A COMPREHENSIVE SOLAR ENERGY POWER SYSTEM FOR THE TURKEY LAKE SERVICE PLAZA

A Research Report and Feasibility Study

January 7, 2010

Contract #: BDK75-977-18

STATE OF FLORIDA • DEPARTMENT OF TRANSPORTATION

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16. Abstract

The Florida Turnpike Enterprise (FTE) has the bold vision of maximizing the use of renewable energy in their operations and potentially supplying all the energy needs of their facilities via solar technologies. A University of Florida research team collaborated with FTE and Florida Department of Transportation staff to examine contemporary solar technologies, particularly solar photovoltaic (PV) systems, for their potential to meet the energy needs of the Turkey Lake Service Plaza. The scope of the research included: (1) Evaluation of Solar Electric (PV), Solar Thermal (hot water), and Solar Lighting systems; (2) Assessment of the renewable energy generation potential of the Service Plaza; (3) Designing and planning of photovoltaic systems to determine the energy output; (4) Identification of innovative financing options; (5) Development of a marketing and education concept for the project. The research team concluded that by implementing the Net Zero Energy scenario, the annual electrical energy needs of all the facilities at the Turkey Lake Service Plaza could be met. A Maximum Energy scenario would generate substantial excess electrical energy and possibly additional revenue. The research team concluded that when all available areas for mounting photovoltaic systems were utilized, about 2 ½ times the Net Zero Energy scenario energy would be generated. The analysis of the financial feasibility found that if a private developer, defined as a utility or other company engaged in providing solar photovoltaic systems, partnered with FTE to install a solar photovoltaic system, it would be feasible for a system to be installed at no cost to the FTE, provided agreements regarding power purchase and other issues are successfully addressed. If the FTE were to own the photovoltaic systems installed at the Service Plaza, the revenue from the value of the energy generated, up to the actual energy consumed on a monthly basis, would be the major source of revenue to pay for the system. The capital cost of the system would be derived from a bond issue that would be paid back over a predetermined period of time.

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EXECUTIVE SUMMARY

The Florida Turnpike Enterprise (FTE) has the bold vision of maximizing the use of renewable energy in their operations and potentially supplying all the energy needs of their facilities via solar technologies. To determine the technical and financial feasibility of executing this vision, the FTE selected the Turkey Lake Service Plaza on the Florida Turnpike for a case study to explore this potential shift to renewable energy sources. A University of Florida research team collaborated with FTE and Florida Department of Transportation staff to examine contemporary solar technologies, particularly solar photovoltaic (PV) systems, for their potential to meet the energy needs of the Turkey Lake Service Plaza. The scope of the research included:

1. Evaluation of Solar Electric (PV), Solar Thermal (hot water), and Solar Lighting systems.
2. Assessment of the renewable energy generation potential of the Service Plaza.
3. Designing and planning of photovoltaic systems to determine the energy output.
4. Identification of innovative financing options.
5. Development of a marketing and education concept for the project.

The research team concluded that by implementing the Net Zero Energy scenario, the annual electrical energy needs of all the facilities at the Turkey Lake Service Plaza could be met. The Net Zero Energy scenario is defined as meeting all the electrical energy needs of a facility over a year and requiring no monthly electrical utility payment.

A Maximum Energy scenario would generate substantial excess electrical energy and possibly additional revenue. A Maximum Energy scenario is defined as installing photovoltaic systems in or on all available areas on the Turkey Lake Service Plaza, including noise walls on the northeast side of the Turnpike within one mile of the Plaza. The research team concluded that when all available areas for mounting photovoltaic systems were utilized, about 2 ½ times the Net Zero Energy scenario energy would be generated.

There are two basic ownership options for both the Net Zero Energy and Maximum Energy scenarios: FTE Ownership or the Lease Option.

The analysis of the financial feasibility found that if a private developer, defined as a utility or other company engaged in providing solar photovoltaic systems, partnered with FTE to install a Solar Photovoltaic system, it would be feasible for a system to be installed at no cost to the FTE, provided agreements regarding power purchase and other issues are successfully addressed. If the FTE were to own the photovoltaic systems installed at the Service Plaza, the revenue from the value of the energy generated, up to the actual energy consumed on a monthly basis, would be the major source of revenue to pay for the system. The capital cost of the system would be derived from a bond issue that would be paid back over a predetermined period of time.

For the Net Zero Energy scenario and FTE ownership, a feasible PV system of about 3.8 megawatts (MW) of peak power would cost $20.4 million. With an annual energy value of about $523,000 and carbon mitigation valued at about $83,000, a 20-year bond of about $9.5 million could be created.   The study proceeded on the assumption that some revenue, about 25% of the total requirement, could be created through sponsorships. A total of $17.3 million of revenue based on a 20-year life cycle would be available, resulting in a shortfall of about $3.1 million that would have to be funded from FTE or FDOT resources.

For the Maximum Energy scenario and FTE ownership, the system costs for a 9.15 MW system would be about $53.8 million.   Based on an annual energy value of $1.3 million per year and annual carbon mitigation value of about $213,000, a 20-year bond valued at $24.4 million could be created. With 25% of the total cost being attributed to sponsorships, total funding of about $44.9 million could be made available, a shortfall of about $8.9 million dollars.

