that save energy, reduce local emissions and greenhouse gases, and lower airport operating costs. Possible strategies include:

- Expanding the use of solar energy for FAA facilities and operations.
- Developing FAA goals and policies for the environment, sustainability, and climate change that lead to new investments in solar by the aviation community (Environmental policy is managed by the Office of Environment and Energy).
- Providing sponsors with information through this guide and other means to help them explore the best options for solar technology, financing, and construction. This includes informing sponsors of the regulatory requirements for solar development and the need for early coordination with the FAA to ensure timely FAA review and approvals.
- Encouraging sponsors to incorporate practical opportunities for solar energy in their long-term master planning process.
- Supporting research initiatives that will contribute to improved siting, design, and safety standards for airport solar facilities as well as greater efficiencies in the FAA review process.

5.2.2 FAA Airport Engineering Guidance

The FAA is putting increased emphasis on sustainability in its airport planning and design programs. The growing acceptance of sustainability in airport planning has grown out of recognition that efficient energy use and environmental design are cost-effective over the long-term and a smart investment in the nation's aviation infrastructure.

The FAA has produced guidance on sustainability planning that demonstrates its commitment to sustainable airport development. For example, the FAA *Design Handbook for Energy Efficiency and Water Conservation at National Airspace System Facilities* states that the FAA should use alternative/renewable power sources where they are shown to be cost-effective.[41] In addition, Advisory Circular 150/5360-9, *Planning and Design of Airport Terminal Facilities at Non-hub Locations*, states under the energy conservation section that:

> *"solar architecture can be incorporated in new or existing buildings to replace or supplement conventional heating systems. Active and/or passive systems can utilize the sun's energy to considerably reduce energy usage in buildings for space heating."*[42]

[41] Design Handbook: Energy Efficiency and Water Conservation at NAS Facilities. September 30, 1997. See Section 5. Alternative and Renewable Electric Power Sources should be utilized in accordance with FAA 6980.26.
[42] AC 150/5360-9 was issued April 1980.

5.2.3 Airport Sustainability Planning

Wise energy use including the generation of renewable energy is central to sustainability programs. The FAA Airports Office initiated an airport sustainability pilot program in 2010. The 10 sponsors participating in the pilot program are conducting one to two year studies of cost-effective sustainability measures at their airports. Six of the studies will be stand-alone sustainability management reports while the remaining four studies will be incorporated into separate chapters of Airport Master Plan Updates. Participating airports were selected based on geographic variability and airport operations (3 Large Hubs, 1 Medium Hub, 3 Small Hubs, 1 Reliever, and 2 General Aviation).

The FAA hopes that the results of the sustainability pilot program will yield a clear direction for the agency in the years ahead. Based on the findings, the FAA is likely to pursue more permanent initiatives in the area of sustainability, including solar energy.

5.3 FAA Airport Funding

The FAA expects that private investment will continue to be the most attractive financing option for airports in the future.

Sponsors often need additional resources to identify the potential for solar energy and to plan and build a solar facility. The FAA recognizes that the most effective strategy for sponsors to accomplish this planning and development is through private financing absent any Federal assistance. The private sector has already developed a proven track record of designing and operating successful airport facilities around the country. Private financing takes advantage of revenues generated from the solar generation of electricity and a complementary package of Federal and state tax incentives and utility renewable energy programs. Sponsors benefit financially from long-term electricity price savings and lease payments. Successful airport projects have been constructed by private developers in California, Colorado, and Massachusetts.

However, the FAA also recognizes that the viability of the private market today is limited geographically. For solar to be economical, a number of financial incentives must be present. Federal tax rebates alone do not guarantee profitability, nor is there a Federal Renewable Energy Standard (RES), which would require utilities in all states to purchase a percentage of the electricity that they deliver to customers from renewable sources. On the state level, many States do not offer meaningful tax incentives or RES programs to spur renewable energy development. Airports located in such states are unlikely to be approached by private investors. Consequently, future FAA activity in this area may need to focus on existing gaps until solar technology prices come down in relation to conventional fuel prices or until larger and more uniform Federal and state tax policies are established.

5.3.1 AIP and PFC Programs

Because most airports have suitable buildings and lands to host solar facilities, future demand for solar funding may be substantial. Therefore, the limited FAA eligibility and funding for the environment dictates that proposed solar projects provide significant benefits and compete effectively with other FAA and airport development priorities.

Airports may be eligible under the FAA Airport Improvement Program (AIP) and Passenger Facility Charge Program (PFC) to receive funding for cost-effective solar applications that are an essential or integral part of the design of an approved terminal building design or development project. Stand-alone

solar projects are not currently eligible under AIP and the PFC Program, unless proposed through the FAA Voluntary Airport Low Emission Program (see below).

5.3.2 VALE Program

The FAA Voluntary Airport Low Emission Program (VALE) was established in 2005 under the AIP and PFC Programs to provide sponsors with funding for low-emission projects to meet the requirements of the Clean Air Act. The program is available to commercial service airports located in EPA-designated nonattainment and maintenance areas. Details of the VALE program can be found at the VALE web site: (www.faa.gov/airports/environmental/vale)

Because the VALE program is designed to address local air quality and criteria pollutants regulated by National Ambient Air Quality Standards, only solar projects located in EPA-designated areas are eligible for VALE funding. Solar thermal projects (e.g., passive solar walls and water heating systems) tend to be more compatible with the program's intent because they offset heating and cooling emissions fueled by a gas or oil fired burner operating on-site. In contrast, solar PV projects reduce airport electricity usage that is delivered by the electricity grid from a regional power plant emission source. For this reason, solar PV is more easily categorized under sustainability with its emphasis on carbon reductions and greenhouse gases.

Two airport PV solar projects have been funded through the VALE program. The first project was a 60 kW facility at George Bush Intercontinental Airport (IAH) in 2009. The solar unit was designed as part of a larger central heating and cooling plant low-emission project, contributing to the overall energy efficiency of the system. The second project was a stand-alone 438 kW facility at Albuquerque International Sunport (ABQ) in 2010 (see case study below).

ABQ met stringent AIP and VALE requirements to obtain VALE funding for its solar project. Additional conditions and terms for FAA approval included:

- The State of New Mexico and the local utilities did not currently provide effective tax rebates and incentives for solar. Thus, ABQ was unlikely to receive attention from the private sector.
- The ABQ solar facility is airport-owned entirely without private investors or partners, thus meeting AIP requirements and revenue restrictions.
- The sponsor agreed to apply all earned renewable energy credits (RECs) to airport utility rate reductions, foregoing sale on the open market. Because ABQ is using the solar power directly at the airport, no PPA was needed.[43] Also, ABQ provided an assurance that the electricity generated from the solar facility will be used to meet airport demand only.[44]
- The local air quality agency provided written assurance to the FAA that the sponsor would receive a full complement of aviation emission reduction credits (AERCs) as if the emission reductions occurred at the airport.
- Solar equipment purchased was manufactured in the U.S.

[43] In cases with a PPA, the FAA requires a signed PPA prior to grant approval. Any available airport RECs must be incorporated into the PPA for appropriate revenue use and the elimination of long-term accounting responsibilities.
[44] AIP funding can only be used to meet airport and aviation-related needs and cannot be used for regional purposes, such as providing incentives for plug-in electric rechargers at an airport parking lot.

Sponsors should contact the Region or ADO early in the established AIP and PFC planning cycle if they are considering a proposed project under the VALE program.

5.4 Recommendations

In the process of conducting the background research for this *Guide* and analyzing the information collected, the FAA has identified several areas affecting airport solar development that need further research or development. Specifically, the FAA recommends the following:

1. Further research and development of reflectivity and communication systems interference standards for solar projects and related analysis requirements, especially for CSP technology.
2. Development of a 7460 supplemental form to improve Part 77 documentation for solar projects, particularly potential reflectivity analysis.
3. Design and development of new assessment tools for modeling and evaluating solar projects.
4. Development of a specific NEPA categorical exclusion (Catex) for small solar projects.
5. A cost-benefit analysis of airport solar applications that compares alternative solar technologies (e.g., PV, thermal, and parabolic) with site design alternatives (e.g., building vs. ground mounting; tracking vs. fixed mounting).

Case Study #5 – Building on Local Initiatives

Albuquerque International Sunport – New Mexico

Source: City of Albuquerque

The City of Albuquerque constructed a 146 kW roof-mounted solar generation system on existing parking structures at the Albuquerque International Sunport in September 2009. The project consists of 480 305-watt solar panels on a fixed mount system. The electricity is used for lighting throughout the parking garage.

The project was an initiative of the Albuquerque Green Program which seeks to demonstrate the City's leadership by making wise and innovative choices to ensure that Albuquerque is a sustainable community. Building on the first project, the City approached the FAA with a proposal to obtain funding for a portion of the second phase under the Voluntary Airport Low Emissions Program (VALE). The second phase project, which was recently approved for funding by the FAA, will add 438 kW of solar capacity to the existing facility and offset regional air emissions from fossil fuel power plants.

The project is a demonstration of how the FAA can target funding to airports for solar projects and produce regional air quality benefits by removing a portion of the airport's electricity demand from the electric grid and replace it with emissions-free generation. Future solar projects to be considered for funding under VALE will need to meet the standards set by the Albuquerque example including system ownership by the airport, significant air quality benefits full emission reduction credits from the State or local air quality agency, and no diversion of revenue generated from the long-term sale of RECs,

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Appendix A

FAA Contact Information

Contact Information for FAA Offices

HEADQUARTERS

Federal Aviation Administration
Office of Airport Planning and Programming (APP)
800 Independence Avenue SW
Washington DC 20591
(202) 267-8775 – Tel.
(202) 267-5302 – Fax

REGIONS AND AIRPORT DISTRICT OFFICES

Alaskan Region
(Alaska)

Federal Aviation Administration
Airports Division, AAL-600
222 West 7th Avenue #14
Anchorage, AK 99513
(907) 271-5438 – Tel.
(907) 271-2851 – Fax

Mailing Address:
222 West 8th Avenue #A36
Anchorage, AK 99513

Central Region
(Iowa, Kansas Missouri, Nebraska)

Federal Aviation Administration
Airports Division, ACE-600
901 Locust, Rm 335
Kansas City, MO 64106.2325
(816) 329-2600 – Tel.
(816) 329-2610/2611 – Fax

New England Region

(Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont)

Federal Aviation Administration
Airports Division, ANE-600
12 New England Executive Park
Burlington, MA 01803
(781) 238-7600 – Tel.
(781) 238-7608 – Fax

Eastern Region

(Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, West Virginia)

Federal Aviation Administration
Airports Division, AEA-600
1 Aviation Plaza
Jamaica, NY 11434
(718) 553-3330 – Tel.
(718) 995-5694 – Fax

Physical Address:
159-30 Rockaway Blvd
Jamaica, NY 11434

Harrisburg Airports District Office
(Delaware, New Jersey, Pennsylvania)

Federal Aviation Administration
3905 Hartzdale Drive, Suite 508
Camp Hill, PA 17011
(717) 730-2830 – Tel.
(717) 730-2838 – Fax

Washington Airports District Office
(District of Columbia, Maryland, Virginia)

Federal Aviation Administration
23723 Air Freight Lane, Suite 210
Dulles, VA 20166
(703) 661-1354 – Tel.
(703) 661-1370 – Fax

New York Airports District Office
(New York)

Federal Aviation Administration
600 Old Country Road, Suite 446
Garden City, NY 11530
(516) 227-3800 – Tel.
(516) 227-3813 – Fax

Beckley Airports Field Office
(West Virginia)

Federal Aviation Administration
176 Airport Circle
Beaver, WV 25813-9350
(304) 252-6216 – Tel.
(304) 253-8028 – Fax

Great Lakes Region

(Illinois, Indiana, Michigan Minnesota, North Dakota, Ohio South Dakota, Wisconsin)

Federal Aviation Administration
Airports Division, AGL-600
2300 East Devon Avenue
Des Plaines, IL 60018
(847) 294-7272 – Tel.
(847) 294-7036 – Fax

Bismark Airports District Office
(North Dakota, South Dakota)

Federal Aviation Administration
2301 University Drive, Bldg 23B
Bismarck, ND 58504
(701) 323-7380 – Tel.
(701) 323-7399 – Fax

Chicago Airports District Office
(Illinois, Indiana)

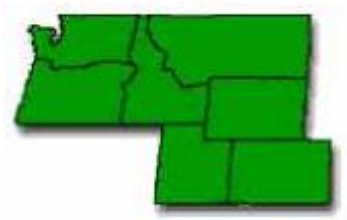
Federal Aviation Administration
2300 East Devon Avenue
Des Plaines, IL 60018
(847) 294-7336 – Tel.
(847) 294-7046 – Fax

Detroit Airports District Office
(Michigan, Ohio)

Federal Aviation Administration
11677 South Wayne Road, Suite 107
Romulus, MI 48174
(734) 229-2900 – Tel.
(734) 229-2950 – Fax

Minneapolis Airports District Office
(Minnesota, Wisconsin)

Federal Aviation Administration
6020 28th Avenue South, Room 102
Minneapolis, MN 55450
(612) 713-4350 – Tel.
(612) 713-4364 – Fax



Northwest Mountain Region

(Colorado Idaho, Montana, Oregon, Utah, Washington, Wyomingt)

Federal Aviation Administration
Airports Division, ANM-600
1601 Lind Avenue SW, Suite 315
Renton, WA 98057-3356
(425) 227-2600 – Tel.
(425) 227-1600 – Fax

Denver Airports District Office
(Colorado, Utah, Wyoming)

Federal Aviation Administration
26805 East 68th Avenue, Suite 224
Denver, CO 80249-6361
(303) 342-1261 – Tel.
(303) 342-1260 – Fax

Seattle Airports District Office
(Idaho, Oregon, Washington)

Federal Aviation Administration
1601 Lind Avenue SW, Suite 250
Renton, WA 98057-3356
(425) 227-2650 – Tel.
(425) 227-1650 – Fax

Helena Airports District Office
(Montana)

Federal Aviation Administration
FAA Building, 2725 Skyway Drive, Suite 2
Helena, MT 59602-1213
(406) 449-5257 – Tel.
(406) 449-5274 – Fax

Southern Region

(Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, South Carolina, Puerto Rico, U.S. Virgin Islands)

Federal Aviation Administration
Airports Division, ASO-600
P.O. Box 20636
Atlanta, GA 30320-0631
(404) 305-6700 – Tel.
(404) 305-6730 – Fax

Physical Address:
1701 Columbia Avenue, Suite 540
College Park, GA 30037

Atlanta Airports District Office
(Georgia, North Carolina, South Carolina)

Federal Aviation Administration
1701 Columbia Avenue, Campus Bldg 2-26-0
College Park, GA 30337-2747
(404) 305-7150 – Tel.
(404) 305-7155 – Fax

Jackson Airports District Office
(Alabama, Mississippi)

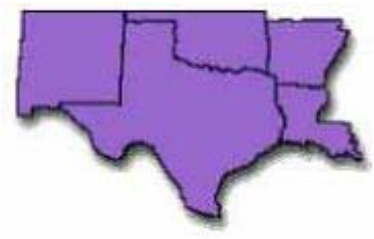
Federal Aviation Administration
100 West Cross Street, Suite B
Jackson, MS 39208-2307
(601) 664-9900 – Tel.
(601) 664-9901 – Fax

Memphis Airports District Office
(Kentucky, Tennessee)

Federal Aviation Administration
2862 Business Park Drive, Building G
Memphis, TN 38118-1555
(901) 322-8180 – Tel.
(901) 322-8195 – Fax

Orlando Airports District Office
(Florida, Puerto Rico, U.S. Virgin Islands)

Federal Aviation Administration
5950 Hazeltine National Drive, Suite 400
Orlando, FL 32822-5024
(407) 812-6331 – Tel.
(407) 812-6978 – Fax



Southwest Region

(Arkansas, Louisiana, New Mexico, Oklahoma, Texas)

Federal Aviation Administration
Airports Division, ASW-600
2601 Meacham Boulevard
Fort Worth, TX 76137-4298
(817) 222-5600 – Tel.
(817) 222-5984 – Fax

Arkansas/Oklahoma Airport Development Office
(Arkansas, Oklahoma)

Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, TX 76137-4298
(817) 222-5630 – Tel.
(817) 222-5987 – Fax

Louisiana/New Mexico Airport Development Office
(Louisiana, New Mexico)

Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, TX 76137-4298
(817) 222-5640 – Tel.
(817) 222-5988 – Fax

Texas Airport Development Office
(Texas)

Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, TX 76137-4298
(817) 222-5650 – Tel.
(817) 222-5989 – Fax

Western-Pacific Region

(Arizona, California, Hawaii, Nevada, Guam, American Samoa, Marshall Islands)

Federal Aviation Administration
Airports Division, AWP-600
P.O. Box 92007
Los Angeles, CA 90009
(310) 725-3600 – Tel.
(310) 725-6847 – Fax

Physical Address:
15000 Aviation Boulevard, Room 3012
Lawndale, CA 90261

Honolulu Airports District Office
(Hawaii, Guam, American Samoa, Marshall Islands)

Federal Aviation Administration
P.O. Box 50244
Honolulu, HI 96850-0001
(808) 541-1232 – Tel.
(808) 541-3566 – Fax

San Francisco Airports District Office
(Nevada, Northern California)

Federal Aviation Administration
831 Mitten Road, Room 210
Burlingame, CA 94010
(650) 876-2778 – Tel.
(650) 876-2733 – Fax

Los Angeles Airports District Office
(Arizona, Southern California)

Federal Aviation Administration
P.O. Box 92007
Los Angeles, CA 90009
(310) 725-3644 – Tel.
(310) 725-6849 – Fax

Physical Address:
15000 Aviation Boulevard, Room 3024
Lawndale, CA 90261

FAA Technical Center

FAA Airport Technical R & D Branch
FAATC/AJP-6310 Building 296
William J. Hughes Technical Center
Atlantic City, NJ 08405
Tel. 609-485-5147
Fax 609-485-4845
http://www.airporttech.tc.faa.gov/index.asp

FAA Airport Facilities Terminal Integration Laboratory
William J. Hughes Technical Center
Building 170
Atlantic City, NJ 08405
Tel. 609-485-6987
http://aftil.tc.faa.gov/

Appendix B

Existing Airport Solar Projects and Contacts

Solar Projects

Airport	Facility Type	Location	Size	Owner	Contact Name	Position	Address	City	Phone	Email
Albuquerque Sunport	Roof	Carport Roofs	146 kW	Airport	Jim Hinde	Director	PO Box 9948	Albuquerque, NM 87119	505-244-7805	Jhinde@cabq.gov
Bakersfield Meadows Field	Ground	Between Terminal and Runway	748 kW	Private Developer	Jack Gotcher	Aviation Director	3701 Wings Way	Bakersfield, CA 93308	661-393-1870	airports@lightspeed.net
Boston Logan	Roof	Parking Garage B	200 kW	Massport	Terry Civic	Utilities Manager	One Harborside Drive, Ste. 200S	Boston, MA 02128	(617) 568-5996	TCivic@massport.com
Denver	Ground (2)	Entrance Road Fuel Farm	2.0 MW, 1.6 MW	Private Developer	Woods Allee	Budget Liaison	8500 Pena Boulevard	Denver, CO 80249	(303) 342-2632	Woods.Allee@flydenver.com
Fresno Yosemite	Ground	Runway End	2 MW	Private Developer	Kevin Meikle	Airport Planner	4995 E Clinton Way	Fresno, CA 93427	559-621-4536	Kevin.Meikle@fresno.gov
Houston George Bush	Roof	Terminal Rooftop	60 kW	Airport	James Parise	EMS Manager	16930 John F. Kennedy Blvd.	Houston, TX 77032	281-233-1756	jim.parise@cityofhouston.net
Oakland	Ground	General Aviation Area	756 kW	Private Developer	Anthony Kekulawela	Port of Oakland	530 Water Street	Oakland, CA 94607	510-627-1647	akekulawela@portoakland.com
San Francisco	Roof	Terminal 3	500 kW	SF Public Utility	Greg McCarthy	Project Engineer	PO Box 8097	San Francisco, CA 94128	650-821-5304	Greg.McCarthy@flysfo.com
San Jose	Roof	Rental Car Facility	1.1 MW	Airport	Dave Maas	Deputy Director Aviation	1732 North First St.	San Jose, CA 95112	408-392-3630	dmaas@sjc.org

*Projects are also located at Austin TX, Burbank CA, Long Beach CA, Prescott AZ, and five airports in Hawaii.