The Lease Option assumes a developer such as a utility of other entity would fund the installation. Due to current tax policy, ARRA 2009 support, and other favorable conditions, the net cost is about breakeven for a 20 year life cycle, assuming bonus depreciation is available. This is true for both the Net Zero Energy scenario and Maximum Energy scenario. For the Net Zero Energy scenario the system cost is about $20.4 million with revenue of $20.1 million over a 20-year life cycle. For the Maximum Energy scenario, the cost of the system is about $53.8 million, with revenue of about $52.5 million. The analysis did use conservative assumptions with respect to systems cost.

Each developer makes different assumptions on costs and return on investment and each has different buying power. For example, Florida Power & Light is developing several large solar installations around the state and their cost per peak watt is relatively low. Initial discussions with the development community indicates they are interested in pursuing the type of installation described here, preferably the Maximum Power scenario.

The research team highly recommends the Turkey Lake Service Plaza be developed into a *Solar Destination.* It would be a location where someone could experience renewable energy firsthand by observing and interacting with various solar installations, including the large scale installation that would power the Turkey Lake Service Plaza.

The marketing portion of this research defined objectives for a campaign, including public awareness of the project before, during, and after the construction of the solar installation. A Solar Walk showcasing innovations like solar umbrellas, solar trees, solar shades, solar electric vehicles, solar charging stations, solar artwork and solar sculptures could serve to stimulate public interest in solar technologies. Public and private sponsors should be included in the project to help promote solar energy as well. It was the conclusion of the marketing and education portion of this research that the Turkey Lake Service Plaza Solar Energy project could serve to greatly increase public awareness of solar technology, its applications to their homes and businesses, and how to finance solar installations.

In conclusion, under present market conditions, with low equipment and construction costs, favorable tax advantages, ARRA 2009 support, and with a partnership between the FTE and a private developer could provide a route for financing either the Net Zero Energy or Maximum Energy scenarios. Timely decision making about installing the Turkey Lake Service Plaza solar power system is important because some of the financial options begin to expire at the end of

2009, while other options will expire at the end of 2010.

A project at the Turkey Lake Service Plaza that implements this research has the potential to stimulate the transformation of Florida's energy infrastructure. The research team's conclusion is that installing a Solar Energy system at Turkey Lake Service Plaza would have multiple benefits for the state and its citizens and the likelihood of success is very high.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

The Florida Turnpike Enterprise (FTE) has a vision of using clean, renewable energy as the primary energy source for its operations. As part of the process of exploring the potential for solar energy, the Turnpike Enterprise decided to use the Turkey Lake Service Plaza as a specific case study of the costs and benefits of solar generated electricity. The Turkey Lake Service Plaza is also the site of the headquarters of both the FTE and the Florida Highway Patrol's turnpike operations and presents some special challenges due to the density of buildings versus open land on the site. In order to further explore the solar potential for Turkey Lake Plaza the Florida Department of Transportation (FDOT) awarded a contract to the University of Florida to conduct research to assess the solar energy generating potential of the Turkey Lake Service Plaza.

BACKGROUND

A Scope of Services was negotiated between the University of Florida and FDOT and the FTE for an innovative, multidisciplinary research project to explore the options for generating clean renewable energy to support Turnpike Enterprise operations. The FTE's Turkey Lake Service Plaza, including one mile north and south of the facility, is the focus for specific applications of solar energy technologies, with the intent that the research and lessons learned from the Turkey Lake Service Plaza Solar Energy Power System will be applied to the wider transportation system managed by the FTE and FDOT. A multidisciplinary University of Florida team, with input on financing options from Florida Power & Light and on revenue generation and corporate sponsorship from Simpler Solar, developed a strategy to achieve these goals. This Scope of Services included Objectives and Tasks with a proposed Schedule and Budget.

In addition to addressing the potential for renewable energy for the Turkey Lake Service Plaza, this research provides a template for the large scale adoption of solar energy technologies for other Florida Turnpike plazas as well as for Florida Department of Transportation facilities and activities. The University of Florida team conducted research on technologies, systems, economic feasibility, financing, education, and marketing applicable to a large scale solar installation at the Turkey Lake Plaza of the Florida Turnpike. As a collateral benefit this project and its associated publicity is designed to introduce the general public to the concept of solar energy because the resulting technology will be prominently displayed in heavily trafficked areas used by a substantial portion of the State's population. The University of Florida team was assembled to provide the necessary expertise in the conceptual design and engineering of solar energy systems, construction, facility operations, marketing, finance, and other disciplines in order to develop a concept for a well-designed, efficient, replicable, and economically suitable solar power system for the Turkey Lake Plaza.

OBJECTIVES AND SUPPORTING TASKS

The following were the Objective and Supporting Tasks for this research:

1. Develop a complete picture of the solar industry and technologies applicable to this project

(1) Survey industry for current technologies to include cost, performance, durability, reliability and maintainability. Technologies included would be photovoltaics (PV), solar hot water, and lighting. Innovative applications such as powerbrellas, solar trees, canopy systems, and solar shades would be included.

(2) Conduct a literature review of emerging solar technologies including thin film, dyed solar cells, inkjet solar cells, multi-junction solar PV, and three-dimensional light-trapping cells, to name a few, to form a picture of near future technologies.

(3) Conduct a literature review of representative solar power generation projects in the U.S. and other countries for their applicability.