Appendix C

Private Developer Ground Lease Example (Denver)

GROUND LEASE AGREEMENT
SUMMARY PAGE

This Summary Page, consisting of two pages, is attached to and made a part of that certain Ground Lease Agreement dated _____, 2009 between the City and County of Denver and the Tenant listed below.

TENANT

Name XYZ Solar

Address Somewhere
Denver, CO

Attention Solar Rep

LEASE PREMISES

Location Denver International Airport ("DIA")

Address 8500 Peña Boulevard
Denver, Colorado 80249-6340

Square Footage _____

PERMITTED USES installation and operation of a photovoltaic power system and related equipment

HOURS OF OPERATION 365 days a year, weather permitting

TERM

Effective Date Date Lease becomes effective upon City Council approval

Expiration Date 25 years from Commencement Date

_____
Tenant

SFCA_472976.2

COMPENSATION (Initial)

Ground Rent	Annual Rate of $TBD.00 per acre
Energy Production at Agreed Price	as provided in Solar Power Purchase Agreement between the Parties

INSURANCE POLICY AMOUNTS

A. Comprehensive General Liability	$1,000,000.00/$2,000,000.00
B. Automobile/Delivery Vehicle Liability	$1,000,000

DESCRIPTION OF EXHIBITS AND ADDENDA

Exhibit A	Lease Premises Legal Description
Exhibit B	Site Plan of Lease Premises and Site Improvements
Exhibit C	Purchase Option Summary Sheet
Exhibit D	Insurance Certificate
Exhibit E	Design Standards, Construction Procedures, and DIA Performance Specifications
Exhibit F	DIA Environmental Requirements

Tenant

CONSTRUCTION SUMMARY PAGE

This Summary Page, consisting of one page, is attached to and made a part of that certain Ground Lease Agreement dated _____, 2007 between the City and County of Denver and the Tenant listed below.

TENANT

Name XYZ Solar

Address Somewhere
Denver, CO

Attention Solar Rep

CONSTRUCTION AND INSTALLATION DEADLINE
December 31, 2010

CONSTRUCTION PERFORMANCE AND PAYMENT BOND AMOUNT
(100% of construction contract price)

CONSTRUCTION INSURANCE POLICY AMOUNTS

A. Builders Risk 100% of construction contract price

B. Minimum Commercial General Liability
Combined Single Limit $1,000,000

General Aggregate $2,000,000

C. Business Auto Liability
Combined Single Limit $1,000,000

D. Worker's Compensation Statutory Requirements

SFCA_472976.2

_____
Lessee

GROUND LEASE AGREEMENT

between

CITY AND COUNTY OF DENVER

and

XYZ Solar

LEASE AGREEMENT

THIS LEASE AGREEMENT ("Lease"), is made and entered into on the _____ day of _____, 2009, by and between the **CITY AND COUNTY OF DENVER**, a municipal corporation of the State of Colorado ("City"), and **XYZ Solar**, a Colorado partnership authorized to do business in the State of Colorado ("Tenant").

WHEREAS, the City owns and operates Denver International Airport ("Airport"), located in the City and County of Denver, Colorado, and Tenant desires to obtain certain rights, services, and privileges in connection with the use of the Airport; and

WHEREAS, the City has determined that in the exercise of its lawful functions, and to serve better the Airport's public use, it is desirable and appropriate that a photovoltaic power system (the "System") be developed, constructed, equipped, and operated on Airport land, and that such use is compatible and appropriate within the uses allowed for Airport land, in order to put the same to full, productive use and for the benefit of the Airport; and

WHEREAS, the City deems it appropriate and necessary in the public interest to have the System, which is owned by Tenant, operated upon the Airport by the Tenant; and

WHEREAS, Tenant hereby binds itself subject to the terms and provision of this Lease to pay to the City the rentals and payments required herein and to otherwise perform all of the terms and conditions of this Lease;

NOW THEREFORE, for and in consideration of the rentals and of the terms and conditions stated in this Lease on the part of the Tenant to be kept, observed and performed, the City does by these presents demise and lease to Tenant, and Tenant has agreed to take and does hereby take from the City, the Lease Premises (as defined below), as they may be improved, all upon and subject to the following terms and conditions:

SECTION 1
GENERAL

1.01 CONSIDERATION. The City enters into this Lease in consideration of the payment by Tenant as herein provided and of the performance and observance by Tenant of the covenants and agreements herein.

1.02 INCORPORATION OF ATTACHED SUMMARY PAGES, EXHIBITS, AND ADDENDA. The Summary Pages attached to the Lease and the Exhibits and Addenda as described on the Summary Pages and attached to this Lease are incorporated into this Lease by reference.

1.03 CONDITIONS PRECEDENT TO EFFECTIVENESS OF LEASE. The Parties agree that acknowledgement of no objection from the Federal Aviation

Administration of the plans for the Generating Facility shall be a condition precedent to the effectiveness of this Lease.

SECTION 2
DEFINITIONS

2.01 AUDITOR. "Auditor" shall mean the City's Auditor and his authorized representative.

2.02 BUILDING CODE. "Building Code" shall mean the Building Code for the City and County of Denver, which is based on the codes developed by the International Code Council ("ICC"). These include the 2003 Series of I Codes, and accompanying National Electrical Code regulated by the National Fire Protection Association and the State of Colorado Electrical Board, as amended by the City Council. The 2004 Denver Building Code Amendments include changes to the following: 2003 International Building Code; 2003 International Residential Code; 2003 International Mechanical Code; 2003 International Fuel and Gas Code; 2003 International Energy Conservation Code; 2003 International Plumbing Code; 2003 International Fire Code; 2005 NEC National Electrical Code. Note: The International Electrical Code, International Zoning Code and International Property Maintenance Codes have not been adopted.

2.03 COMMENCEMENT DATE. "Commencement Date" shall mean the date of completion established and memorialized by a written notice issued by Tenant and addressed to the Manager, and acceptance of the System, which shall be no later than December 31, 2009, and shall be established and memorialized by a written notice issued by the Manager and addressed to Tenant.

2.04 DIA DESIGN STANDARDS. "DIA Design Standards" shall mean the design standards and criteria for Denver International Airport, and as they may be amended from time to time.

2.05 DIA DEVELOPMENT GUIDELINES. "DIA Development Guidelines" shall mean the tenant development guidelines and criteria established for Airport tenants and concessionaires for design, construction, installation, signage, and related matters, and as they may be amended from time to time.

2.06 DIA ENVIRONMENTAL GUIDELINES. "DIA Environmental Guidelines" shall mean the environmental standards and criteria established for tenant operators at the Airport, and as hereafter amended, to the extent they apply to this project.

2.07 LAND. "Land" shall mean the parcel of real property legally described on Exhibit A and generally depicted on Exhibit B attached hereto and containing the number of acres, more or less, as set forth therein. The City expressly reserves from the Land all oil, gas, and other mineral rights, air rights, and water rights.

2.08 LEASE PREMISES. "Lease Premises" shall mean the Land upon which the System is installed.

2.09 MANAGER OR MANAGER OF AVIATION. "Manager" or "Manager of Aviation" shall mean the Manager of the City's Department of Aviation.

2.10 PAST DUE INTEREST RATE. "Past Due Interest Rate" shall mean interest accruing at One Percent (1%) per month commencing on the fifth calendar day after the date such amount is due and owing until paid to the City.

2.11 POWER PURCHASE AGREEMENT. "Power Purchase Agreement" shall mean that certain Power Purchase Agreement of even date herewith, between Tenant as Power Provider, and the City as Purchaser.

2.12 SITE IMPROVEMENTS. "Site Improvements" shall mean all initial construction and any improvements on the Lease Premises, as well as any other improvements outside of the Lease Premises but on Airport property, including access roadway improvements, drainage improvements, utility and System interconnects, as described in Exhibit B attached hereto, and any future improvements approved by the Manager and constructed by Tenant pursuant to terms of this Lease.

2.13 SYSTEM. "System" shall mean the solar panels, mounting substrates or supports, wiring and connections, power inverters, service equipment, and utility interconnections installed by Tenant on the Lease Premises and part of the photovoltaic power generating system owned and operated by Tenant.

2.14 TENANT'S EQUIPMENT. "Tenant's Equipment" shall mean personal property and equipment, and signs used in the operation of the business of Tenant on the Lease Premises but not specifically part of the System.

SECTION 3
LEASE OF PREMISES

3.01 LEASE RIGHTS GRANTED. The City grants to Tenant the right to construct upon, occupy and use the System on the Lease Premises consistent with and subject to all of the terms and provisions of this Lease. The rights and privileges granted herein are subject to prior easements, rights of way, and other matters affecting title to the Land. The Land is expressly subject to an avigation easement hereby reserved to the City and the Airport for the flight of aircraft over the Lease Premises. Should any easements or rights of way to the Land that would prevent Tenant's performance hereunder or under the Power Purchase Agreement materialize at some future date, the City agrees to resolve and work around such matters at its sole cost and expense.

3.02 USE OF LEASE PREMISES. Tenant shall have the right to construct upon and use the Lease Premises solely for the installation and operation of the System and related services as set forth on the Summary Pages. Tenant shall also

have the right to store Tenant's inventory of spare parts for the operation and maintenance of the System at the Airport's parts distribution facility, with such space not to exceed 100 square feet. The City shall make such stored spare parts available to Tenant within two (2) business days upon request by Tenant. The Lease Premises shall be utilized for no other purposes, unless otherwise authorized in writing by the Manager of Aviation. It is understood that the use of Lease Premises is restricted by the zoning code designation by the City, by the Intergovernmental Agreement (IGA) dated April 21, 1988, between the City and Adams County, and by all applicable rules, regulations, statutes or ordinances promulgated by any federal, state, or municipal agency having jurisdiction over the Lease Premises. The Land is zoned O-2, Open Space, and such zoning code designation specifically allows energy production.

3.03 RIGHTS NOT EXCLUSIVE. The City reserves the right to grant to other tenants the right to provide the same or similar services as described on the Summary Pages at other locations at the Airport and in the City; provided, however, that such grant to other tenants shall not interfere with Tenant's rights hereunder or Tenant's ability to perform as Power Provider under the Power Purchase Agreement. Tenant expressly understands and agrees that although it has the exclusive right to produce solar energy on the Lease Premises, its rights to produce solar energy for the City and County of Denver are not exclusive.

3.04 CITY RESERVATION; NO INTERFERENCE. The City reserves for itself the right to install utilities upon areas of the Lease Premises as necessary or convenient for the operation of the Airport, and the City further shall have the right to grant easements in areas of the Land for the installation of utilities, provided that the use of such areas or the grant of such easements does not unreasonably interfere with the Tenant's operations and use of the Lease Premises. The Tenant shall not be entitled to any compensation or abatement of rent if the use of such areas or the grant of such easements does not unreasonably interfere with the Tenant's operations or use of the Lease Premises. Notwithstanding the above, and notwithstanding the System's presence as a fixture on the Lease Premises, the City represents to Tenant that the City has legal title to the Land and that there are no circumstances known to the City and no commitments to third parties that may damage, impair, or otherwise adversely affect or interfere with the System or its function by blocking the System's insolation and access to sunlight; furthermore, the City covenants that the City shall not cause or permit any such interference with the System's insolation and access to sunlight.

3.05 MEANS OF ACCESS. Tenant, its agents and employees, have a non-exclusive right of ingress to and egress from the Lease Premises by a means of access located outside the Land as specified by the City. The City may, at any time, temporarily or permanently, close or consent to or request the closing of any roadway or other right-of-way for such access, ingress and egress, and any other area at the Airport or in its environs presently or hereafter used as such, so long as there is reasonable access, ingress and egress available to the Lease Premises except in the case of severe snow storms, other extreme and materially adverse weather conditions, and any increased security alerts. Tenant hereby releases and discharges the City of

and from any and all claims, demands or causes of action which the Tenant may at any time have against the City arising or alleged to arise out of the closing of any roadway or other right-of-way for such access, ingress and egress or other area at the Airport or in its environs used as such, so long as reasonable and proper notice of such modification was given by the City to Tenant, and reasonable access, ingress and egress is available after any such modification.

3.06 RIGHT OF INSPECTION. The City retains the full right of entry upon the Land and to the Lease Premises, with reasonable notice to Tenant, for any purpose necessary, incidental to or in connection with its obligations hereunder, or in the exercise of its governmental functions, or for the purpose of making any inspection or conducting any testing it deems necessary. The City shall not be obligated to notify Tenant in advance of any entry upon the Land and/or the Lease Premises by the City or agent of the City that is deemed by the City to be of any emergency nature, in the sole discretion of the City, and the City agrees to give notice to Tenant within a reasonable time after such emergency entry. No such entry by or on behalf of the City upon the Land and/or the Lease Premises shall constitute or cause a termination of the Lease nor shall such entry be deemed to constitute an interference with the possession thereof by the Tenant.

SECTION 4
TERM

4.01 TERM. "Term" shall mean the period commencing at noon on the Effective Date and expiring at noon on the Expiration Date specified on the Summary Pages.

4.02 TERMINATION OF LEASE BY CITY FOR AVIATION PURPOSES. The City reserves the right to terminate this lease for the purpose of implementing any master plan for development or expansion of the Airport, as required by the Federal Aviation Administration, or as required for air navigation purposes. In the event the Manager of Aviation determines that the City requires use of the property for aviation purposes during the Term, and such aviation purposes require termination of the lease, the City shall have the right to terminate this Lease upon six (6) months prior written notice to Tenant and payment of the Termination Value in Exhibit C. Notwithstanding the System's presence as a fixture on the Site, in such instance when the City requires termination of the lease, the City shall be responsible for all associated costs of removal. If such notice is provided under this paragraph, then the City, at its option, may offer to Tenant comparable and suitable alternate land which shall to the extent possible be similar to the property as to size and general location, and provided Tenant is not in default hereunder, shall pay to Tenant a Relocation Reimbursement equal to the actual removal, reinstallation, interconnection expenditures and all costs of deployment incurred by Tenant for such relocation, should Tenant, in its reasonable discretion, agree to such relocation. In such instance when the City requires relocation, the City shall pay to Tenant, in addition to other amounts set forth in this section, a monthly payment (prorated as needed) equal to the average power purchase set forth

in Section 4 of the Power Purchase Agreement for the preceding twelve (12) months, or however long the System has been in Commercial Operation if less than twelve (12) months, for the period of time during which the System is not in Commercial Operation due to the relocation.

4.03 HOLDING OVER. If Tenant holds over after termination of this Lease, thereafter Tenant's occupancy shall be at sufferance but otherwise Tenant shall be bound by all terms and conditions as herein provided in the absence of a written agreement to the contrary. Nothing herein shall be construed to give Tenant the right to hold over at any time, and the City may exercise any and all remedies at law or in equity to recover possession of the Lease Premises, as well as any damages incurred by the City.

4.04 SURRENDER OF LEASE PREMISES. Upon the expiration or earlier termination of this Lease on the date specified in any demand for possession by the City after any default by Tenant, Tenant covenants and agrees that, at the City's sole option, (i) the City shall elect to purchase the System in accordance with Section 4.05 or (ii) if the City is not in default under the Power Purchase Agreement, then at Tenant's expense Tenant shall remove the System or such portion thereof as is specified by the Manager, within one hundred twenty (120) days of such expiration or termination or within such additional time as is granted by the Manager. If termination of this Lease is due to the default of City, and the City elects not to purchase the System, the City shall be responsible for removal costs for the System. If all or any portion of the System is removed as requested by the City, Tenant shall, at tenants expense, restore the Land or property to conditions existing prior to the installation of such improvements or applicable portions thereof, and upon failure to do so the City may cause such removal and restoration to be done at Tenant's expense. If Tenant fails to remove any of System by the expiration or termination of this Lease, the City may, at its option, keep and retain any such System or dispose of the same and retain any proceeds therefrom, and the City shall be entitled to recover from Tenant any costs of the City in removing the same and in restoring the Lease Premises subject to ordinary wear and tear, in excess of the actual proceeds, if any, received by the City from disposition thereof.