2. Determine and assess the current energy consumption at the Turkey Lake Service Plaza

(1) Gather and analyze energy consumption data for buildings, exterior lighting, and hot water usage at the Turkey Lake Solar Plaza.

(2) Determine the solar PV area, solar hot water, and solar lighting requirements for the Plaza based on the consumption data.

3. Configure selected solar PV, hot water, and lighting systems for the Turkey Lake Service Plaza to provide the maximum energy at minimal life cycle cost

(1) Assess the open areas, car and truck parking areas, building roofs, and sound walls for mounting of PV solar panels and systems.

(2) Determine the optimal configurations of solar hot water and solar lighting to support Plaza operations

(3) Integrate innovative solar artwork, solar shades, and other similar supplementary devices into the solar power scheme to provide opportunities for the public to interact with solar power technology.

4. Identify and Assess Innovative Financing Options

(1) Determine the costs of the Solar Power System for the purpose of establishing the level of financing required to support the project.

(2) Perform first cost and life cycle costing analyses of the solar power system including issues of maintenance, component replacement, and other cost related issues.

(3) Identify innovative financing options to minimize the first cost and operating costs of the solar power system. This would include Purchase Power Agreements (PPA); agreements with utilities to meet their Renewable Energy Portfolio requirements; capturing of carbon credits; capturing of tax credits; and sale of green power to green building projects. Assess

these innovative financing options to determine those best suited for the Turkey Lake Service Plaza project.

(4) Identify and assess corporate sponsorship options and potential revenue from advertising using the Turkey Lake Plaza as a ‘destination’ to capitalize on this opportunity.

(5) Assess novel opportunities for financing which can be factored into supporting the project. An example might taking advantage of the electronic toll system and potential contributions from Florida citizens as they recharge their accounts.

(6) Assess potential opportunities for financing that may arise due to the federal Stimulus Package.

5. Develop a Marketing and Educational Plan

(1) Create a concept for marketing the project to the general public before, during, and after the installation of the solar systems.

(2) Develop a concept for a “solar trail” for use in educating the general public.

(3) Integrate innovative technologies into the marketing plan to capture the imagination of the public, to include Solar Umbrellas, Solar Trees, Solar Shades, Solar Electric Vehicles and solar charging stations.

(4) Develop a plan for integrating marketing and advertising from solar manufacturers, suppliers, and installers for education of the public about the availability of solar energy systems

6. Assess the Collateral Impacts of the Project

(1) Assess the job creation impacts of the Turkey Lake Solar Plaza project.

(2) Assess the potential for attracting solar businesses into Florida based on projects such at the Turkey Lake Plaza Solar Power Project.

7. Develop Recommendations for Other Turnpike Enterprise and FDOT Solar Projects

(1) Assess the general potential for incorporating the solar strategy developed for Turkey Lake Plaza into other transportation system related projects such as toll plazas, other service plazas, maintenance yards, and other FDOT buildings.

(2) Provide recommendations regarding all the key elements of the Turkey Lake Plaza project to include technical, financial, marketing and education, and other issues that would assist in accelerating the uptake of solar power in FDOT and Turnpike Enterprise contexts as well as generally throughout the State of Florida.

SOLAR POTENTIAL FOR FLORIDA

Considering geological and climatic conditions, Florida is a state that has the potential to benefit from solar as a source of renewable energy. Data on annual average daily direct normal solar radiation for the United States show Florida with 14 million joules per square meter (MJ/m^{2}) compared with up to 28 MJ/m^2 for other areas. This data indicates that Florida is not in the very best location when it comes to solar energy. However, solar radiation is high enough for Florida to be considered a potential place for taking advantage of solar as a renewable source of energy. To evaluate the feasibility of a renewable energy system, economic consideration is an important factor. While a renewable solar energy system has certain environmental benefits, it is the net monetary benefit that determines economic viability of a renewable energy system. While the solar energy is essentially free, the cost of collecting and converting it into useful forms can be quite expensive. There have been numerous studies on economic evaluation of solar energy systems. Some of the studies evaluated costs and benefits of different technologies for conversion of solar to energy in Florida.

The first draft of a report by Navigant Consulting commissioned by state regulators and released in November 2008 indicated that some solar PV and solar hot water technologies have great potential as sources of renewable energy in Florida but concentrating solar power such as that used in the California desert has very low potential (Navigant Consulting 2008). The report from Navigant Consulting is a key document commissioned by the Public Service Commission to help regulators and legislators decide how much renewable energy utilities should be required to provide in order to reduce dependence on foreign oil and emission of greenhouse gases that lead to global warming. Navigant's report says that solar PV cells have the technical potential to produce more than 200,000 gigawatts of power in Florida by the year 2020 if hundreds of thousands of residential and commercial rooftops are used, as well as large ground-based solar fields. The state could realistically expect utilities to generate 6% to 27% of retail electric sales from renewable energy by 2020. Figure 1.1 is a summary of the renewable energy generation in Florida from the Navigant report.

PV technology uses solar cells to convert sunlight directly to electricity. Since PV modules and arrays produce direct current (DC), an inverter converts direct current to alternating current (AC)for use by electric appliances and equipment. The PV technology is relatively simple in design with no moving parts and very low maintenance, however, PVmodules are too expensive at the present time to compete with other sources of energy except for special application. Currently, PV modules cost $2 to $8 per peak (bright sunlight) watt. The cost of electricity from PV technology, assuming an installed cost of $8 per peak watt, is estimated at $0.28 per kWh. In some areas such as desert southwest U.S., with higher annual average daily direct solar radiation, the cost of PV electricity is estimated at $0.22 per kWh.

In addition to the high cost of PV systems, the storage of excess electric power produced by photo cells is also a major issue for application of PV technology. Perhaps once PV cells become economically competitive, the connection of a residential PV system to the utility grid willl make it possible for the excess power to be used by the grid system. It is estimated that at a cost of $1.00 to $1.50 per peak watt, electricity produced by PV technology may be competitive with other sources of energy.

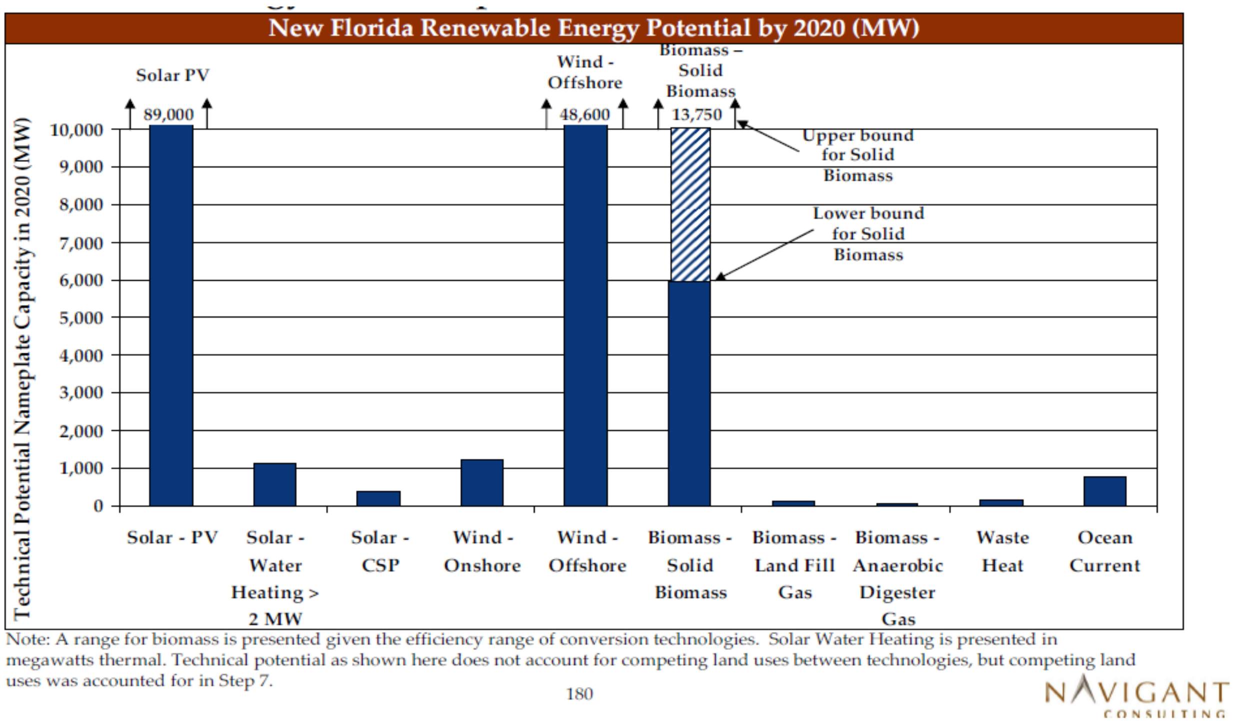

Figure 1.1 Renewable Energy Potential for Florida (Navigant Consulting 2008)

Solar energy installations are beginning to rapidly expand and in early December 2008 Florida Power & Light (FPL), the state's biggest utility, broke ground on what it says will be the first utility-scale solar investment in the state — and the second-largest of its kind in the country when it is fully turned on in 2010. This solar thermal plant, which is located on the Atlantic coast just north of Palm Beach County, will consist of 180,000 PV panels spread over 500 acres (Figure 1.2). It also matches solar power with an existing combined-cycle natural gas plant, so that when the sun is not shining, the natural gas can take over the work of powering the turbines. The plant is the first of three solar facilities that FPL is constructing in Florida, which the utility says will make the state the second-largest solar energy producer in the country. California is currently the largest solar energy producer.

Figure 1.2 An artist's rendering of Florida Power & Light's planned combined-cycle solar and natural gas power plant in Palm Beach County. (Source: FP&L)

In addition to solar PV power, there is also substantial potential for solar hot water heating systems, from residential scale to commercial scale. Navigant Consulting estimated the annual solar thermal hot water potential to be from 1,900 to 2,200 gigawatt-hours.

Spurring the development of Florida's solar energy potential have been a wide range of incentive programs provided by the State, local governments, and utility companies. The City of Gainesville worked out a plan with Gainesville Regional Utility to provide significant incentives for solar installations by paying more for solar generated electricity than customers pay for energy from the utility. This so-called "feed-in tariff" would replace current rebate programs and GRU would pay around 26 cents per kilowatt hour for solar electricity.