4.05 OPTION FOR PURCHASE OF SYSTEM. At any time after the sixth anniversary of the Commencement Date, the City may elect, in its sole discretion and at its sole option, to purchase the System from the Tenant, including all rights and privileges held by the Tenant. If the City elects to purchase the System prior to the Expiration Date, the City shall pay to the Tenant the greater of the then Fair Market Value or Buyout Price set forth in the Purchase Option Summary Sheet attached to this Ground Lease as Exhibit C. If the City elects to exercise the purchase option at the Expiration Date, the purchase price shall be the then Fair Market Value. Not less than ninety (90) days prior to the projected date for exercise of the purchase option, the City shall provide written notice to Tenant of the City's desire to determine the Fair Market Value of the System. The city shall not elect to exercise its Purchase Option until after a Fair Market Value has been determined. Upon the exercise of the foregoing purchase option plus receipt of the Fair Market Value or Buy-Out Price, as applicable,

and all other amounts then owing by the City to Tenant, the parties will execute all documents necessary to cause title to the System to pass to the City as-is, where-is; provided, however, that Tenant shall remove any encumbrances placed on the System by the Tenant. The "Fair Market Value" of the System shall be the value determined by the mutual agreement of the City and Tenant within thirty (30) days of the City's notice of desire to determine the Fair Market Value pursuant to this Section 4.05. If the City and Tenant cannot mutually agree to a Fair Market Value, then the parties shall select a nationally recognized independent appraiser with experience and expertise in the solar photovoltaic industry to value such equipment. Such appraiser shall act reasonably and in good faith to determine the Fair Market Value and shall set forth such determination in a written opinion delivered to the parties. The valuation made by the appraiser shall be the price at which the City may, in its sole discretion, determine to exercise its Purchase Option. The costs of the appraisal shall be borne by the parties equally. To the extent transferable, the remaining period, if any, on all warranties for the System will be transferred from Tenant to the City at no cost to the City. If the parties are unable to agree on the selection of an appraiser, such appraiser shall be selected by the two appraiser firms proposed by each party. Upon any such purchase of the System by the City, Tenant shall convey all its title, ownership rights, and any other interests Tenant holds in the System and the renewable energy certificates and other revenues related to the System. Such purchase and assignment shall be conditioned upon the consent of Public Service Co. of Colorado to the transfer and assignment of the agreements between the Tenant and Public Service Co. of Colorado.

SECTION 5
COMPENSATION

5.01 COMPENSATION

A. Ground Rent. Tenant agrees to pay the City the Ground Rent set forth on the Summary Pages beginning on the Effective Date and thereafter on January 1 of each calendar year, in advance and without demand, during the Term, as it may be modified from time to time, subject to the City's right to reestablish said Ground Rent under Section 5.05. The Ground Rent for any partial month during the Term shall be prorated on a per diem basis.

B. Purchase Price and Energy Output. Tenant agrees to provide to the City, and the City agrees to purchase, the Energy Output at the Purchase Price specified in the Power Purchase Agreement.

5.02 INTEREST ON PAST DUE AMOUNTS

Any payments not made to the City within five (5) business days after the date such amount is due and owing shall accrue interest at the Past Due Interest Rate, as herein defined.

5.03 PLACE AND MANNER OF PAYMENTS

All Ground Rent and other compensation payable to the City hereunder shall be made payable to "Airport Revenue Fund" without notice at the following:

Office of the Manager of Aviation
Denver International Airport
P.O. Box 492065
Denver, Colorado 80249-2065

or at such other place as the Manager of Aviation or his authorized representative may hereafter designate by notice in writing to Tenant.

All sums shall be payable in legal tender of the United States. Any check given to the City shall be received by it subject to collection, and Tenant agrees to pay any charges, fees or costs incurred by the City for such collection, including reasonable attorney's fees.

5.04 BOOKS OF ACCOUNT AND AUDITING.

Tenant expressly agrees that the City's Manager and Auditor and their authorized representatives may inspect any sales tax return or report and accompanying schedules and data which Tenant may file with the City pursuant to the City's Retail Sales Tax Article, and any reporting and Environmental Incentive data which Tenant may file with the Public Service Co. of Colorado, and waives any claim of confidentiality which it may have in connection therewith.

5.05 REESTABLISHMENT OF RENTALS, FEES AND CHARGES

The City, through its Manager of Aviation, may from time to time, at intervals of not more than five (5) years, at the Manager of Aviation's sole discretion, and subject to the requirements of any outstanding bond ordinance pertaining to the Airport, reestablish the rentals, fees and charges provided for herein. The City agrees that such right shall not be exercised prior to an effective date which is the sixth anniversary of the Commencement Date, and such reestablished schedule of rentals, fees and charges shall be reasonable in relation to the cost of providing, operating and maintaining property, services and facilities of the airport system.

If the Manager of Aviation proposes any change in the schedule of rentals, fees and charges, the City will give notice thereof to Tenant not less than ninety (90) days before the same is to become effective. Should the proposed changes result in an increase of more than Five Percent (5%) in the dollar amount of compensation paid by Tenant for the prior calendar year, then Tenant may decline to pay compensation at the new rate(s). Tenant shall promptly (but in no event less than thirty (30) days prior to the proposed effective date of such schedule of rentals, fees and charges) advise the Manager of Aviation of its intention to cancel and terminate this Lease. Upon such notice of intent to cancel and terminate, Tenant shall surrender the Demised Premises upon a date specified by the Manager of Aviation but in no event less than one hundred twenty (120) days after the Tenant's notice of intent to cancel. In no event shall the rate

increase go into effect if Tenant has timely delivered its intent to cancel and terminate this Lease. Should Tenant fail to give timely notice of cancellation and termination, then it shall be deemed to have accepted the new rate(s) of compensation as promulgated by the Manager of Aviation.

No failure by the City to reestablish the rentals, fees, and charges at a five-year interval date shall constitute a waiver of the City's right to reestablish the rentals, fees, and charges at any time thereafter.

SECTION 6
CONSTRUCTION AND INSTALLATION OF SYSTEM

6.01 CONSTRUCTION OF SYSTEM. Tenant shall, at its sole cost, construct and install the System and Site Improvements in full compliance with approved plans and specifications and the requirements of Exhibit E as hereinafter provided.

6.02 CONSTRUCTION OF SITE IMPROVEMENTS. Tenant shall, at its sole cost, construct and install the Site Improvements in full compliance with approved plans and specifications as hereinafter provided.

6.03 APPROVAL OF PLANS AND SPECIFICATIONS. As more fully described in Exhibit E attached, full and complete plans and specifications for all work, site development, facilities and improvements, and a schedule of the time required to complete same, shall be submitted to Airport Engineering for review and written approval, with such review and written approval to be issued in a reasonably timely manner. The plans and specifications shall be separately submitted to the City's Building Inspection Division for consolidated review by the Building Inspection and Fire Department.

First-class standards of design and construction shall be required in connection with all such work, facilities and improvements, and all improvements shall conform with applicable statutes, FAA approval requirements, ordinances, building codes, regulations, DIA Design Standards, DIA Development Guidelines and DIA Environmental Guidelines and other general requirements of the Airport and the City. The approval given by the City shall not constitute a representation or warranty as to such conformity nor does the City warrant the suitability of the site for the Tenant's operations; responsibility therefor shall at all times remain with Tenant.

6.04 CONSTRUCTION PERIOD. Tenant shall complete the construction and installation of the System and Site Improvements no later than the date set forth on the Summary Pages ("Construction Period"). The Construction Period shall be extended by the Manager if completion of the System or Site Improvements was delayed through no fault of Tenant. Notwithstanding the foregoing, in no event shall construction delays affect the date upon which compensation is due. The City shall inspect the construction and perform acceptance tests to demonstrate System output

and proper performance of System interconnection.

6.05 COORDINATION OF CONSTRUCTION. Tenant shall cooperate with the City and its planners, designers, architects, and engineers in the construction and installation of the System and Site Improvements on the Lease Premises and comply with the approved plans and specifications of the Building Code, and to the extent applicable the DIA Development Guidelines. Tenant recognizes that during its Construction Period construction may also occur in adjacent areas surrounding its Lease Premises, and Tenant agrees to monitor construction in adjacent areas and coordinate the work of its contractors with the construction, scheduling and construction staging occurring in adjacent areas.

Tenant shall prevent activities associated with the construction or installation of the System at the Airport from interfering with travelers, other businesses or Airport operations, and such activities may be required to be accomplished during off hours, in whole or in part, requiring overtime payments to workers.

Tenant shall be responsible for all utilities needed during construction.

Tenant or its contractor shall at all times keep the construction site and surrounding area in a clean, orderly and safe condition free of accumulated construction debris and waste materials, and shall be responsible for removal of all construction debris and waste materials to a suitable licensed landfill off DIA property.

All construction work, materials, and installations involved in or incidental to the construction on the Lease Premises shall be subject at all times to inspection and approval by the City. The City shall at all times have the right of access to the Lease Premises to monitor and inspect the construction of the Site Improvements to assure that such improvements are constructed and installed in compliance with the approved plans and specifications.

The City shall have the right to halt construction or deny access to the Lease Premises at any time if such construction is at material variance from the approved plans and specifications until such material variance is corrected, or if such construction poses an immediate safety hazard at the Airport, until such safety hazard is eliminated. The City shall cooperate and use its best efforts to alleviate and resolve any such material variance or impediment to the safe operation of the Airport so as to permit continuation of construction as expeditiously as possible.

6.06 ENVIRONMENTAL REQUIREMENTS FOR CONSTRUCTION. In the performance of construction activities for the Tenant Improvements or Site Improvements, Tenant is responsible for insuring that it or its contractor complies with all federal, state and local environmental requirements including without

limitation the requirements of Exhibit F attached and the following:

A. Environmental Control. Tenant shall comply with the requirements under Denver International Airport Technical Specifications Section for Environmental Controls and Temporary Erosion and Sedimentation Control.

B. Air Pollution. If required by law, Tenant shall obtain a fugitive dust permit from the Colorado Department of Health and Environment.

C. Stormwater Permit. If required by law, Tenant shall obtain a construction stormwater permit from the Colorado Department of Health and Environment.

D. Soil Erosion and Sedimentation Control. Tenant shall submit a plan for the City review and approval pertaining to proposed measures to control soil erosion and sedimentation during construction. The plan shall comply with Technical Specification for Temporary Erosion and Sedimentation Control. These specifications address topsoil stripping, soil stockpiling, runoff control, sedimentation (traps), air and water pollution, maintenance and inspection. Tenant shall implement prudent industry practices in preventing soil erosion and controlling sedimentation.

E. Solid and Hazardous Waste Controls. Tenant is responsible for minimizing the amount of "solid" and hazardous waste generated during construction activities. "Solid waste" is defined as all putrescible and non-putrescible solid, semi-solid and liquid wastes, but does not include hazardous waste. An attempt should be made to recycle generated waste. Disposal of waste shall be used as a last resort. Tenant is responsible for the safe disposal of all solid and hazardous waste and shall dispose of such waste in accordance with all applicable laws, regulations and ordinances.

Tenant shall minimize the land disposal of construction waste to the maximum extent practicable. Activities under this provision include the recycling of rebar, concrete, oil, asphalt and drywall.

F. Noise and Vibration Control. Tenant shall comply with all noise and vibration control requirements of Denver International Airport Technical Specification Section 01566.

6.07 AS-BUILT DRAWINGS. Not later than sixty (60) days after completion of all work for the System and any Site Improvements, Tenant shall provide the City complete sets of as-built drawings prepared in accordance with Exhibit E attached. If Tenant fails to provide the as-built drawings after written notice from the City, the City may elect to have the drawings completed and charge Tenant for the costs associated therewith. Tenant agrees that, upon the request of the City, Tenant will inspect the Lease Premises jointly with the City to

verify the as-built drawings. All material improvements made by Tenant shall be subject to inspection by the City and approval by Manager within fourteen (14) calendar days of request for approval, and shall be removed and replaced at Tenant's sole cost immediately if disapproved.

6.08 BUILDING PERMIT. Tenant or its contractor are solely responsible for applying for, obtaining, and paying for all required building permits, licenses and other approvals, and is responsible for submitting plans and specifications to the City's Building Inspection Division for the necessary building permits.

6.09 CONSTRUCTION BONDS. Prior to the commencement of construction, Tenant shall deliver to the Manager a payment and performance bond in a sum not less than One Hundred Percent (100%) of construction contract price payable to Tenant's contractor. Said bond shall guarantee prompt and faithful payment by the Tenant directly to Tenant's contractors and by Tenant's contractors to all persons supplying labor, materials, team hire, sustenance, provisions, provender, supplies, rental machinery, tools and equipment used directly or indirectly by the said contractor, subcontractor(s) and suppliers in the prosecution of the work provided for in said construction contract and shall protect the City from any liability, losses or damages arising therefrom.

All bonds shall be issued by a surety company licensed to transact business in the State of Colorado and satisfactory to and approved by the City and shall be in form and with condition as provide in DIA Development Guidelines.

In lieu of a construction bond, the Tenant may provide only such alternate forms of security as are permitted in DIA Development Guidelines, in such form and with conditions as provided therein.

6.10 CONSTRUCTION INSURANCE. Tenant agrees to secure or require each contractor to secure and to keep in full force and effect during and until completion of the System and Site Improvements the following insurance:

A. Builder's Risk Insurance. A builder's risk insurance policy covering 100% of the construction contract amount.

B. Commercial General Liability Insurance. A commercial general liability insurance policy on a comprehensive form, written on an occurrence basis and including coverage for premise/operations, products/completed operations, contractual, independent contractors, broad form property damage, personal injury, and fire legal liability. This commercial general liability insurance policy shall be in an amount not less than Two Million Dollars ($2,000,000) for bodily injury and property damage in a combined single limit per occurrence and in aggregate, for liability associated with this Lease.

This policy shall be written with an insurance provider acceptable to and approved by the City. It shall further cover the obligations assumed by Tenant hereunder and shall name and endorse the City as an additional insured. This policy shall contain a waiver of subrogation in favor of the City. This insurance policy shall not contain any care, custody or control exclusions, and shall not contain any exclusion for bodily injury to or sickness, disease or death of any employee of Tenant or any of its contractors which would conflict with or any way impair coverage under the contractual liability endorsement.

C. Business Auto Liability Insurance. A business auto liability insurance policy which includes coverage for owned, non-owned and hired vehicles in an amount not less than One Million Dollars ($1,000,000) for landside or tunnel access in a combined single limit for damage or bodily injury, including wrongful death, as well as from claims for property damage, which may arise from the ownership, use or maintenance of owned or non-owned vehicles, including rented vehicles, and including their use on or off City property or by City personnel. This policy shall name and endorse the City as an additional insured and shall contain a waiver of subrogation in favor of the City.

D. Worker's Compensation Insurance. Worker's compensation insurance which shall comply with the requirements of the Worker's Compensation Act of Colorado and shall provide coverage including employer's liability with a minimum limit of One Million Dollars ($1,000,000) to protect Tenant from any and all claims arising from performance of work under this Lease.

The above amounts may be increased or modified by the Manager, or in accordance with the DIA Development Guidelines, at any time during construction.

6.11 LIMITATION ON LIABILITY. Tenant agrees that no liability shall attach to the City for any damages or losses incurred or claimed by Tenant or any other person or party on account of the construction or installation of the System and any Site Improvements or other improvements to or upon the Airport made by Tenant. Tenant agrees that no liability shall attach to the City for any interference or delay caused by construction in adjacent areas or Airport operations, including without limitation damages or losses in the nature of delay damages, lost labor productivity, and impact damages. The City agrees that no liability shall attach to Tenant as a result of any City-caused interference or delay.

6.12 COMPLIANCE WITH ALL LAWS AND REGULATIONS. Tenant agrees not to use or permit the Lease Premises to be used for any purpose prohibited by the laws of the United States or the State of Colorado or the ordinances or Charter of the City and County of Denver, or not authorized hereunder, and it further agrees that it will use the Lease Premises in accordance with all applicable federal, state and local laws and all general rules and regulations adopted by the City or the Manager for the management, operation and control of the Airport, either promulgated by the City on its own initiative or in compliance with regulations, requirements or actions of the

Federal Aviation Administration or other authorized federal agency. Tenant further agrees to submit any report or reports or information which the City is required by law or regulation to obtain from Tenant or which the Manager may request relating to Tenant's operations.

A. PREVAILING WAGE. Tenant shall require its contractors and all of its subcontractors and subtenants to pay every worker, laborer or mechanic employed by them in the performance of the construction of improvements on the Lease Premises prevailing wages, including fringe benefits or their cash equivalent, for the same class and kind of work in the City and County of Denver, as determined by the Career Service Board under the provisions of Section 20-76 of the Denver Revised Municipal Code. The wages shall be those prevailing at the time of the contractor's final bid, and Tenant shall require the contractor to submit with its bid the wage schedule applicable. The contractor shall post in a prominent and easily accessible place at the site of the improvements the scale of wages to be paid by the contractor and all subcontractors at any tier working under the contractor. The contractor shall furnish to the Auditor or his authorized representative, each week during which work is in progress, a true and correct copy of the payroll records of all workers employed to perform the work. All payroll records shall include information showing the number of hours worked by each worker, the hourly pay of such worker, any deductions made from pay, and the net amount of pay received by such worker for the period covered by the payroll. The payroll record shall be accompanied by a sworn statement concerning the records of all workers performing the work, either for the contractors or subcontractors, that payments were made to the workers as set forth in the payroll records, that no deductions were made other than those set forth in such records, and that all workers were paid the prevailing wages as of the contractor's final bid for the work. Compliance with above requirements shall be deemed a work "specification" as such word is used in Section 49-173, Denver Revised Municipal Code. Violation of the prevailing wage requirement and its documentation, herein above set forth, shall result in an order from the Manager of Aviation for the work to cease until there is satisfactory evidence that the violation has been remedied and will not recur. The issuance of a stop-work order shall not relieve the contractor's surety of any liability on the contractor's bond or bonds, but such a stop-work order shall be deemed a default by the contractor insofar as said surety's obligation is concerned.

B. SMALL BUSINESS OPPORTUNITY DIVISION. The Director of the Division of Small Business Opportunity (DSBO) will review the employment practices of Tenant's contractors and all levels of subcontractors and suppliers, and the utilization by the contractors of Minority and Women Business Enterprises (MBE and WBE) and/or Disadvantaged Business Enterprises (DBE), in connection with work performed on the Lease Premises. The reviews will be made to determine whether or not all applicable rules, regulations, ordinances, and laws governing equal employment opportunity, affirmative action programs, and MBE, WBE and DBE requirements are complied with.

This Lease is subject to all applicable provisions of Divisions 1 and 3 of Article III of Chapter 28 of the City's Revised Municipal Code and the MBE and WBE Program's

Rules and Regulations. Tenant acknowledges its continuing duty, pursuant to Denver's MBE and WBE Ordinances, to maintain throughout the duration of the Construction Period compliance with the level of SBE participation upon which the City approved the award of this Lease to the Tenant, which is Ten Percent (10%) of the construction services component of the project.

6.13 RESTRICTION ON CHANGES AND ALTERATIONS. Tenant agrees not to materially improve, change, alter, add to, remove or demolish all or any of the System or Site Improvements without the prior written consent of the Manager or his authorized representative. Tenant must comply with all conditions which may be imposed by the Manager. Full and complete specifications for all work and material improvements, along with a statement of the time required to complete such work shall be submitted to and approved in writing by the Manager or his authorized representative within fourteen (14) calendar days of submission and before construction work commences. Four copies of plans for all changes or alterations shall be given to the Director, Airport Engineering for review and written approval prior to commencement of construction. After City's final approval, City shall return to Tenant one approved copy for its records and shall retain one approved copy as an official record thereof.

6.14 TITLE TO IMPROVEMENTS; TITLE TO SYSTEM. Tenant agrees that all improvements to the Lease Premises or Airport property, including approved changes and renovations, which are affixed to the realty, shall become the property of the City upon their completion and acceptance by the City. Notwithstanding the foregoing, and notwithstanding the System's presence as a fixture on the Lease Premises, Tenant shall retain title to and be the legal and beneficial owner of the System, and the System shall remain the property of Tenant or Tenant's assigns until such time as the City purchases the System. The City consents to Tenant recording a memorandum of this Lease in the land registry or title records of the county where the Lease Premises are located or other applicable government office. Tenant shall be entitled to, and is hereby authorized to, file one or more precautionary financing statements or fixture filings in such jurisdictions as it deems appropriate with respect to the System in order to protect Tenant's rights in the System. The City expressly denies any ownership, interest, operation, responsibility, or liability for the installation, operation or maintenance of the System or the Tenant's Equipment at any time during the Term.

SECTION 7
OPERATION AND USE OF LEASE PREMISES

7.01 OPERATIONS. System production and operation requirements:

A. Tenant shall use commercially reasonable efforts to operate the System in accordance with the interconnection agreement and any Solar*Rewards SO-REC Contract, each by and between Tenant and Public Service Co. of Colorado.

B. Upon reasonable prior written notice, duly authorized representatives

of governmental entities shall be allowed access to the Lease Premises for inspection purposes. Tenant agrees to obtain at its own expense, and maintain at all times, all licenses and certificates necessary for its operations on the Lease Premises.

C. Safety and Security: The Airport requires personnel badging and vehicle permitting pursuant to federal regulations of the Transportation Security Administration and Federal Aviation Administration. Tenant shall be required to obtain and pay for all required access authorizations, background checks, and badges and permits. If required, Tenant shall establish and maintain a secured (fenced) perimeter at its primary operations area and escort or provide escort for all vendors and suppliers requiring access to the Lease Premises. The parties agree that no secured (fenced) perimeter is required as of the Effective Date. Tenant reserves the right to establish and maintain a secured (fenced) perimeter in the future should Tenant determine such a perimeter necessary.

7.02 HOURS OF OPERATION. Except for scheduled maintenance outages and emergency situations, Tenant agrees to keep its System in operation during all daylight hours, unless otherwise authorized in writing by the Manager or his authorized representative.

7.03 CARE OF AREA. Tenant agrees that it will keep the Lease Premises in a neat, clean, safe, sanitary and orderly condition at all times, and free of all paper, rubbish, spills, and debris. Tenant, at its own expense, shall collect and deposit all trash and refuse at frequent intervals from the Lease Premises. Accumulation of boxes, cartons, barrels or other similar items shall not be permitted outside enclosed areas on the Lease Premises.

7.04 COMPLIANCE WITH ALL LAWS AND REGULATIONS: OPERATIONS. Tenant understands that Section 6.11 applies to all actions governed by this Lease throughout the Term, and understands that it must meet the requirements of all applicable laws, including the Prevailing Wage ordinance and SBE and DBE requirements.

7.05 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS. Tenant, in conducting any activity on the Lease Premises, shall acquire all necessary federal, state, local and airport permits and comply with all requirements of such permits and comply with the requirements of Exhibit F attached hereto, regarding the storage, use and disposal of hazardous materials, petroleum products, or any other substance.

The City shall have a right of access to the Lease Premises without prior notice to inspect the same to confirm that Tenant is using the Lease Premises in accordance with this Lease. In the event the City's inspection of the Lease Premises reveals evidence of a potential non-compliance with the terms of this Lease, at the City's request, Tenant shall conduct any further testing and analysis as is necessary to ascertain whether the Tenant is in compliance with this Lease; if such further testing and analysis determines that Tenant is in compliance with this Lease, the City shall be

solely responsible for all costs and expenses related to such further testing and analysis.

7.06 STORAGE TANKS. Neither above ground nor underground storage tanks will be permitted on the Lease Premises (this includes special enclosure equipment).

7.07 WASTE OR IMPAIRMENT OF VALUE. Tenant agrees nothing shall be done or kept on the Lease Premises which might impair the value of the City's property or which would constitute waste or a public or private nuisance. The parties acknowledge that the Lease Premises is being used to host an electricity grid-connected photovoltaic solar power plant.

7.08 STRUCTURAL OR ELECTRICAL OVERLOADING. Tenant agrees that nothing shall be done or kept on the Lease Premises and no improvements, changes, alterations, additions, maintenance or repairs shall be made to the System and any Site Improvements which might result in an overload of utility lines serving the Airport or interfere with electric, electronic or other equipment at the Airport. In the event of violations hereof, Tenant agrees to immediately remedy the violation at Tenant's expense, as soon as reasonably practicable once Tenant becomes aware of such violation.

7.09 NOISE, ODORS, VIBRATIONS AND OTHER ANNOYANCES. Tenant shall conduct its operations in an orderly and proper manner so as not to commit any nuisance on the Lease Premises or annoy, disturb or be offensive to others at the Airport and shall take all reasonable measures, using the latest known and practicable devices and means, to eliminate any unusual, nauseous or objectionable noise, vapors, odors, lights and vibrations.

7.10 ACCESSIBILITY. Tenant shall not do or permit to be done anything which might interfere with or hinder police, firefighting, or other emergency personnel in the discharge of their duties.

7.11 NO OTHER ENCUMBRANCES. Tenant covenants and agrees not to encumber the Lease Premises or the City property without the prior written consent of the Manager, and to keep the Lease Premises free from all liens and encumbrances.

SECTION 8
UTILITIES, DRAINAGE, MAINTENANCE AND SERVICES

8.01 UTILITIES. Tenant, at its sole cost and expense, shall make, obtain, and establish all electrical interconnections with the utility system(s) in accordance with Xcel procedures and requirements, to measure and transmit the generated power, and all other utility connections, hook-ups or taps as necessary for the operation of the System on the Lease Premises. Tenant shall secure all necessary applications and permits for such connections and shall pay all application and permit fees, hook-up or tap fees. Tenant further agrees at its sole cost and expense to provide meters adequate and

required to measure the amount of generated power and utilities used or consumed by the City and to maintain said equipment in such a manner as to supply accurate measurements of such transmission to, and usage, and consumption by, the City.

8.02 DRAINAGE. Tenant shall either be responsible for detaining on the Lease Premises the developed flow from its improvements and discharging such flow at its historic rate or constructing offsite detention ponds at a location acceptable to the Manager and Tenant shall maintain such drainage facilities. Tenant agrees to insure that an agreement for drainage crossing or slope created by Tenant's construction and any discharge point from the Land shall be constructed with capacity to pass storm from the one-hundred (100) year developed flow with adequate freeboard in accordance with the requirements of Urban Drainage and Flood Control District and the City. Tenant shall keep such drainageways clear of debris and obstructions and maintain them in good condition for the passage of the required flow and avoid erosion degradation.

8.03 MAINTENANCE. The cost of maintenance, care and any necessary replacement of the System and Site Improvements shall be borne by Tenant. Tenant agrees, at its expense and without cost or expense to the City, during the Term hereof that:

A. Tenant shall keep the System and Site Improvements in good order and condition and will make all necessary and appropriate repairs and replacements thereof promptly and in a good and workmanlike fashion without diminishing the original quality of such improvements;

B. Tenant shall not permit rubbish, debris, waste materials or anything unsightly or detrimental to health, or likely to create a fire hazard, or conducive to deterioration, to remain on any part of the Lease Premises or to be disposed of improperly.

C. Tenant shall provide and maintain obstruction lights and all similar equipment or devices now or at any time required by any applicable law, ordinance or municipal, state or federal regulation.

D. Tenant shall be responsible for the removal of snow and ice on the Lease Premises and on access road improvements solely to the extent Tenant needs to use the access road improvement in order to access the Lease Premises.

E. Tenant shall be responsible for the maintenance, replacement and upkeep of the grass, shrubs, trees and all landscaped areas on the Lease Premises.

F. The Manager or his authorized representative shall have the right to make reasonable objections regarding the maintenance and appearance of the Lease Premises. Tenant agrees to promptly discontinue or remedy any reasonably objectionable condition within five (5) days after written notice by the Manager or his

authorized representative.

8.04 COMMON USE SERVICES. The Manager may establish common use services at the Airport, including but not limited to trash and refuse removal, deliveries, industrial waste handling, recycling, and security guards. The Manager reserve the right to establish charges for common use services based upon documented actual costs. Trash, sewer, and deliveries will be common use services which Tenant may be required to use and pay its prorata actual share; however, other common use services may be utilized at Tenant's option. Tenant agrees to pay the charges for those common use services which are utilized by Tenant.

8.05 INTERRUPTION OF SERVICES. Tenant agrees that the City shall not be liable for failure to supply any utility services. The City reserves the right to temporarily discontinue utility services at such time as may be necessary by reason of accident, unavailability of employees, repairs, alterations or improvements or whenever by reason of strikes, lockouts, riots, acts of God or any other happenings beyond the control of the City. The City shall not be liable for damages to persons or property for any such discontinuance, nor shall such discontinuance in any way be construed as cause for abatement of rent or operate to release the Tenant from any of its obligations hereunder, except as otherwise provided in Section 11.

SECTION 9
INSURANCE; PERSONAL LIABILITY; TAXES

9.01 INSURANCE. Tenant further agrees to secure at its own expense, and to keep in force at all times during the Term hereof, insurance for general and professional liability, automobile, and worker's compensation in the amounts and on the form of insurance certificate specified on the attached Exhibit D.

Each such policy or certificate shall contain a valid provision or endorsement that the policy may not be canceled, terminated, materially changed or modified without 30 days prior written notice thereof having been given by certified mail, return receipt requested, to the Manager of Aviation, Airport Office Building, Denver International Airport, 8500 Peña Boulevard, Denver, Colorado 80249-6340.

Each such policy or certificate shall further provide that any coverage afforded the City and County of Denver as an additional insured under the policies shall apply as primary insurance and any other insurance issued to the City and County of Denver shall apply as excess and noncontributing insurance. In addition, a waiver of subrogation in favor of the City shall be attached to each of the policies. Tenant shall include as insureds under its policies all subcontractors, if any, or shall furnish separate certificates and endorsements for each subcontractor, if any. All coverage for subcontractors, if any, shall be subject to all of the requirements stated herein.

9.03 NO PERSONAL LIABILITY. No employee of the City shall be held personally liable under this Lease or because of its execution or attempted execution.

9.04 TAXES, LICENSES, LIENS AND FEES. Tenant shall timely pay all personal property taxes, possessory interest taxes, business or license taxes or fees, service payments in lieu of such taxes or fees, annual or periodic license or use fees, excises, assessments, bonds, levies, fees or charges of any kind which are assessed, levied, charged, confirmed, or imposed by any public authority due to Tenant occupancy and use of the Lease Premises (or any portion or component thereof). Tenant also agrees not to permit any mechanic's or materialman's or any other lien to become attached or be foreclosed upon the Land, the Lease Premises or improvements thereto, or any part thereof, by reason of any construction work or labor performed or materials furnished by any mechanic or materialman. Tenant agrees to furnish to the Manager, upon request, duplicate receipts or other satisfactory evidence showing the prompt payment by it of Social Security, unemployment insurance and worker's compensation insurance, and–all required licenses and all taxes. Tenant further agrees to promptly pay when due all bills, debts and obligations incurred by it in connection with its operations hereunder and not to permit the same to become delinquent and to suffer no lien, encumbrance, judgment or execution to be filed against the Lease Premises or improvements thereon which will in any way impair the rights of the City under this Lease.

SECTION 10
DEFAULT AND REMEDIES

10.01 TENANT DEFAULT. Tenant shall be in default under this Lease if Tenant:

A. Fails to timely pay within thirty (30) days after such amount is due to the City the compensation, rent or any other payment required hereunder; or

B. Becomes insolvent, or takes the benefit of any present or future insolvency or bankruptcy statute, or makes a general assignment for the benefit of creditors, or consents to the appointment of a receiver, trustee or liquidator of any or substantially all of its property; or

C. Transfers its interest under this Lease, without the prior written approval of the City, by reason of death, operation of law, assignment, sublease or otherwise, to any other person, entity or corporation with the exception of permitted assignments under Section 12.05; or

D. Abandons, deserts or vacates the Lease Premises; or

E. Suffers any lien or attachment to be filed against the Lease Premises, the Airport or the City's property because of any act or omission of Tenant, and such lien or attachment is not discharged or contested by Tenant in good faith by proper legal proceedings within twenty (20) days after receipt of notice thereof by Tenant; or

F. Fails to keep, perform and observe any other promise, covenant or agreement set forth in this Lease and such failure continues for a period of more than thirty (30) days after delivery by Manager of a written notice of such breach or default, except where a shorter period is specified herein, or where fulfillment of its obligation requires activity over a period of time and Tenant within ten (10) days of notice commences in good faith to perform whatever may be required to correct its failure to perform and continues such performance without interruption except for causes beyond its control; or

G. Gives its permission to any person to use for any illegal purpose any portion of the Airport made available to Tenant for its use under this Lease.

10.02 REMEDIES FOR THE CITY. If Tenant defaults in any of the covenants, terms and conditions herein, the City may exercise any one or more of the following remedies:

A. The City may elect to allow this Lease to continue in full force and effect and to enforce all of the City's rights and remedies hereunder, including without limitation the right to collect rent as it becomes due together with Past Due Interest; or

B. The City may cancel and terminate this Lease and repossess the Lease Premises, with process of law, and without liability for so doing, upon giving thirty (30) days written notice to Tenant of its intention to terminate, at the end of which time all the rights hereunder of the Tenant shall terminate, unless the default, which shall have been stated in such notice, shall have been cured within such thirty (30) days. Notwithstanding the foregoing, Tenant shall be allowed only two notices of default hereunder which it may cure within the thirty (30) day time specified in this section. The third and any additional notice thereafter shall be cured by Tenant within fifteen (15) days and if Tenant fails to cure within such time frame, then the City at its sole option may (1) cancel and terminate all of the rights hereunder of the Tenant, and the City may, upon the date specified in such notice, reenter the Lease Premises and remove therefrom all property of the Tenant and store the same at the expense of the Tenant, or (2) elect to proceed under subparagraph C. below.

If the City elects to terminate, Tenant shall be liable to the City for all amounts owing at the time of termination, including but not limited to rent due plus interest thereon at the Past Due Interest Rate together with any other amount to fully compensate the City for all loss of rent, damages, and costs, including attorney's fees, caused by Tenant's failure to perform its obligations hereunder, or which in the ordinary course would likely result therefrom.

C. The City may elect to reenter and take possession of the Lease Premises and expel Tenant or any person claiming under Tenant subject to the time period set forth in Section 10.01(F), and remove all effects as may be necessary, without prejudice to any remedies for damages or breach. Such reentry shall not be

construed as termination of this Lease unless a written notice specifically so states; however, the City reserves the right to terminate the Lease at any time after reentry. Following reentry, the City may relet the Lease Premises, or any portion thereof, for the account of Tenant, on such terms and conditions as the City may choose, and may make such repairs or improvements as it deems appropriate to accomplish the reletting. The City shall not be responsible for any failure to relet or any failure to collect rent due for such reletting; however, the City agrees to make such efforts to relet as are consistent with state law in Colorado.

Tenant shall be liable to the City for all costs of reletting, including attorney's fees and repairs or improvements. Notwithstanding re-entry by the City, Tenant shall continue to be liable for all amounts due as rent under this Lease, on the dates specified and in such amounts as would be payable if default had not occurred. Upon expiration of the Term, or any earlier termination of the Lease by the City, the City, having credited to the account of Tenant any amounts recovered through reletting, shall refund, without interest, any amount which exceeds the rent, damages, and costs payable by Tenant under this Lease.

10.03 CROSS DEFAULT WITH POWER PURCHASE AGREEMENT. Notwithstanding anything to the contrary under this Lease or the Power Purchase Agreement, if the City fails to timely pay any amounts due under the Power Purchase Agreement for six (6) months after such amount is due to Tenant, Tenant shall have the right, but not the obligation, to terminate this Lease and the Power Purchase Agreement, and to compel the City to purchase the System from the Tenant by paying the greater of the then Fair Market Value or Buyout Price set forth in attached Exhibit C, in accordance with Section 4.05.

10.04 REMEDIES CUMULATIVE. The remedies provided in this Lease shall be cumulative and shall in no way affect any other remedy available under law or equity.

10.05 ADMINISTRATIVE HEARING. Disputes arising out of this Lease shall be resolved by administrative hearing before the Manager following the procedures outlined in Denver Revised Municipal Code Section 5-17; provided, that the City shall retain its right to obtain an order of eviction in accordance with applicable state law. It is further agreed that no cause of action shall be brought against the City until there has been full compliance with the terms of this paragraph.

10.06 WAIVERS. The waiver by either party of any breach of any term, condition, or provision herein contained shall not be deemed to be a waiver of such term, condition, or provision, or any subsequent breach of the same, or any other term, condition, or provision contained herein.