SOLAR ENERGY POTENTIAL FOR TURKEY LAKE SERVICE PLAZA

The Headquarters of the FTE is at Turkey Lake Service Plaza in Ocoee, Florida. The facilities were consolidated from several other locations in 2000 and now consist of:

- FTE Headquarters – three stories, 114,000 square feet
- Operations building – two stories, 22,200 square feet
- Florida Highway Patrol building – two stories, 22,500 square feet
- SunWatch building/associated maintenance yard – one story, 7,200 square feet

In addition to the FTE facilities at Turkey Lake Plaza there are several other buildings for servicing the customers using the Turnpike, including shops, restaurants, and a service station. The property itself includes substantial open space that could potentially be exploited to maximize the production of energy from solar PV or solar thermal technologies. Additionally the buildings lend themselves to the application of solar lighting technologies such as solar tubes, fiberoptic, and hybrid solar lighting systems.

For the purposes of this project, the noise walls in the vicinity of the Turkey Lake Plaza were included in the analysis. For the purpose of designing a solar PV system, 1 mile of the walls both north and south of the Plaza, were included in the analysis. By placing several rows of panels on the noise walls, a large number of solar panels with significant energy generating potential can be installed.

The analysis of technologies and the system design for Turkey Lake Plaza was based on three scenarios and eight phases. The eight phases of this project correspond to the various areas that had the potential for installation of PV panels. The following are the eight phases that were examined for their installation potential together with the PV technologies that were examined for their feasibility and other technical areas of examination, for example tracking and mounting options.

Phase	PV Systems	Other
1. Open Areas	Thin film, thick film, organic PV (such as Konarka)	Tracking options, multi-panel options (2 or more)
2. Building Roofs	Thin film, thick film, organic PV (such as Konarka)	Tracking options
3. Employee Parking	Thin film, thick film, organic PV (such as Konarka), EV charging stations	None
4. Visitor Parking	Thin film, thick film, organic PV (such as Konarka), EV charging stations	None
5. Truck Parking	Thin film, thick film	Mounting options, “idle mode” use
6. Noise Walls	Thin film, thick film	Tracking options, mounting options, combination mounting (top and sides of walls), multi-panel option (2 or more)
7. Retention Ponds	Thin film, thick film, organic PV (such as Konarka)	Tracking options, multi-panel options (2 or more), floating system
8. Education and Marketing	All	Locate corporate display areas, solar walk zone

Table 1.1 The project was divided into phases that are in general order of cost, with Phase 1 for the open areas likely being the least costly and producing high power output. Phase 8 could be executed at any point in time because its purpose is not to generate energy, but to educate the public.

A wide array of technologies was examined for applicability to the Turkey Lake Service Plaza and this analysis and its conclusions are described in *Chapter 2, Solar Technology Assessmen*t.

The three scenarios were selected to span the range of possible installations that were being examined for the Plaza. These three scenarios are as follows:

Scenario 1. Maximum Energy. The goal is to maximize solar generated electricity production and to use virtually all the available surfaces on the Turkey Lake Service Plaza for mounting PV panels.

Scenario 2. Net Zero Energy. For this scenario the analysis is based on eliminating high cost/low benefit options and focuses on relatively high energy outputs. The basis for this Scenario is the Net Zero Energy case and the goal was to determine the conditions under which the Turkey Lake Service Plaza could become energy self-sufficient.

Scenario 3. Showcase Energy. The final scenario focused less on energy generation and more on maximizing education and marketing. In this scenario a variety of solar systems and a limited field mounted array would be installed on the Turkey Lake Service Plaza for the purpose of providing Floridians with information about solar energy and giving manufacturers and installers an opportunity to link with consumers in a central location.

For each of these scenarios there are multiple options depending on the PV technology selected and these are spelled out in *Chapter 3, System Selection and Design Alternatives*. Infrastructure issues such as mounting systems and electrical connections are described in *Chapter 4, Site Infrastructure and Energy Issues*. The energy consumption profiles for the Turkey Lake Service Plaza were used to determine the potential for making the Plaza energy self-sufficient

TIMING FOR SOLAR ENERGY DEVELOPMENT
A variety of factors are making the development of solar projects in the 2009-10 time frame especially favorable. The following are some of the major factors that are lowering the cost of installing large scale solar energy projects, resulting in a largely favorable financial picture for most projects:

1. **Construction costs are low**. Because solar energy projects involve substantial construction activity, with fewer building projects and greatly increased competition, these costs are very low at present.
2. **Interest rates are low.** The present recession has motivated the Fed to lower interest rates to a near zero level, with proportional decreases in financing costs across the board.
3. **Equipment costs are low.** The downturn in the global economy and an oversupply of solar PV equipment due to excess manufacturing capacity has caused prices to fall to record lows.
4. **ARRA 2009.** The American Recovery and Reinvestment Act of 2009 provides a wide variety of incentives for renewable energy systems to include 30% grants.
5. **Tax Incentives.** A number of tax incentives, such as Investment Tax Credits and Accelerated Depreciation significantly reduce the net cost of installation and incentivize investments in solar energy.

This report will address three major options for FTE to consider when addressing the actual financing of a potential solar project for Turkey Lake Service Plaza.

1. **Option 1 FTE Ownership.** In this option, FTE would finance, build, own, operate, and maintain the solar installation. The financing would be largely from a bond issue that would translate the future savings in electricity costs for a specified period of time into capital for the solar installation. Other revenue could be generated from an ARRA 2009 grant, from the sale of excess renewable energy, and through revenue generated as a result of carbon mitigation and renewable energy credits (RECs).

2. **Option 2 Private Developer.** A utility such as Progress Energy or FP&L would finance, build, operate and maintain the solar installation under this scenario. Financing would be derived from ARRA 2009 grants, Investment Tax Credits, the sale of electricity, carbon credits and renewable energy credits, and accelerated depreciation. In this scenario the developer would likely want a Purchase Power Agreement (PPA) with FTE in which FTE would pay the developer for the electricity generated by the solar installation.

3. **Option 3, Combination of FTE Ownership and Private Developer.**

The various financing options that would apply to a major Turkey Lake Service Plaza solar installation are covered in *Chapter 5, Innovative Financing Options*.

MARKETING AND EDUCATION

In addition to the technical assessment of solar energy systems and systems design for the Turkey Lake Solar Project, a Marketing and Educational Plan was included in the project scope. It became clear at the onset of the project that the Turkey Lake Plaza has an excellent location for showcasing the solar energy potential of Florida, not only to the general public that uses the facilities but also to an audience of manufacturers and suppliers. The Plaza could become in effect a "destination," much in the same sense as other attractions in Florida. It could be a clearing house for information about renewable energy for homeowners and businesses as well as provide information about solar technology, financing, and incentive programs. Four major objectives guided the design of the marketing and education plan:

1. Showcase FDOT/FTE as Progressive and Innovative Organizations in a Post-Carbon World

In the minds of most citizens FDOT and FTE are connected to a carbon based economy based on fossil fuel vehicles and unsustainable transportation networks. In fact, both organizations see themselves as progressive and have already taken huge steps towards thinking about the future of more sustainable transportation networks and alternative energy and fuel sources. The Turkey Lake Solar Project presents an excellent opportunity to educate the public about current FDOT/FTE initiatives and reframe the agencies as progressive and innovative leaders in the post-carbon future in Florida.

2. Support Exponential and Immediate Growth of Solar in Florida

According to an April 2009 briefing from the non-partisan group Florida TaxWatch, Florida stands at "an opportune crossroads and... is uniquely positioned to take advantage of public and governmental encouragement to reach beyond the historical dependency of the US on fossil fuel." The briefing goes on to state that while Florida's appetite for energy appears insatiable, the state is also poised to become the second-largest producer of electricity from the sun in the nation (after California) within the next few years. After the 111 MW currently under construction are completed, however, there are no large projects on the drawing boards. This means that the entire solar industry in Florida could lose its critical momentum and the state could lose future jobs from manufacturing, installation, and research to competitor states. Consequently projects like the potential solar energy installation at Turkey Lake Plaza are key to maintaining this critical momentum and attracting jobs and industry based on renewable energy to Florida.

3. Develop Turkey Lake as a Solar Destination
Making the Turkey Lake Plaza a solar destination that attracts diverse audiences was identified as a key objective in the initial stages of this research project. This objective is closely related to the first two objectives, to showcase the FDOT and FTE as innovative and to foster immediate growth of solar in the state, but it takes them a step further. The idea here is to develop a nuanced understanding of who is visiting the plaza, who might be encouraged to visit it, and how to make the service plaza unique in the state and the nation as a place of active learning and engagement with solar technologies. The Marketing and Educational Plan handles this objective by addressing each audience segment individually, always with the goal in mind of making Turkey Lake a world-class destination for solar.

4. Find Options That Are Interactive, Engaging and Creative for Each Phase of the Project
Throughout the research, the interaction of the public with the solar installation was a key element in selecting and designing the installations. The need to engage the project's various audiences prompted the use of the Community-Based Social Marketing framework discussed above. The messages and tools proposed in this plan were designed to maximize opportunities inherent in the previous three objectives: to showcase the FDOT and FTE as innovative organizations, to promote the rapid development of the solar industry in Florida and to develop Turkey Lake as a solar destination. All three are best accomplished by keeping this final objective in mind— by engaging the public in each phase of the project in the most interactive and creative ways imaginable.

Using these four objectives as guidance for the marketing and education campaign, a total of 15 different projects were identified to support the marketing and education objectives. These projects are described in *Chapter 6, Marketing and Education*.

ENERGY AND POWER TERMINOLOGY

It is important to understand the power and energy terminology used in the design and layout of the solar power system for the Turkey Lake Service Plaza.

Power units include watts (w), kilowatts (Kw), and megawatts (MW) and represent the instantaneous level of energy flowing through the system. One Kw is 1,000 watts and a MW is 1,000 Kw. The power output of a solar PV installation varies as the sun tracks across the sky and the angle of incident solar radiation on the solar panels changes. In order to have a uniform approach to rating solar systems, they are rated based on their maximum solar output which occurs under ideal conditions. A typical solar module may have a peak output of 160 watts which is written as 160 w_p. A typical solar array for a house may have a peak power output of 5 kilowatts which is written as 5 Kw_p. A large array of the size needed to power the Turkey Lake Service Plaza may be rated on the order of about 4 megawatts of peak power or 4 MW_p.

Consumers do not pay for power but they do pay a fee for the peak power used over the course of a month. This can be on the order of $10.00 per Kw at the peak and can result in substantial costs to the consumer. A solar PV array can minimize peak power charges because the peak normally occurs at the time of day when the output of the solar array is at its maximum. During the day excess energy is sent out to the electrical grid and in the evening this excess energy is taken back and used by the facilities.