SECTION 11
DAMAGE, DESTRUCTION OR LOSS

11.01 DAMAGE TO OR DESTRUCTION OF LEASE PREMISES. If the System and any Site Improvements, or any portion thereof, are destroyed or damaged by fire, the elements or such other cataclysmic event, the Tenant shall promptly remove all debris resulting from such damage to the System and any Site Improvements and at its sole discretion, may repair and/or reconstruct the System and any Site Improvements with due diligence, at its sole cost and expense, in accordance with the plans and specifications for the Lease Premises as they existed prior to such damage or in accordance with the current needs of the Tenant as approved by the Manager.

11.02 LOSS OR DAMAGE TO PROPERTY. Neither party shall be liable for any loss of property by theft or burglary from the Airport or for any damage to person or property on the Airport resulting from electric lighting, or water, rain or snow, which may come into or issue or flow from any part of the Airport or Airport Site, or from the pipes thereof, or that may be caused by a party's employees or any other cause, and each party agrees to make no claim for any such loss or damage at any time.

11.03 RELEASE OF CITY. The parties hereto agree that neither party shall be liable to the other party for any injury to or death of any of either party's agents, representatives or employees or of any other person or for any damage to any of such party's property or loss of revenue caused by any third person in the maintenance, construction, or operation of facilities at the Airport, or caused by any third person using the Airport, or caused by any third person navigating any aircraft on or over the Airport, whether such injury, death or damage is due to negligence or otherwise.

11.04 MUTUAL WAIVER/INSURANCE COVERAGE. The City and Tenant each waive any and every claim for recovery from the other for any and all loss of or damage to the Lease Premises or to the contents thereof, which loss or damage is covered by valid and collectible fire and extended insurance policies, to the extent that such loss or damage is recoverable under such insurance policies. Since this mutual waiver will preclude the assignment of any such claim by subrogation or otherwise to an insurance company or any other person, Tenant agrees to give to each insurance company which has issued, or may issue, to the Tenant policies of fire and extended coverage insurance, written notice of the terms of this mutual waiver, and to have such insurance policies properly endorsed, if necessary, to prevent the invalidation of the insurance coverage by reason of this waiver.

SECTION 12
MISCELLANEOUS PROVISIONS

12.01 ADVERTISING AND PUBLIC DISPLAYS. Tenant shall not install or have installed or allow to be installed upon or within the Lease Premises, without the prior written approval of the Manager or his authorized representative, any sign on the Land which is visible to the exterior of the buildings or on the Land, either lighted or unlighted, static or animated, poster, banners or other display of advertising media, including

material supplied by manufacturers of merchandise offered for sale, as well as other types of display specified in the DIA Design Standards. Permission will not be granted for any advertising which fails to comply with DIA Design Standards or DIA Development Guidelines, or any advertising material, fixture or equipment which extends beyond the Lease Premises.

12.02 AGREEMENT BINDING UPON SUCCESSORS. This Lease, subject to the provisions of the section entitled "Assignment,", shall be binding upon and extend to the heirs, personal representatives, successors and assigns of the respective parties hereto.

12.03 AGREEMENT MADE IN COLORADO. This Lease shall be deemed to have been made in and shall be construed in accordance with the laws of the State of Colorado.

12.04 AGREEMENT SUBORDINATE TO AGREEMENTS WITH UNITED STATES. This Lease is subject and subordinate to the terms, reservations, restrictions and conditions of any existing or future agreements between the City and the United States, the execution of which has been or may be required as a condition precedent to the transfer of federal rights or property to the City for Airport purposes and the expenditure of federal funds for the development of the Airport or airport system. The provisions of the attached Appendices 1, 2 and 3 are incorporated herein by this reference.

12.05 ASSIGNMENT.

A. Neither party shall have the right to assign any of its rights, duties or obligations under this Lease without the prior written consent of the other party, which consent may not be unreasonably withheld or delayed. Notwithstanding the foregoing, the Tenant may assign any of its rights, duties or obligations under this Lease (i) to one or more of its affiliates, (ii) to one or more affiliates or third parties in connection with a sale-and-leaseback or other financing transaction, (iii) to any present or future purchaser of the power generated by the System, (iv) to any person or entity succeeding to all or substantially all of the assets of the Tenant, or (v) to a successor entity in a merger or acquisition transaction.

B. With respect to an assignment pursuant to clause (ii) in the immediately preceding sentence, the City acknowledges and agrees that, upon receipt of written direction by a financing-transaction assignee of the Tenant ("Lender"), and notwithstanding any instructions to the contrary from the Tenant, the City will recognize Lender, or any third party to whom Lender has reassigned the rights of the Tenant under this Lease, as the proper and lawful lessee of the Lease Premises and as the proper and lawful successor to the Tenant with respect to access to the Lease Premises across or through the Land and fully entitled to receive the rights and benefits of the Tenant hereunder so long as Lender (or its assignee) performs the obligations of the Tenant hereunder. The City shall be protected and shall incur no liability in acting

or proceeding in good faith upon any such foregoing written notice and direction by Lender which the City shall in good faith believe (a) to be genuine and (b) a copy of which shall have been delivered to the Tenant. The City shall be under no duty to make any investigation or inquiry as to any statements contained or matters referred to in any such foregoing notice and direction, but may accept and rely upon them as conclusive evidence of the truth and accuracy of such statements.

In addition, the City agrees and consents as follows:

(i) The City agrees to notify Lender in writing, at the address to be designated by Lender upon not less than five (5) business days' written notice to the City prior to any notice by the City hereunder, of any act or event of default of the Tenant under the Lease of which the City has knowledge that would entitle the City to cancel, terminate, annul, or modify the Lease or dispossess or evict the Tenant from the Lease Premises or otherwise proceed with enforcement remedies against the Tenant, and Lender shall have the same amount of time as the Tenant, but at least ten (10) days with respect to any monetary default and at least thirty (30) days with respect to any non-monetary default, to cure any default by the Tenant under the Lease; provided that in no event shall Lender be obligated to cure any such default.

(ii) Notwithstanding that the System is a fixture on the Lease Premises, and subject to the terms and conditions hereof, the City hereby subordinates any lien it may have in and to the property used by the Tenant in the conduct of its business and which is or may from time to time hereafter be located at the Lease Premises, and to which the Tenant has granted or will grant a security interest to Lender (all such property and the records relating thereto shall be hereafter called the "Collateral") to the lien of Lender; provided, however, that this subordination shall not prevent the City from exercising any right or remedy against the Tenant to which the City may be entitled under the terms of the Lease or as may be provided by applicable law, nor shall it prevent the City from exercising any lien it may have on any property of the Tenant, including the Collateral, so long as the City recognizes Lender's prior right to the Collateral described above. The City recognizes and acknowledges that any claim or claims ("Claims") that Lender has or may have against such Collateral by virtue of any lien or security interest, is superior to any lien, security interest, or claim of any nature which the City now has or may hereafter have to such Collateral by statute, agreement or otherwise. The subordination of lien provided for herein shall be effective until the discharge of the Claims. The City further agrees to notify any purchaser of the Lease Premises, and any subsequent mortgagee or other encumbrance holder, of the existence of the foregoing waiver of the City's lien, which shall be binding upon the executors, administrators, successors and transferees of the City, and shall inure to the benefit of the successors and assigns of Lender.

(iii) The City consents to Lender's security interest in the Collateral and

waives all right of levy for rent and all claims and demands of every kind against the Collateral, such waiver to continue so long as any sum remains owing from the Tenant to the Lender. The City agrees that the Collateral shall not be subject to distraint or execution by, or to any claim of, the City.

(iv) The City hereby consents to Lender accessing the Lease Premises and the Land for the purpose of inspecting the Collateral.

12.06 BOND ORDINANCES. This Lease is in all respects subject and subordinate to any and all the City bond ordinances applicable to the Airport and airport system and to any other bond ordinances which should amend, supplement or replace such bond ordinances. The parties to this Lease acknowledge and agree that all property subject to this Lease which was financed by the net proceeds of tax-exempt bonds is owned by the City, and Tenant agrees not to take any action that would impair, or omit to take any action required to confirm, the treatment of such property as owned by the City for purposes of Section 142(b) of the Internal Revenue Code of 1986, as amended. In particular, the Tenant agrees to make, and hereby makes, an irrevocable election (binding on itself and all successors in interest under this Lease) not to claim depreciation or an investment credit with respect to any property subject to this Lease which was financed by the net proceeds of tax-exempt bonds and shall execute such forms and take such other action as the City may request in order to implement such election.

12.07 FORCE MAJEURE. Neither party hereto shall be liable to the other for any failure, delay or interruption in the performance of any of the terms, covenants or conditions of this Lease to the extent such failure, delay or interruption is due to causes which were not reasonably foreseeable and beyond the control of that party, including without limitation strikes, boycotts, labor disputes, embargoes, shortages of materials, acts of God, acts of the public enemy, acts of superior governmental authority, weather conditions, floods, riots, rebellion, sabotage or any other circumstance for which such party is not responsible or which is not in its power to control, but in no event shall this paragraph be construed so as to allow Tenant to reduce or abate its obligation to pay the rent or compensation as provided herein.

12.08 INCONVENIENCES DURING CONSTRUCTION. Tenant recognizes that from time to time during the Term, it may be necessary for the City to commence or complete extensive programs of construction, expansion, relocation, maintenance and repair in order that the Airport and its facilities may be completed and operated in accordance with any present or future master layout plan, and that such construction, expansion, relocation, maintenance and repair may inconvenience the Tenant in its operation at the Airport. Tenant agrees that no liability shall attach to the City, its officers, agents, employees, contractors, subcontractors and representatives by way of such inconveniences, and Tenant waives any right to claim damages or other consideration therefrom.

12.09 INDEPENDENT CONTRACTOR. The parties agree that Tenant shall at

all times have the status of an independent contractor without the right or authority to impose tort or contractual liability upon the City. Nothing in this Lease shall be construed to mean or imply that Tenant is a partner, joint venturer, agent or representative of, or otherwise associated with, the City. Neither the City nor Tenant shall represent to others that one party is a partner, joint venturer, agent or representative of, or otherwise associated with, the other party.

12.10 NOTICES. All notices required to be given to the City or Tenant hereunder shall be in writing and sent by certified mail, return receipt requested, to:

City:	Manager of Aviation Denver International Airport 8500 Peña Boulevard, 9th Floor Denver, Colorado 80249-2065
with a copy to:	Airport Property Office Denver International Airport 8500 Peña Boulevard, Rm. 9870 Denver, Colorado 80249-2065
Tenant:	Solar Rep XYZ Solar Somewhere Denver, CO XYX email 333-333-3333 (o) 333-444-4444 (c)

Either party hereto may designate in writing from time to time the address of substitute or supplementary persons to receive such notices. The effective date of service of any such notice shall be the third day from the date such notice is mailed to Tenant or Manager.

12.11 PARAGRAPH HEADINGS. The paragraph headings herein are for convenience in reference only and are not intended to define or limit the scope of any provision of this Lease.

12.12 PATENTS AND TRADEMARKS. Tenant represents that it is the owner of or fully authorized to use any and all services, processes, machines, articles, marks, names or slogans used by it in its operations under this Lease.

12.13 SECURITY. Tenant shall cause its officers, contractors, agents and employees to comply with any and all existing and future security regulations adopted by the City pursuant to regulations of the Transportation Security Administration and Federal Aviation Administration, as they may be amended from time to time.

12.14 SEVERABILITY. If any provision in this Lease is held by a court to be invalid, the validity of other provisions herein which are severable shall be unaffected.

12.15 THIRD PARTIES. This Lease shall not be deemed to confer upon any third party or parties (except parties to whom the Tenant may assign this Lease in accordance with the terms hereof, and except any successor to the City) any right to claim damages or to bring any action or proceeding against either the City or the Tenant because of any breach hereof or because of any of the terms, covenants, agreements and conditions herein.

12.16 USE, POSSESSION OR SALE OF ALCOHOL OR DRUGS. Tenant, its officers, agents, and employees shall cooperate and comply with the provisions of the Federal Drug-Free Workplace Act of 1988 and Denver Executive Order No. 94, or any successor thereto, concerning the use, possession or sale of alcohol or drugs. Violation of these provisions or refusal to cooperate with implementation of the policy can result in the City's barring Tenant from the City facilities or participating in City operations.

12.17 CITY SMOKING POLICY. Tenant acknowledges that smoking is not permitted in Airport buildings and facilities except for designated Airport Smoking Concessions, and so agrees that it will prohibit smoking by its employees and the public in indoor areas and within 15 feet of entryways.

12.18 NONDISCRIMINATION. In connection with the performance of work under this Lease, Tenant agrees not to refuse to hire, discharge, promote or demote, or to discriminate in matters of compensation against any person otherwise qualified, solely because of race, color, religion, national origin, gender, age, military status, sexual orientation, marital status, or physical or mental disability; and Tenant further agrees to insert the foregoing provision in all subcontracts hereunder.

12.19 ENTIRE AGREEMENT. The parties agree that the provisions herein constitute the entire agreement and that all representations made by any officer, agent or employee of the respective parties unless included herein are null and void and of no effect. No amendments, unless expressly reserved to the Manager herein, shall be valid unless executed by an instrument in writing by all the parties with the same formality as this Lease.

12.20 FINAL APPROVAL. This Lease is expressly subject to and shall not be or become effective or binding on either party until approved by the City Council and fully executed by all signatories hereto, including all signatories of the City and County of Denver.

[END OF DOCUMENT]

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

ATTEST:

_____
STEPHANIE Y. O'MALLEY, Clerk and Recorder, Ex-officio Clerk of the City and County of Denver

APPROVED AS TO FORM:

DAVID R. FINE, City Attorney for the City and County of Denver

By_____
Assistant City Attorney

CITY AND COUNTY OF DENVER

By_____
Mayor

RECOMMENDED AND APPROVED:

By_____
Manager of Aviation

REGISTERED AND COUNTERSIGNED:

By_____
Manager of Finance

Contract Control Number:

By_____
Auditor

"CITY"

PARTY OF THE FIRST PART

ATTEST:

By:_____

Title:_____

XYZ Solar
A Delaware limited liability company

By:_____

Title:_____
Chief Executive Officer

PARTY OF THE SECOND PART

29

EXHIBIT A

LEGAL DESCRIPTION

[To be provided]

EXHIBIT B

SITE PLAN FOR DEMISED PREMISES AND SITE IMPROVEMENTS

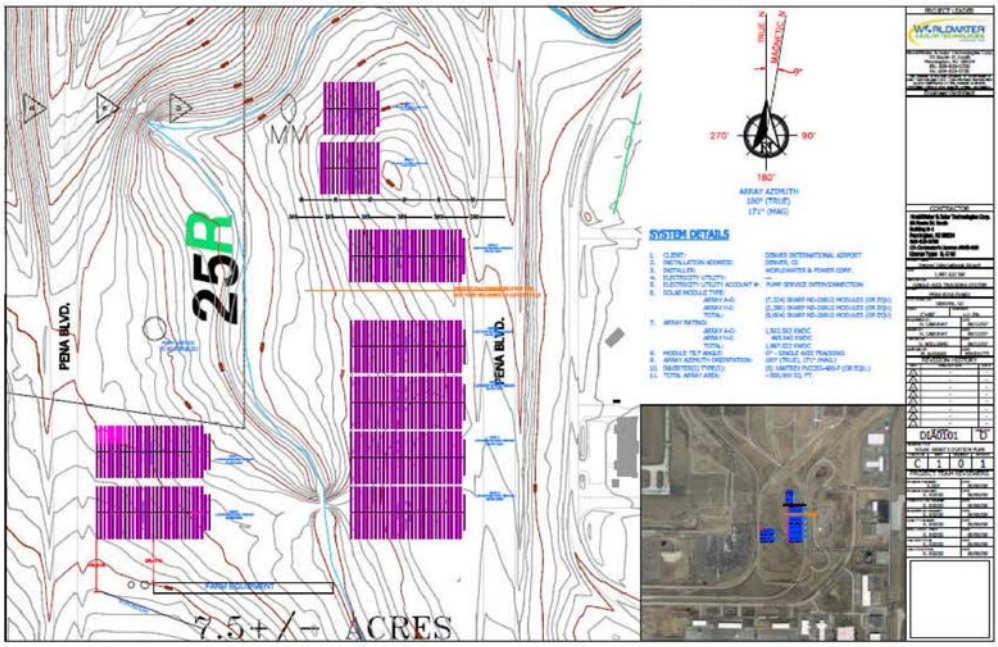


Exhibit B to Ground Lease Agreement

EXHIBIT C

PURCHASE OPTION SUMMARY SHEET

BEGINNING OF YEAR	AMOUNT
1	$10,000,000
2	$10,000,000
3	$10,000,000
4	$10,000,000
5	$10,000,000
6	$5,200,000
7	??
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Exhibit C to Ground Lease Agreement

EXHIBIT D

INSURANCE CERTIFICATE

[DIA TO PROVIDE]

EXHIBIT E

DESIGN STANDARDS, CONSTRUCTION PROCEDURES and DIA PERFORMANCE SPECIFICATIONS

Section 1. Design Standards. The Tenant agrees to use and comply with the Denver International Airport Design Standards Manuals for design of any improvements to the facility. The Tenant further agrees to design and construct such improvements in accordance with the Denver International Airport Tenant Development Guidelines (TDGs), as they may be amended from time to time, and any other applicable design, construction, and maintenance standards.

All design drawings submitted by the Tenant to the City shall be provided in the latest release of AutoCAD format in accordance with the City's Design Standards Manual.

Approval of the City's Designated Representative (City) shall extend to and include consideration of architectural and aesthetic matters and the City reserves the right to reject any designs submitted and to require the Tenant to resubmit designs and layout proposals until they meet with the City's approval. If any portion of the plans and specifications is disapproved by the City, the Tenant shall promptly submit necessary modifications and revisions thereof.

Section 2. Construction Procedures.

A. Compliance with standards: All construction work shall comply with the requirements of and standards established by the City and all other appropriate governmental agencies and entities. The City shall at all times have the right to monitor and inspect any construction to assure that the improvements are constructed and installed in compliance with the Plans and Specifications.

B. Submissions required: To assist the City in monitoring and inspecting such construction, the Tenant's contractor(s) or subcontractor(s) shall submit, or cause to be submitted to the City, for information and record purposes, copies of all the following:

(i) field test reports;
(ii) material certificates;
(iii) approved shop drawings to be reviewed for compliance with the Airport design and construction standards;
(iv) requests for payment to contractors or subcontractors;
(v) progress reports;
(vi) notification of substantial completion of the leased facilities and all site improvements and final acceptance thereof;
(vii) two copies of maintenance and operation manuals in connection with building systems and all updates thereof;
(viii) as-constructed drawings; and

(ix) any other documents related to the construction of the improvements which may be reasonably requested by the City.

C. SOW Changes: No change order which materially changes the scope of the work shall be effected by the Tenant without the approval of the City, whose approval shall not be unreasonably withheld. The City will approve, conditionally approve, or disapprove submissions of change orders which materially change the scope of the work within a reasonable period of time following receipt thereof. Any conditional approval or disapproval shall be accompanied by an explanation as to the reason for the condition.

D. City Inspection: All construction work, materials, and installations involved in or incidental to the construction of the improvements undertaken by the Tenant throughout the term hereof shall be subject at all times to inspection and approval by the City.

E. Advance Notice of Modification: The Tenant shall give or cause to be given to the City advance notice before performing any material modification to the improvements.

F. Compliance with Plans: The Tenant shall cause all construction work, workmanship, materials, and installations to be in full compliance with plans and specifications. The City shall have the right to halt construction of the improvements at any time if such construction is at material variance from the Plans and Specifications until such variance is corrected, or if such construction poses an immediate safety hazard at the Airport, until such safety hazard is eliminated. The City shall cooperate and use its best efforts to alleviate and resolve any such variance or impediment to the safe operation of the Airport so as to permit continued construction as expeditiously as possible.

G. Utilities: The Tenant shall perform utility location identification prior to any excavation activities. In addition, Tenant shall obtain such utility connections or hook-ups as shall be necessary and shall have the right to receive all necessary utilities and services, and shall secure all necessary applications and permits and shall pay all application and permit fees, hook-up and all other user charges of whatever nature occasioned thereby, except tap and developer fees. The Tenant further agrees to provide meters adequate to measure the amount of utilities and water used or consumed and to maintain said equipment in such a manner as to supply accurate measurement of such usage and consumption.

H. Wages: The Tenant shall include in its agreements with its general contractors covenants that require the construction contractor and its subcontractors of any tier to pay all workers, mechanics, and laborers in accordance with the "Agreement of Fair Employment and Work Stabilization for New Denver Airport," which agreement provides for payment according to rates

and classifications established under the federal Davis-Bacon Act and Denver Revised Municipal Code Section 20-76, whichever is greater. The Tenant further agrees, if requested by the City, to fully comply with the procedural requirements of Denver Revised Municipal Code Section 20-76 by requiring its general contractors and their subcontractors of any tier to submit to the City true and correct copies of the payroll records of all workers, laborers, and mechanics employed.

I. Expense of Alterations. Any work necessary to make any alterations, improvements, or additions to the facility throughout the Term shall be done at the Tenant's cost and expense, in accordance with and subject to all of the required approvals, submittals, and procedures, and all other requirements of whatsoever nature, as set forth herein.

J. Documents on Completion: Upon completion of such work, the Tenant shall deliver to the City revised as-constructed drawings, evidence of payment, contractor's affidavits, and full and final waivers of any liens for labor, services, or materials. The Tenant shall include in its agreement with its contractors provisions whereby such contractors shall defend and hold the City harmless from all costs, damages, liens, and expenses related to such work.

L. As-Builts: Within sixty (60) days after completion of construction of the improvements, the Tenant shall furnish to the City two sets of as-constructed drawings, in the latest release of AutoCAD, showing in detail all construction, including the locations of all underground and above ground utility lines.

K. Standard of Performance: All work done by the Tenant or its contractors shall be done in a first-class workmanlike manner using only good grades of materials and shall comply with all insurance requirements and all applicable laws and ordinances and rules and regulations of governmental departments or agencies. Whenever a conflict arises between State or local law, ordinances or regulations and Federal law or regulations, Federal law or regulations applicable to this agreement shall control.

EXHIBIT F
DIA ENVIRONMENTAL REQUIREMENTS

Section 1. General Requirements. Tenant, in conducting any activity on DIA property, shall comply with all applicable airport, local, state, and federal rules, regulations, statutes, laws, and orders (Environmental Requirements) and the applicable Environmental Guidelines developed for DIA's Environmental Management System (EMS), as summarized in DIA Rules and Regulations Part 180. DIA's Environmental Guidelines, Environmental Policy, and all Rules and Regulations are available at www.flydenver.com/biz/index.asp. These Environmental Requirements address, but are not limited to, requirements regarding the storage, use, and disposal of Hazardous Materials, solid and hazardous waste, or petroleum products; the National Environmental Policy Act (NEPA); and other federal, state, and local water, wastewater, and air quality regulations.

A. EMS: DIA's EMS has been certified to the ISO 14001 standard. DIA's EMS includes the above-noted airport-wide Environmental Policy and is designed around the significant aspects identified in DIA Rule and Regulation 180. It is a requirement of the standard that all entities providing products, goods, and/or services on behalf of DIA ensure that their personnel are aware of DIA's Environmental Policy, DIA's significant environmental aspects, and the specific environmental aspects and associated impacts for the products, goods, and/or services that will be provided by the Tenant.

B. Permits: Tenant shall acquire all necessary federal, state, local, and airport permits/approvals and comply with all permit/approval requirements necessary for its activities on the Lease Premises. Tenant shall prepare and update all plans and provide all information required by the City for regulatory compliance purposes.

C. Hazardous Materials Limited: Any hazardous materials not reasonably necessary for Tenant's operations are barred from DIA premises. Tenant shall identify all hazardous materials to be used at DIA along with a description of how these materials and any associated hazardous or other waste materials generated by Tenant will be managed while on airport property. This information is required prior to the Tenant conducting activities on DIA property.

D. MSDSs: Prior to operation, Tenant shall provide to the City copies of Material Safety Data Sheets (MSDSs) for all chemicals to be used in their activities, including those used for cleaning and maintenance. This obligation is continuing for the Term, and Tenant shall provide updated MSDSs and MSDSs for new chemicals, as such information is updated and as new chemicals are placed into use, as applicable.

E. Pollution Prevention: Tenant is encouraged to utilize the concepts of pollution prevention, energy efficiency, and waste minimization with regard to its activities at DIA.

Section 2. Review of Environmental Documents. Tenant, at the request of the City, shall make available for inspection and copying, upon reasonable notice and at reasonable times, any or all of the documents and materials that the Tenant has prepared pursuant to any Environmental Requirement hereunder or submitted to any governmental or regulatory agency. If there is a requirement to file any notice or report of a release or threatened release of a substance on, under, or about the work conducted on DIA property, Tenant shall provide a copy of such report or notice to the City.

Section 3. Access for Environmental Inspection. The City shall have an unimpeded right of access to the occupancy or work areas with reasonable prior notice to Tenant to inspect the same in order to confirm that Tenant is conducting its activities in accordance with this Lease. In the event the City's inspection of the Lease Premises reveals evidence of a potential non-compliance with the terms of this Lease, at the City's request, Tenant shall conduct any testing and analysis at its cost as is necessary to ascertain whether the Tenant is in compliance with this Lease. If such further testing and analysis determines that Tenant is in compliance with this Lease, the City shall be solely responsible for all costs and expenses related to such further testing and analysis.

Section 4. Correction of Environmental Non-Compliance. If the Tenant fails to comply with any applicable Environmental Requirement and such non-compliance continues uncorrected for thirty (30) days after written notice to Tenant, the City, in addition to its rights and remedies described elsewhere in this Lease, at its election, may enter the facility and/or work area and take such measures as may be necessary to ensure compliance with the Environmental Requirements, all at the Tenant's expense.

Section 5. Duty to Notify City. In the event of a release or threatened release of a substance in excess of acceptable levels established by applicable law and relating to or arising out of the Tenant's use or activities on DIA, or in the event any claim, demand, cause of action, or notice is made against the Tenant with regard to the Tenant's failure or alleged failure to comply with any requirement hereunder, the Tenant, immediately shall notify the City verbally by contacting the Airport Communications Center (303-342-4200) and the appropriate regulatory agency. Tenant shall immediately control and remediate the contaminated media and, as provided below, follow-up Tenant's verbal notice with a written report within three days of such incident. In addition, the Tenant shall provide the City, at Tenant's expense, with copies of any written claims, demands, notices or actions so made.

Section 6. Environmental Remediation. Tenant shall undertake all actions necessary to remedy or remove any released or spilled materials in excess of acceptable levels established by applicable law and any other contamination discovered on or under DIA property introduced by Tenant and shall restore the Access Premises to its condition immediately prior to the initiation of this Lease in compliance with all applicable local, state, federal, or airport laws, rules, regulations, or orders. This work shall be performed at Tenant's expense and the City shall have the right to review the project plan and review and inspect all such work at any time using consultants and representatives of the City's choice. Tenant shall further conduct surface and subsurface monitoring pertaining to Tenant's activities hereunder to ensure compliance with applicable laws, rules, regulations, and permits.

Section 7. Environmental Requirements for Construction. Tenant agrees to ensure that its premises are designed, constructed, operated, and maintained in a manner that minimizes environmental impacts through application of appropriate preventive measures and complies with Environmental Requirements. Tenant shall comply with the DIA Tenant Development Guidelines, as amended, for any alterations to existing facilities or the construction of any new facilities. In addition, the Tenant shall comply with Exhibit E of this agreement.

Appendix D

Power Purchase Agreement Example (Denver)

APPENDIX NO. 3

NONDISCRIMINATION IN AIRPORT EMPLOYMENT OPPORTUNITIES

The Party of the Second Part assures that it will comply with pertinent statutes, Executive Orders and such rules as are promulgated to assure that no person shall, on the grounds of race, creed, color, national origin, sex, age, or handicap be excluded from participating in any activity conducted with or benefiting from Federal assistance. This Provision obligates the Party of the Second Part or its transferee for the period during which Federal assistance is extended to the airport program, except where Federal assistance is to provide or is in the form of personal property or real property or an interest therein or structures or improvements thereon. In these cases, this Provision obligates the Party of the Second Part or any transferee for the longer of the following periods: (a) the period during which the property is used by the sponsor or any transferee for a purpose for which Federal assistance is extended, or for another purpose involving the provision of similar services or benefits; or (b) the period during which the airport sponsor or any transferee retains ownership or possession of the property. In the case of contractors, this Provision binds the contractors from the bid solicitation period through the completion of the contract.

It is unlawful for airport operators and their lessees, tenants, concessionaires and contractors to discriminate against any person because of race, color, national origin, sex, creed, or handicap in public services and employment opportunities.

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SOLAR POWER PURCHASE AGREEMENT

THIS SOLAR POWER PURCHASE AGREEMENT (as it may be amended from time-to-time, this "Agreement"), is made and entered into the_____day of_____, 2009 by and between the **CITY AND COUNTY OF DENVER**, a municipal corporation of the State of Colorado ("City" or "Purchaser"), and **XYZ Solar**, a Colorado partnership authorized to do business in the State of Colorado ("Power Provider").

W I T N E S S E T H:

WHEREAS, Power Provider desires to install electricity grid-connected photovoltaic, solar power plants with a total generating capacity rated at approximately 1,600 kWp (the "Generating Facility") located at the City's Denver International Airport ("Airport"), in Denver, Colorado; and

WHEREAS, the City desires to purchase from Power Provider and Power Provider desires to sell to Purchaser the entire energy output of the Generating Facility;

NOW, THEREFORE, in consideration of the promises and the mutual benefits from the covenants hereinafter set forth, Power Provider and the City agree as follows:

1. Line of Authority

The City's Manager of Aviation, his designee or successor in function (hereinafter referred to as the "Manager") authorizes and directs all work performed under this Agreement. Until otherwise notified by the Manager, the City's Deputy Manager of Aviation for Maintenance and Engineering ("Deputy Manager") is designated as the authorized representative of the Manager through whom services performed under this Agreement shall be directed and coordinated. Administrative reports, memoranda, correspondence and other submittals required of the Power Provider shall be processed in accordance with the Deputy Manager's directions.

2. Definitions

(a) "Commercial Operation" means the condition existing when the Generating Facility is (i) mechanically complete and operating as specified in Exhibit A, and (ii) energy is delivered through the Generating Facility's meter and to the Site's electrical system under an approved and executed Utility interconnection agreement.

(b) "Commercial Operation Date" means the date on which Power Provider notifies Purchaser in accordance with Section 3(c) that the Generating Facility has achieved Commercial Operation.

(c) "Energy Delivery Point" means the energy delivery point within the Site's electrical system on Purchaser's side of the Site's Utility meter, as designated in the Utility interconnection agreement described in Section 2(a).

(d) "Energy Output" means the total quantity of all actual net energy generated by the Generating Facility (measured in kWhac) and delivered in accordance with Section 10 to the Energy Delivery Point, in any given period of time. Energy Output does not include the Environmental Incentives.

(e) "Environmental Attributes" means the characteristics of electric power generation at the Generating Facility that have intrinsic value, separate and apart from the Energy Output, arising from the perceived environmental benefits of the Generating Facility of the Energy Output, including but not limited to all environmental and other attributes that differentiate the Generating Facility or the Energy Output from energy generated by fossil-fuel based generation units, fuels or resources, characteristics of the Generating Facility that may result in the avoidance of environmental impacts on air, soil or water, such as the absence of emission of any oxides of nitrogen, sulfur or carbon or of mercury, or other gas or chemical, soot, particulate matter or other substances attributable to the Generating Facility or the compliance of the Generating Facility or the Energy Output with the law, rules and standards of the United Nations Framework Convention on Climate Change (the "UNFCCC") or the Kyoto Protocol to the UNFCCC or crediting "early action" with a view thereto, or laws or regulations involving or administered by the Clean Air Markets Division of the Environmental Protection Agency or successor administrator or any state or federal entity given jurisdiction over a program involving transferability of rights arising from Environmental Attributes and Reporting Rights.

(f) "Environmental Incentives" means all rights, credits (including tax credits), rebates, benefits, reductions, offsets, and allowances and entitlements of any kind, howsoever entitled or named (including carbon credits and allowances), whether arising under federal, state or local law, international treaty, trade association membership or the like, arising from the Environmental Attributes of the Generating Facility or the Energy Output or otherwise from the development or installation of the Generating Facility or the production, sale, purchase, consumption or use of the Energy Output. Without limiting the forgoing, "Environmental Incentives" includes green tags, renewable energy credits, tradable renewable certificates, portfolio energy credits (collectively, "Solar Renewable Energy Credits" or "SRECs"), the right to apply for (and entitlement to receive) incentives under the Self-Generation Incentive Program, the Emerging Renewables Program or other incentive programs offered by the State of Colorado and the right to claim federal income tax credits under Sections 45 and/or 48 of the Internal Revenue Code.

(g) "Force Majeure" has the meaning given to it in Section 29.

(h) "Generating Facility" means the electric power generation equipment, controls, meters, switches, connections, conduit, wires and other equipment connected to the Energy Delivery Point installed as a fixture on the Site by Power Provider for the purposes of providing electric power to Purchaser under this Agreement, and which shall be owned solely by Power Provider throughout the term of the Lease.

(i) "kWp" means kilowatt rated power.

(j) "kWac" means kilowatt alternating current.

(k) "kWhac" means kilowatt-hour alternating current.

(l) "Lease" means the Ground Lease Agreement between the Purchaser and the Power Provider of even date herewith.

(m) "Party" means Power Provider or Purchaser.

(n) "Parties" means Power Provider and Purchaser.

(o) "PUC" means the Public Utilities Commission of Colorado.

(p) "Reporting Rights" means the right of Power Provider to report to any federal, state, or local agency, authority or other party, including without limitation under Section 1605(b) of the Energy Policy Act of 1992 and provisions of the Energy Policy Act of 2005, or under any present or future domestic, international or foreign emissions trading program, that Power Provider owns the Environmental Attributes and the Environmental Incentives associated with the Energy Output.

(q) "Site" means Purchaser's facility at Denver International Airport in Denver, Colorado or at such other location agreed to by Power Provider and Purchaser.

(r) "Utility" means Public Service Company of Colorado, the electric distribution company responsible for electric energy transmission and distribution service at the Site.

3. Installation and Operation of the Generating Facility

(a) Power Provider shall install the Generating Facility in accordance with the terms and conditions of the Lease, which, upon Commercial Operation, is targeted to have a combined generating capacity rating as shown in Exhibit A. Power Provider shall provide Purchaser reasonable notice of the progress of the installation of the Generating Facility and shall provide reasonable notice to Purchaser of the Commercial Operation Date.

(b) Power Provider shall be solely responsible for all costs and the performance of all tasks required for installation of the Generating Facility. Promptly following the execution of this Agreement, Power Provider shall commence pre-installation activities relating to the Generating Facility, which shall include, without limitation, the following:

(i) obtain financing for installation of the Generating Facility, and Solar Renewable Energy Credits for operation of the Generating Facility;

(ii) obtain all permits, contracts and agreements required for installation of the Generating Facility;

(iii) obtain all necessary authority from the PUC or other regulatory entities for the operation of Generating Facility and sale and delivery of Energy Output to Purchaser;

(iv) effect the execution of all agreements required for Utility interconnection of the Generating Facility; and

(v) enter into contract(s) for installation of the Generating Facility, subject to the terms of the Lease and any proposed financing.

(c) Power Provider shall (i) use commercially reasonable efforts to cause installation of the Generating Facility to be completed and to cause the Generating Facility to begin Commercial Operation on or before December 31, 2008; or (ii) on such date, notify Purchaser of the actual or estimated Commercial Operation Date. Successful completion of parts (i) - (vi) of Section 3(b) shall be conditions precedent to Power Provider's obligations to install and operate Generating Facility and otherwise perform its obligations under this Agreement. If the activities contemplated in parts (i) - (v) of Section 3(b) are not completed by December 31, 2007, Power Provider shall have the option to terminate the Agreement without triggering the default provisions of this Agreement or any liability under this Agreement. Alternatively, in the event that such conditions precedent are not satisfied by such date, the Parties may mutually agree to amend this Agreement to revise the Commercial Operation Date and the term of this Agreement.

(d) Power Provider shall prevent activities associated with installation, operation and maintenance of the Generating Facility from disrupting or interfering with Purchaser's operation of the Airport.