Energy is simply the power multiplied by the time the power is used. One Kw of power used for one hour is one kilowatt-hour or Kwh. A Kwh is the unit of energy that is billed to consumers of electrical energy, generally ranging from $0.08 to about $0.30 per Kwh depending on the source of the electricity.

In sizing a solar array, the energy consumption profile of the facilities using the electrical energy must be known and the solar array is normally sized to meet some or all of the electrical energy requirements. For Turkey Lake Service Plaza, one of the scenarios, the Net Zero Energy scenario, describes a system sized to meet all the electricity needs of the Plaza, which was determine to be 3.8 MW_p (see Chapter 3). This size of system will generate all the electricity needed by the facilities on the Plaza over the course of a year. For Turkey Lake Service Plaza the annual electricity consumption is about 5.9 million Kwh (see Chapter 4). The 3.8 MW_p array designed for the Plaza will generate about 6.2 million Kwh, slightly more that needed to meet the annual electricity needs of the Plaza.

The electricity generated by PV arrays is direct-current (DC) electricity and it must usually be converted to alternating current (AC) electricity for use in buildings and for other purposes. The device that accomplishes this conversion is called an *inverter* because it takes the constant voltage DC power and converts it to a 60 cycle per second AC wave. Additionally a built-in synchronizer ensures that the AC wave from the PV system is in phase with the other electricity being used by the system.

Solar generated electricity is generally more costly than electricity as indicated in Table 1.1. These costs indicate the capital cost for a given size plant which is normally stated in Kw of peak power (Kw_p) and range from low for a gas turbine, to relatively expensive for solar PV power. It should be noted that although the cost of a unit Kwh of electricity corresponds roughly to the capital cost, but other factors come into play in the final price of electricity. Solar PV, although having a high capital cost, has no moving parts and is therefore very inexpensive to operate and maintain, potentially making PV power plants competitive with coal and nuclear power plants. Additionally both PV and wind energy are currently the beneficiaries of large government subsidies and tax breaks. They also have the added benefit of not contributing to climate change as they generate electricity and are pollution free in their operation, an enormous societal and environmental benefit. The financing options available for large scale solar power projects such as that proposed for the Turkey Lake Service Plaza are described in Chapter 4 of this report.

Technology	Cost in $ per Kw
Gas Turbine	$ 420
Wind	$1208
Coal fired power plant with scrubbers	$1290
Conventional hydroelectric	$1500
Biomass power plant	$1869
Nuclear power plant	$2081
Solar photovoltaic (PV)	$5370

Table 1.2 Installed costs for various electrical power options in cost per Kw of peak power (Kw_p). The solar PV costs shown are based on the Net Zero Energy scenario described in Chapter 3.

SUMMARY

This research project is a multidisciplinary effort to analyze the potential for the application of solar energy to the Turkey Lake Service Plaza. All available solar technologies were assessed in terms of applicability and cost for installation at Turkey Lake. Included in the technology assessment were solar PV systems, solar hot water technology, and electronic components, such as inverters for inverting and distributing the generated energy. Various tracking technologies that maintain the PV systems in an optimum orientation to the sun were evaluated for their technical and economic viability. Eight Phases of installation were used to guide the selection of technologies and the design of solar PV arrays. The eight Phases were evaluated in three major Scenarios (Maximum Energy, Net Zero Energy, and Showcase Energy) to assess the options for a solar PV installation at the Plaza. In addition to the technical evaluation of solar energy at the Plaza, financing options for the solar installations were analyzed, focusing on two major scenarios: FTE Ownership and Private Developer. Finally, in order to capitalize on the magnitude of the project and its central location in Florida, a marketing and education plan was developed to both bring the project to the attention of the general public and to accelerate the uptake of renewable energy in the State.

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CHAPTER 2
SOLAR TECHNOLOGY ASSESSMENT

The purpose of this chapter is to give an overview of solar technologies as they apply to the Turkey Lake Service Plaza on the Florida Turnpike. The technologies reviewed include all types of photovoltaic (PV) systems along with solar lighting, solar water heating, and electric energy storage systems. Three Excel spreadsheets and a MS Access file giving detailed information on the aforementioned technologies are provided as separate files. A summary is also provided as part of Appendix A.

BASIC INFORMATION

Solar energy can be converted into useful energy employing one of the following concepts: photovoltaic (PV) conversion, thermal conversion, and direct indoor lighting. For photovoltaic conversion, the smallest unit is a photovoltaic cell. A group of cells constitutes a module. A group of modules on the same mount constitutes a panel. A group of panels put together constitutes an array. Figure 2.1 is an illustration of the various available PV technologies. Figure 2.2 shows the distribution of PV start-up companies in the United States as of December 2007. Figure 2.3 shows greenhouse gas emissions of PV systems based on three silicon technologies compared to a number of other energy technologies (Suna et al., 2008).