(e) Power Provider shall be solely responsible for operation and maintenance of the Generating Facility and shall, at all times during the term of this Agreement, maintain the Generating Facility in good operating condition. Power Provider shall bear all risk of loss with respect to the Generating Facility, and shall have full responsibility for its operation and maintenance in compliance with all laws, regulations and governmental permits. In accordance with the Lease, Purchaser shall provide adequate and secure storage space at the Site to store the spare parts inventory for the Generating Facility for the term of this Agreement.

(f) The Power Provider and the Purchaser hereby agree and acknowledge that notwithstanding the Generating Facility's presence on the Site, Purchaser shall have no ownership interest in the Generating Facility and no responsibility for its operation or maintenance. Neither Purchaser nor any party related thereto shall have the right or be deemed to operate the Generating Facility for purposes of Section 7701(e)(4)(A)(i) of the Internal Revenue Code.

(g) All property taxes related to the Generating Facility shall be the responsibility of Power Provider.

(h) Power Provider shall provide general and umbrella liability insurance coverage as set forth in the Lease between the Parties.

(i) Notwithstanding any other provision of this Agreement, the effectiveness of this Agreement, including the obligations and responsibilities of the Parties, is contingent upon the arrangement and entering into of a Lease for the length of this Agreement between Purchaser and Power Provider. Notwithstanding the Generating Facility's presence on the Site, except as required by the Federal Aviation Administration or as required for air navigation purposes,

Purchaser shall not cause or permit any interference with the Generating Facility's insolation and access to sunlight, as such access exists as of the effective date of this Agreement.

(j) Purchaser represents to Power Provider that there are no circumstances known to Purchaser and no commitments to third parties that may damage, impair, or otherwise adversely affect the Generating Facility or its function by blocking sunlight to the Generating Facility.

(k) The Parties share a common desire to generate favorable publicity regarding the Generating Facility and their association with it. The Parties agree that they will, from time-to-time, issue press releases regarding the Generating Facility and that they shall cooperate with each other in connection with the issuance of such releases. Each Party agrees that it shall not issue any press release regarding the Generating Facility without the prior written consent of the other Party, which consent shall not be unreasonably withheld or delayed.

(l) Power Provider shall use commercially reasonable efforts to cause Purchaser to maintain the area in the immediate vicinity of the Generating Facility in a reasonably neat and clean condition.

4. Purchase and Sale of Power; Term

(a) Purchase and Sale. Beginning on the Commercial Operation Date, and continuing for the term of this Agreement, Purchaser shall purchase and accept delivery from Power Provider at the purchase price set forth in Section 4(b) below, and Power Provider shall sell and deliver to Purchaser the entire Energy Output (in such amount of output as the Generating Facility produces from time to time). Purchaser shall not resell any of the Energy Output except for any net-metering.

(b) Purchase Price. Purchaser shall pay Power Provider an amount equal to the Energy Output multiplied by the Purchase Price per kWhac (pursuant Exhibit B). Such amount shall be paid in accordance with the terms of Section 11.

(c) Taxes. In the event that any taxes are assessed against the generation, sale, delivery or consumption of Energy Output, Purchaser shall pay for all such amounts due.

(d) Term. The purchase and sale obligation under Section 4(a) with respect to Energy Output from the Generating Facility shall commence on the Commercial Operation Date and expire at the time and date of expiration of the Lease ("Expiration Date"). Notwithstanding the foregoing sentence, subject to termination contemplated in Section 3(c) or following a default by a Party as described in Section 17, the term of this Agreement shall commence on the date first written above and expire at the Expiration Date.

(e) Early Termination by Power Provider. Power Provider shall have the right, but not the obligation, to terminate this Agreement prior to expiration of its term only upon the occurrence of:

(i) an unstayed order of a court or administrative agency having the effect of subjecting the sales of Energy Output to federal or state regulation of prices;

(ii) elimination or alteration of one or more Environmental Incentives or other change in law that results in a material adverse economic impact on Power Provider;

(iii) an annual level of direct beam solar resource availability that is less than or equal to 90% of historical averages as measured by long-term weather data (minimum of five (5) years) collected at the Site and/or other reliable calibrated and appropriate weather station representative of the Site; or

(iv) the termination of the Lease prior to the Expiration Date for any reason other than Power Provider's breach of the Site Lease.

5. Maximum Contract Payment Obligation

Any other provision of this Agreement notwithstanding, in no event shall the City's payment obligation for the services provided hereunder be any amount in excess of the sum of *(sum of estimated power payments)* ($x,xxx,xxx) over the term of this Agreement, unless this Agreement is amended to increase such amount.

6. Contract Funding

All payments under this Agreement shall be paid from the City and County of Denver Airport System Operations and Maintenance Fund and from no other fund or source. The City is under no obligation to make payments from any other source.

The City is under no obligation to make any future encumbrances or appropriations for this Agreement nor is the city under any obligation to amend this Agreement to increase the Maximum Contract Liability stated above.

It is expressly understood and agreed that the obligation of the City to make payments to the Power Provider shall only extend to monies appropriated by the Denver City Council, paid into the Treasury of the City and encumbered for the purposes of this Agreement. The Power Provider acknowledges that (i) the City does not by this Agreement irrevocably pledge present cash reserves for payments in future fiscal years, and (ii) this Agreement is not intended to create a multiple-fiscal year direct or indirect debt or financial obligation of the City.

7. The Power Provider's Project Manager

(a) The Power Provider shall provide a Project Manager who is trained, qualified and acceptable to the Airport's Contract Administrator. The Project Manager shall have full authority to act for the Power Provider at all times to carry out the provisions of this Agreement.

(b) The Project Manager shall make sufficient regular inspections, or otherwise as necessary, either in person or by a designated representative, to ensure the work is performed as specified. The Project Manager shall provide a copy of all inspection reports to the Airport's Contract Administrator.

(c) The Power Provider agrees that it shall obtain the approval of the Airport's Contract Administrator of the Power Provider's proposed Project Manager. The Power Provider shall

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submit a resume of the proposed Project Manager, along with other information reasonably requested by the City, in order to obtain such approval.

8. Environmental Attributes

(a) Delegation of Attributes. Notwithstanding the Generating Facility's presence on the Site, Power Provider shall own, and may assign or sell in its sole discretion, all right, title and interest associated with or resulting from the development and installation of the Generating Facility or the production, sale, purchase or use of the Energy Output including, without limitation:

(i) all Environmental Incentives and all Environmental Attributes; and

(ii) the Reporting Rights and the exclusive rights to claim that: (A) the Energy Output was generated by the Generating Facility; (B) Power Provider is responsible for the delivery of the Energy Output to the Energy Delivery Point; (C) Power Provider is responsible for the reductions in emissions of pollution and greenhouse gases resulting from the generation of the Energy Output and the delivery thereof to the Energy Delivery Point; and (D) Power Provider is entitled to all credits, certificates, registrations, etc., evidencing or representing any of the foregoing.

(b) Impairment of Solar Renewable Energy Credits. Following notice by Power Provider of actions or omissions which could impair or jeopardize either the sale of SRECs to the Utility or the production of power hereunder, except as required by the Federal Aviation Administration or as required for air navigation purposes, Purchaser shall not take any such action or suffer any such omission at the Site. To the fullest extent Purchaser is able to comply, Purchaser shall take such action or suffer such omission as necessary to assist Power Provider in qualifying for receipt of SRECs payment.

9. Metering

(a) Power Provider shall install and maintain a standard revenue quality meter with electronic data acquisition system ("DAS") capabilities at the Generating Facility. The meter shall measure the alternating current output of the Generating Facility on a continuous basis. Power Provider shall be responsible for maintaining the metering equipment in good working order and, if Purchaser so requests, for testing at Purchaser's sole expense the same once per calendar year and certifying the results of such testing to Purchaser. In the event of a failure of the electronic meter reading system and until such failure has been corrected, Power Provider shall be responsible for conducting monthly on-site readings of the standard electricity meter to determine the output of the Generating Facility delivered to Purchaser. Data retrieved from any such meter shall serve as the basis for invoicing Purchaser for all delivered energy.

(b) Power Provider shall maintain all DAS data and shall provide to Purchaser a report of the Site's individual metered energy, as read and collected on a monthly basis, once each month within fourteen (14) business days after the last day of the preceding month. Power Provider shall verify and adjust all DAS data at least once per calendar year based on readings from the foregoing standard meter. Subject to Section 9(a), such data, as verified and adjusted, shall serve as the basis for invoicing Purchaser for all delivered energy. Power Provider shall preserve all data compiled hereunder for a period not less than three years.

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(c) Not more than twice per calendar year, Purchaser shall have the right to audit all such DAS data upon reasonable notice, and any such audit shall be at Purchaser's sole cost (unless an audit reveals at least a ten percent (10%) overcharge to Purchaser, in which case Power Provider shall bear the cost of that audit). Purchaser shall have a right of access to all meters at reasonable times and with reasonable prior notice for the purpose of verifying readings and calibrations. If the metering equipment is found to be inaccurate, it shall be corrected and past readings shall be promptly adjusted in an equitable manner.

10. Delivery

(a) Title and risk of loss of the Energy Output shall pass from Power Provider to Purchaser upon delivery of the Energy Output at the Energy Delivery Point. All deliveries of Energy Output hereunder shall be in the form of three-phase, sixty-cycle alternating current or similar to properly integrate with the Site's electrical system. Purchaser shall purchase and accept delivery of metered Energy Output at the Energy Delivery Point .

(b) Power Provider shall ensure that all energy generated by the Generating Facility conforms to Utility specifications for energy being generated and delivered to the Site's electric distribution system, which shall include the installation of proper power conditioning and safety equipment, submittal of necessary specifications, coordination of Utility testing and verification, and all related costs.

(c) Purchaser shall be responsible for arranging delivery of Energy Output from the Energy Delivery Point to Purchaser's facilities and any installation and operation of equipment on Purchaser's side of the Energy Delivery Point necessary for acceptance and use of the Energy Output. The Parties acknowledge that adjustments in the terms and conditions of this Agreement may be appropriate to account for rule changes in the respective Utility or Utility control areas, by the respective independent system operators, or their successors, that could not be anticipated at the date of execution of this Agreement or that are beyond the control of the Parties, and the Parties agree to make such commercially reasonable amendments as are reasonably required to comply therewith, subject to the approval of City Council with respect to Purchaser.

11. Invoices and Payment

Power Provider shall deliver to Purchaser an annual invoice on December 31 of each calendar year during the term of this Agreement, stating the Energy Output delivered to Purchaser during the preceding calendar year and calculating the purchase price therefor. The Power Purchaser's annual invoice shall be in form satisfactory to the City. The Power Purchaser agrees that the Airport's Contract Administrator may from time to time require changes to the format and content of the annual invoice to be submitted by the Power Purchaser.

The City shall process all invoices for payment received from the Power Provider on a timely basis in accordance with the City's Prompt Payment Ordinance, Section 20-107, et. seq. of the Denver Revised Municipal Code ("DRMC"). The Power Provider agrees that interest and late fees shall be payable by the City hereunder only to the extent authorized and provided for in the City's Prompt Payment Ordinance.

12. Disputes

Either Party may, in good faith, dispute the correctness of any invoice or any adjustment to an invoice rendered or adjust any invoice for any arithmetic, computational or meter-related error within twelve (12) months of the date the invoice or adjustment to an invoice was rendered. In the event a Party disputes all or a portion of an invoice, or any other claim or adjustment arises, that Party shall pay the disputed and undisputed portion when due and provide the other Party notice of the dispute and the amount in dispute. In such event, the Parties shall first use good faith, reasonable, diligent efforts to resolve such dispute within a reasonable period of time not to exceed thirty (30) days from the date of such notice. If the Parties do not resolve such a dispute within such thirty (30) days, then such dispute, or any other disputes arising under or related to this Agreement, shall be resolved by administrative hearing which shall be conducted in accordance with the procedures set forth in Section 5-17, Revised Municipal Code of the City and County of Denver. The Parties hereto agree that the Manager of Aviation's determination resulting from said administrative hearing shall be final, subject only to the Power Provider's right to appeal the determination under Colorado Rule of Civil Procedure, Rule 106.

13. Title to Generating Facility and other Property Rights

(a) Notwithstanding the Generating Facility's presence on the Site, Power Provider shall at all times retain title to and be the legal and beneficial owner of the Generating Facility, and the Generating Facility shall remain the property of Power Provider or Power Provider's assigns. Power Provider shall be entitled to, and is hereby authorized to, file one or more precautionary financing statements or fixture filings in such jurisdictions as it deems appropriate with respect to the Generating Facility in order to protect its rights in the Generating Facility.

(b) The Parties specifically acknowledge and agree that Power Provider shall be the owner of the Generating Facility for federal income tax purposes, and in that connection, shall be entitled to the depreciation deductions associated with the Generating Facility as well as any tax credits or other tax benefits provided under the Code to which such Generating Facility may be entitled.

(c) Nothing in this Agreement shall be construed to convey to Purchaser a license or other right to trademarks, copyrights, technology or other intellectual property of Power Provider.

14. Representations and Warranties

Each Party represents and warrants to the other Party that (a) such Party is duly organized, validly existing and in good standing under the laws of the state of its formation and has all requisite power and authority to enter into this Agreement, to perform its obligations hereunder and to consummate the transactions contemplated hereby; (b) the execution and delivery of this Agreement and the performance of such Party's obligations hereunder have been duly authorized by all necessary company action; (c) this Agreement is a legal, valid and binding obligation of such Party enforceable against such Party in accordance with its terms, subject to the qualification, however, that the enforcement of the rights and remedies herein is subject to (i) bankruptcy and other similar laws of general application affecting rights and remedies of creditors and (ii) the application of general principles of equity (regardless of whether considered in a proceeding in equity or at law); and (d) neither the execution and delivery of this Agreement

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by such Party nor compliance by such Party with any of the terms and provisions of this Agreement conflicts with, breaches or contravenes the provisions of such Party's organizational documents or any state statutes as applies to such Party. Power Provider further represents and warrants to the Purchaser that to Power Provider's knowledge, no governmental approval (other than any governmental approvals which have been previously obtained or disclosed in writing to Purchaser) is required in connection with the due authorization, execution and delivery of this Agreement by Power Provider or the performance by Power Provider of its obligations hereunder which Power Provider has reason to believe that it will be unable to obtain in due course. Purchaser further represents and warrants to the Power Provider that to the Purchaser's Department of Aviation's knowledge, except for building permits and approval by the City Council, no governmental approval (other than any governmental approvals which have been previously obtained or disclosed in writing to Power Provider) is required in connection with the due authorization, execution and delivery of this Agreement by Purchaser or the performance by Purchaser of its obligations hereunder which Purchaser has reason to believe that it will be unable to obtain in due course.

15. Covenants and Liens

Notwithstanding the Generating Facility's presence on the Site, Purchaser shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien (including mechanics', labor or materialman's lien), charge, security interest, encumbrance or claim on or with respect to the Generating Facility or any interest therein. Purchaser also shall pay promptly before a fine or penalty may attach to the Generating Facility any taxes, charges or fees of whatever type of any relevant governmental authority for which Purchaser is responsible. If Purchaser breaches its obligations under this Section, it shall immediately notify Power Provider in writing, shall promptly cause such liens to be discharged and released of record without cost to Power Provider.

16. Loss

If the Generating Facility is (i) materially damaged or destroyed, or suffers any other material loss or (ii) condemned, confiscated or otherwise taken, in whole or in material part, or the use thereof is otherwise diminished so as to render impracticable or unreasonable the continued production of energy, to the extent there are sufficient insurance or condemnation proceeds available to Power Provider, Power Provider shall either cause (A) the Generating Facility to be rebuilt and placed in Commercial Operation at the earliest practical date or (B) another materially identical Generating Facility to be built in the proximate area of the Site and placed in Commercial Operation as soon as commercially practicable.

17. Default and Remedies

(a) Event of Default. With respect to a Party, there shall be an event of default if:

(i) such Party fails to pay any amount within thirty (30) days after such amount is due, or as otherwise provided by the City's Prompt Payment Ordinance;

(ii) except as otherwise set forth in this Section 17(a), such Party is in breach of any representation or warranty set forth herein or fails to perform any material obligation set forth in this Agreement and such breach or failure is not cured within sixty (60) days after notice from the non-defaulting Party; provided, however, that the cure period shall be extended by the number of days during which the defaulting Party is prevented from taking curative action solely by Force Majeure if the defaulting Party had begun curative action and was proceeding diligently, using commercially reasonable efforts, to complete such curative action;

(iii) such Party admits in writing its inability to pay its debts generally as they become due;

(iv) such Party files a petition or answer seeking reorganization or arrangement under the federal bankruptcy laws or any other applicable law or statute of the United States of America or any State, district or territory thereof;

(v) such Party makes an assignment for the benefit of creditors;

(vi) such Party consents to the appointment of a receiver of the whole or any substantial part of its assets;

(vii) such Party has a petition in bankruptcy filed against it, and such petition is not dismissed within 90 days after the filing thereof;

(viii) a court of competent jurisdiction enters an order, judgment, or decree appointing a receiver of the whole or any substantial part of such Party's assets, and such order, judgment or decree is not vacated or set aside or stayed within 90 days from the date of entry thereof;

(ix) under the provisions of any other law for the relief or aid of debtors, any court of competent jurisdiction shall assume custody or control of the whole or any substantial part of such Party's assets and such custody or control is not terminated or stayed within 90 days from the date of assumption of such custody or control; or

(x) Purchaser or Power Provider materially breaches the Lease.

(b) Remedies. Upon default by one Party, the other Party shall have the right, but not the obligation, to terminate or suspend this Agreement with respect to all obligations arising after the effective date of such termination or suspension (other than payment obligations relating to obligations arising prior to such termination or suspension). The Parties agree that in the event of a default under this contract that leads to termination, the non-defaulting Party may pursue all remedies available to it in law and in equity.

(c) No Waiver. Any waiver at any time by either Party of its rights with respect to an event of default under this Agreement, or with respect to any other matters arising in connection with

this Agreement, shall not be deemed to be a waiver with respect to any subsequent default or other matter. Any waiver under this Agreement must be in writing signed by the waiving Party.

(d) Notwithstanding any provision to the contrary under this Agreement, neither Purchaser nor any party related to Purchaser shall bear or be deemed to bear any significant financial burden if there is nonperformance by Power Provider under this agreement, as the phrase "any significant financial burden if there is nonperformance" is used in Section 7701(e)(4)(A)(ii) of the Internal Revenue Code.

(e) Notwithstanding any provision to the contrary under this Agreement, neither Purchaser nor any party related to Purchaser shall be deemed to receive any significant financial benefit if the operating costs of the Generating Facility are less than the standard of performance and/or operation set forth in this Agreement, as the phrase "significant financial benefit if the operating costs of [the Generating Facility] are less than the standards of performance or operation" is used in Section 7701(e)(4)(A)(iii) of the Internal Revenue Code.

18. Limitation of Liability

IN NO EVENT SHALL EITHER PARTY BE LIABLE TO THE OTHER PARTY FOR CONSEQUENTIAL, INCIDENTAL, PUNITIVE, EXEMPLARY OR INDIRECT DAMAGES, LOST PROFITS OR BUSINESS INTERRUPTION DAMAGES, BY STATUTE, IN TORT, CONTRACT OR OTHERWISE.

19. Agreement Subordinate to Agreements with United States

This Agreement is subject and subordinate to the terms, reservations, restrictions and conditions of any existing or future agreements between the City and the United States, the execution of which has been or may be required as a condition precedent to the transfer of federal rights or property to the City for Airport purposes and the expenditure of federal funds for the development of the Airport or airport system. The provisions of the attached Appendices 1 and 3 are incorporated herein by this reference.

20. Airport Security

(a) It is a material requirement of this Agreement that the Power Provider at its sole expense and without reimbursement by the City shall comply with all rules, regulations, written policies and authorized directives from the City and/or the Transportation Security Administration with respect to Airport security. The Power Provider shall conduct all of its activities at the Airport in compliance with the Airport security program, which is administered by the Security Division of the City's Department of Aviation. Violation by the Power Provider or any of its employees, subcontractors or vendors of any rule, regulation or authorized directive from the City or the Transportation Security Administration with respect to Airport Security shall be grounds for immediate termination by the City of this Agreement for cause.

(b) The Power Provider, promptly upon notice of award of this Agreement, shall meet with the Airport's Assistant Security Manager to establish badging and vehicle permit requirements for Power Provider's operations under this Agreement. The Power Provider shall obtain the proper access authorizations for all of its employees, subcontractors and vendors who will enter

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the Airport to perform work or make deliveries, and shall be responsible for each such person's compliance with all Airport rules and regulations, including without limitation those pertaining to security. Any person who violates such rules may be subject to revocation of his/her access authorization. The failure of the Power Provider or any subcontractor to complete any required services hereunder shall not be excused on account of the revocation for good cause of access authorization of any person.

(c) The security status of the Airport is subject to change without notice. If the security status of the Airport changes at any time during the term of this Agreement, the Power Provider shall take immediate steps to comply with security modifications which occur as a result of the changed status. The Power Provider may at any time obtain current information from the Airport Security Office regarding the Airport's security status in relation to the Power Provider's operations at the Airport.

(d) The Power Provider shall return to the City at the expiration or termination of this Agreement, or upon demand by the City, all access keys or access badges issued to it or any subcontractor for any area of the Airport, whether or not restricted. If the Power Provider fails to do so, the Contractor shall be liable to reimburse the City for all the City's costs for work required to prevent compromise of the Airport security system. The City may withhold funds in the amount of such costs from any amounts due and payable to the Power Provider under this Agreement.

21. Nondiscrimination

In connection with the performance of work under this Agreement, Power Provider agrees not to refuse to hire, discharge, promote or demote, or to discriminate in matters of compensation against any person otherwise qualified, solely because of race, color, religion, national origin, gender, age, military status, sexual orientation, marital status, or physical or mental disability; and Power Provider further agrees to insert the foregoing provision in all subcontracts hereunder.

22. Bond Ordinances; Governing Law; Venue

This Agreement shall be deemed to have been made in, and shall be construed in accordance with the laws of the State of Colorado and the Charter and Ordinances of the City and County of Denver. This Agreement is in all respects subject and subordinate to any and all City bond ordinances applicable to the Denver Municipal Airport System and to any other bond ordinances which amend, supplement, or replace such bond ordinances. Venue for any action hereunder shall be in the City and County of Denver, State of Colorado.

23. Inspection of Records

(a) In connection with any services performed hereunder on items of Work toward which federal funds may be received under the Airport and Airway Improvement Act of 1982, as amended, the City and County of Denver, the Federal Aviation Administration, the Comptroller General of the United States and any other duly authorized representatives shall have access to any books, documents, papers and records of the Power Provider which are directly pertinent to a specific grant program for the purpose of making audit, examination, excerpts and transcriptions.

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The Power Provider further agrees that such records will contain information concerning the specific tasks performed along with the applicable federal project number.

(b) The City and the Auditor of the City or any of his duly authorized representatives, until the expiration of three years after the final payment under this Agreement, shall have access to and the right to examine any directly pertinent books, documents, papers and records of the Power Provider which are related to Work performed under this Agreement without regard to whether the Work was paid for in whole or in part with federal funds or was otherwise related to a federal grant program.

(c) In addition to the foregoing, Each Party hereto shall keep complete and accurate records of its operations hereunder and shall maintain such data as may be necessary to determine with reasonable accuracy any item relevant to this Agreement. Each Party shall have the right to examine all such records insofar as may be necessary for the purpose of ascertaining the reasonableness and accuracy of any statements of costs relating to transactions hereunder.

24. Assignment

(a) Neither Party shall assign this Agreement or any of its rights hereunder without the prior written consent of the other Party, which consent shall not be unreasonably withheld or delayed. Notwithstanding the foregoing, either Party may upon written notice, without the need for consent from the other Party (and without relieving itself from liability hereunder), (i) transfer, pledge or assign this Agreement as security for any financing or to an affiliated special purpose entity created for the financing or tax credit purposes related to Generating Facility; (ii) transfer or assign this Agreement to any person or entity succeeding to all or substantially all of the assets of such Party, provided, however, that any such assignee shall agree to be bound by the terms and conditions hereof; (iii) assign its rights under this Agreement to a successor entity in a merger or acquisition transaction, provided, however, that any such assignee shall agree to be bound by the terms and conditions hereof; or (iv) transfer or assign this Agreement to one or more affiliates, provided, however, that any such assignee shall agree to be bound by the terms and conditions hereof. Notwithstanding, and in addition to, the foregoing, Purchaser may not assign this Agreement to an entity with a Credit Rating lower than that of Purchaser at the time without the following matching credit support provisions, as implemented by Purchaser:

If at any time Power Provider has a concern about Purchaser's obligations hereunder, including its ability to pay, Power Provider shall require Purchaser to provide Performance Assurance (as defined below) within ten (10) days of receipt of notice from Power Provider that such Performance Assurance will be required. "Performance Assurance" shall mean collateral in the form of either cash or letter(s) of credit for six (6) months of payment, or other security reasonably acceptable to Power Provider. "Credit Rating" shall mean, with respect to an entity on any date of determination, the respective rating then assigned to its unsecured and senior long-term debt or deposit obligations (not supported by third-party credit enhancement) by Standard & Poor's Ratings Services (a division of McGraw-Hill), Moody's Investors Service, Inc., or their respective successors.

(b) With respect to a transfer, pledge or assignment by Power Provider pursuant to clause (i) in the second sentence of Section 24(a), Purchaser and Power Provider acknowledge and agree

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that, upon receipt of written notice and direction by any financing-transaction assignee ("Lender") of Power Provider that Power Provider is in default under its financing agreements with Lender, and notwithstanding any instructions to the contrary by Power Provider, Purchaser, as directed in writing by Lender, will recognize such Lender, or any third party to whom such Lender has reassigned the rights of Power Provider under this Agreement, as the proper and lawful provider of power under this Agreement and fully entitled to receive payments with respect thereto so long as such Lender (or its assignee) performs the obligations of Power Provider hereunder. Purchaser shall be protected and shall incur no liability in acting or proceeding in good faith upon any such foregoing written notice and direction by Lender which Purchaser shall in good faith believe (a) to be genuine and (b) a copy of which shall have been delivered to Power Provider. Purchaser shall be under no duty to make any investigation or inquiry as to any statements contained or matters referred to in any such foregoing notice and direction, but may accept and rely upon them as conclusive evidence of the truth and accuracy of such statements.

(c) Purchaser agrees to notify Lender in writing, at the address to be designated by Lender upon not less than five (5) business days' written notice to Purchaser prior to any notice by Purchaser hereunder, of any act or event of default of Power Provider under the Agreement of which Purchaser has knowledge that would entitle Purchaser to cancel, terminate, annul, or modify the Agreement or otherwise proceed with enforcement remedies against Power Provider, and Lender shall have the same amount of time as Power Provider, but at least ten (10) days with respect to any monetary default and at least thirty (30) days with respect to any non-monetary default, to cure any default by Power Provider under the Agreement; provided that in no event shall Lender be obligated to cure any such default.

25. No Third Party Beneficiaries

It is expressly understood and agreed that enforcement of the terms and conditions of this Agreement, and all rights of action relating to such enforcement, shall be strictly reserved to the City and the Power Provider, and nothing contained in this Agreement shall give or allow any such claim or right of action by any other or third person on such Agreement. It is the express intention of the City and the Power Provider that any person other than the City or the Power Provider receiving services or benefits under this Agreement shall be deemed to be an incidental beneficiary only.

26. Independent Contractor

Power Provider shall at all times have the status of an independent contractor without the right or authority to impose tort or contractual liability upon the City. Nothing in this Agreement shall be construed to mean or imply that Power Provider is a partner, joint venturer, agent or representative of the City. Neither the City nor Power Provider shall represent to others that one Party is a partner, joint venturer, agent or representative of, or otherwise associated with, the other Party.

27. Notices

All notices required to be given to the City or Power Provider hereunder shall be in writing and sent by certified mail, return receipt requested, to:

City:	Manager of Aviation Denver International Airport 8500 Pena Boulevard, 9th Floor Denver, Colorado 80249-2065 With a copy to: Airport Property Office Denver International Airport 8500 Pena Boulevard, 9th Floor Denver, Colorado 80249-2065
Power Provider:	XYZ Solar Address Contact Phone Numbers

Either Party hereto may designate in writing from time to time the address of substitute or supplementary persons within the State of Colorado to receive such notices. The effective date of service of any such notice shall be three days after the date such notice is mailed to Power Provider or Manager.

28. Final Approval

This Agreement is expressly subject to and shall not be or become effective or binding on either Party until it is approved by Denver's City Council and fully executed by all signatories hereto, including all signatories of the City and County of Denver.

29. Force Majeure

Power Provider shall not be liable to Purchaser for any failure, delay or interruption in the performance of any of the terms, covenants or conditions of this Agreement to the extent such failure, delay or interruption is due to causes which were not reasonably foreseeable and are beyond the control of Power Provider, including without limitation strikes, boycotts, labor disputes, embargoes, shortages of materials, acts of God, acts of the public enemy, acts of superior governmental authority, weather conditions, floods, riots, rebellion, sabotage or any other circumstance for which Power Provider is not responsible or which is not in its power to control.

30. Set-Off

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Except as otherwise set forth herein, each Party reserves to itself all rights, set-offs, counterclaims and other remedies and/or defenses to which it is or may be entitled, arising from or out of this Agreement or arising out of any other contractual arrangements between the Parties. All outstanding obligations to make, and rights to receive, payment under this Agreement may be offset against each other.

31. Binding Effect

The terms and provisions of this Agreement, and the respective rights and obligations hereunder of each Party, shall be binding upon, and inure to the benefit of, the Parties and their respective successors and permitted assigns.

32. Amendments

No modification of this Agreement shall be effective except by written amendment executed by the Parties; provided, however, if Purchaser has been notified that Power Provider has assigned any of its rights, duties or obligations under this Agreement to a Lender, then the prior written consent of Lender is required as well.

33. Counterparts

Any number of counterparts of this Agreement may be executed and each shall have the same force and effect as the original.

34. Other Agreements

This Agreement constitutes the entire agreement between the Parties relating to the subject matter hereof and supersedes any other prior agreements, written or oral, between the Parties concerning such subject matter (other than the Lease and the Utility interconnection agreement referred to in Section 2(a) above). In the event of an irreconcilable conflict between a provision of this Agreement and a provision of the Lease, such that it is impossible to give effect to both, the Lease shall control to resolve such conflict.

35. Severability

Should any provision of this Agreement for any reason be declared invalid or unenforceable by final and non-appealable order of any court or regulatory body having jurisdiction, such decision shall not affect the validity of the remaining portions, and the remaining portions shall remain in full force and effect as if this Agreement had been executed without the invalid portion.

36. Survival

Any provision(s) of this Agreement that expressly or by implication comes into or remains in full force following the termination or expiration of this Agreement shall survive the termination or expiration of this Agreement.

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37. Legal Effect of Contract

(a) The Parties acknowledge and agree that the transaction contemplated under this Agreement constitutes a "forward contract" within the meaning of the United States Bankruptcy Code, and the Parties further acknowledge and agree that each Party is a "forward contract merchant" within the meaning of the United States Bankruptcy Code.

(b) The Parties acknowledge and agree that, for accounting or tax purposes, this Agreement is not and shall not be construed as a capital lease and, pursuant to Section 7701(e)(3) of the Internal Revenue Code, this Agreement is and shall be deemed to be a service contract with respect to the sale to the Purchaser of electric energy produced at an alternative energy facility.

38. Cooperation

Upon the receipt of a written request from the other Party and without further consideration, each Party shall provide materials, information, assurances and take such additional actions as are reasonably necessary and desirable to carry out the terms and intent hereof. Neither Party shall unreasonably withhold, condition or delay its compliance with any reasonable request made pursuant to this section. Without limiting the foregoing, the Parties acknowledge that they are entering into a long-term arrangement in which the cooperation of both of them will be required.

39. Waiver

The waiver by either Party of any breach of any term, condition, or provision herein contained shall not be deemed to be a waiver of such term, condition, or provision, or any subsequent breach of the same, or any other term, condition, or provision contained herein.

[Signature Page to Follow]

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IN WITNESS WHEREOF, the parties hereto have executed this Solar Power Purchase Agreement as of the day and year first above written.

ATTEST:

_____
STEPHANE Y. O'MALLEY, Clerk and Recorder, Ex-officio Clerk of the City and County of Denver

APPROVED AS TO FORM:

DAVID R. FINE, Attorney for the City and County of Denver

By_____
Assistant City Attorney

CITY AND COUNTY OF DENVER

By_____
Mayor

RECOMMENDED AND APPROVED:

By_____
Manager of Aviation

REGISTERED AND COUNTERSIGNED:

By_____
Manager of Finance

Contract Control Number:

By_____
Auditor-Contract Control No. _____

"CITY" or "PURCHASER"

POWER PROVIDER

Oak Leaf Energy Partners

By:

By:_____

Name:
Title: Chief Executive Officer

"POWER PROVIDER"

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Exhibit A

Estimated Annual Production for First Year

***Purchaser* PV Projects**

Location	**Size**	**Est. Annual 1st Year Production**	**Type**	**Number and Type of Module**
Denver, Colorado			Fixed Tilt Ground Mount	

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Exhibit B

Purchase Price

Year of Contract[1]	Rate	Price Escalator
1		0%
2		0%
3		0%
4		0%
5		0%
6		0%
7		0%
8		0%
9		0%
10		0%
11		0%
12		0%
13		0%
14		0%
15		0%
16		0%
17		0%
18		0%
19		0%
20		0%
21		0%
22		0%
23		0%
24		0%
25		0%
Thereafter		

Annual Price Escalator: Each year[1] during the term of the Agreement, the purchase price shall be adjusted upward by the price escalator listed in this Exhibit B.

[1] Each year starts at 0000 hours on the Date of Commercial Operation (or anniversary) and runs through 2400 hours on the date before the following anniversary (*e.g.*, 0000 hours on January 1 through 2400 hours on December 31).

APPENDIX NO. 1

STANDARD FEDERAL ASSURANCES

NOTE: As used below the term "contractor" shall mean and include the "Party of the Second Part," and the term "sponsor" shall mean the "City."

During the term of this contract, the contractor, for itself, its assignees and successors in interest (hereinafter referred to as the "contractor") agrees as follows:

1. Compliance with Regulations. The contractor shall comply with the Regulations relative to nondiscrimination in federally assisted programs of the Department of Transportation (hereinafter "DOT") Title 49, Code of Federal Regulations, Part 21, as they may be amended from time to time (hereinafter referred to as the "Regulations"), which are herein incorporated by reference and made a part of this contract.

2. Nondiscrimination. The contractor, with regard to the work performed by it during the contract, shall not discriminate on the grounds of race, color, sex, creed or national origin in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor shall not participate either directly or indirectly in the discrimination prohibited by section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Regulations.

3. Solicitations for Subcontractors, Including Procurements of Materials and Equipment. In all solicitations either by competitive bidding or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by the contractor of the contractor's obligations under this contract and the Regulations relative to nondiscrimination on the grounds of race, color, or national origin.

4. Information and Reports. The contractor shall provide all information and reports required by the Regulations or directives issued pursuant thereto and shall permit access to its books, records, accounts other sources of information, and its facilities as may be determined by the sponsor or the Federal Aviation Administration (FAA) to be pertinent to ascertain compliance with such Regulations, orders, and instructions. Where any information required of a contractor is in the exclusive possession of another who fails or refuses to furnish this information, the contractor shall so certify to the sponsor of the FAA, as appropriate, and shall set forth what efforts it has made to obtain the information.

5. Sanctions for Noncompliance. In the event of the contractor's noncompliance with the nondiscrimination provisions of this contract, the sponsor shall impose such contract sanctions as it or the FAA may determine to be appropriate, including, but not limited to:

a. Withholding of payments to the contractor under the contract until the contractor complies, and/or

b. Cancellation, termination, or suspension of the contract, in whole or in part.

6. Incorporation of Provisions. The contractor shall include the provisions of paragraphs 1 through 5 in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Regulations or directives issued pursuant thereto. The contractor shall take such action with respect to any subcontract or procurement as the sponsor or the FAA may direct as a means of enforcing such provisions including sanctions for noncompliance. Provided, however, that in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, the contractor may request the sponsor to enter into such litigation to protect the interests of the sponsor and, in addition, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

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