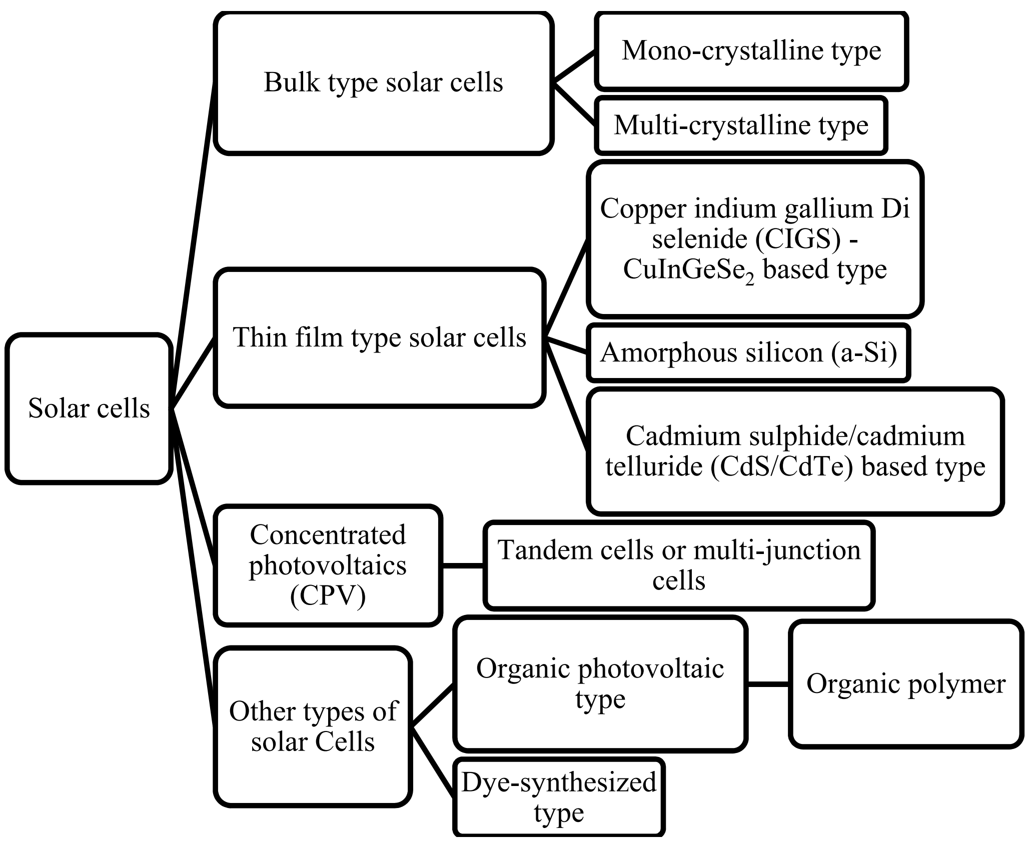

Figure 2.1 Available photovoltaic technologies

Figure 2.2 PV start-ups in the United States (courtesy Photon International, December 2007)

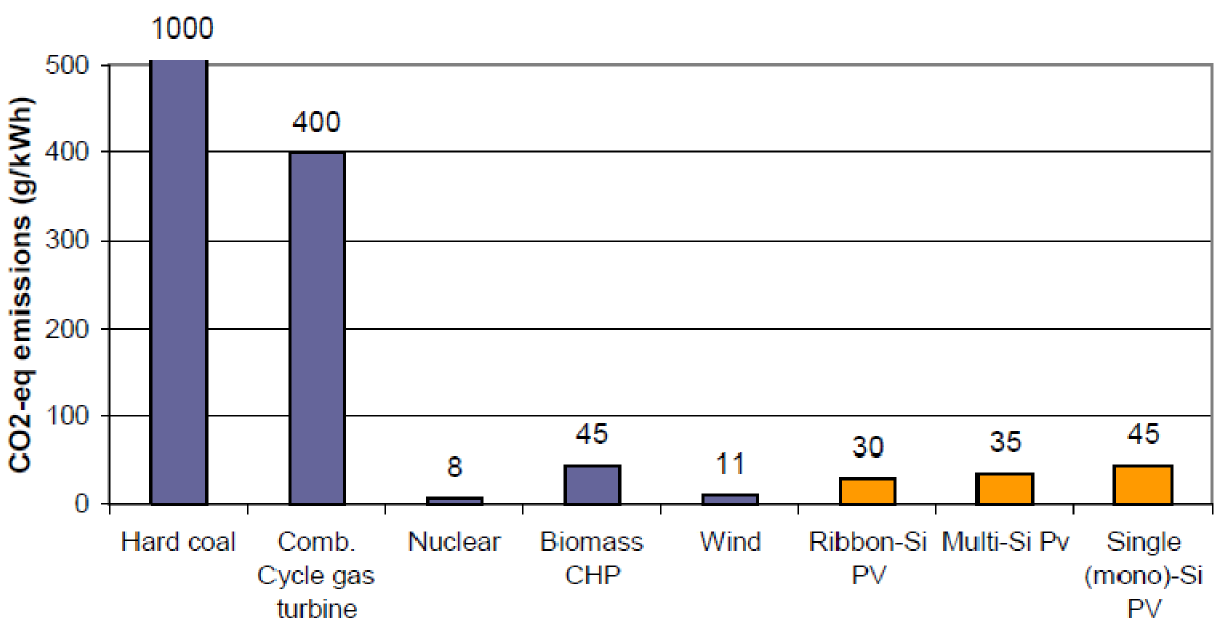

Figure 2.3 Greenhouse gas emissions of PV systems based on three silicon technologies compared to a number of other energy technologies (Suna et al., 2008)

Optical Performance
An anti-reflective (AR) coating of silicon nitride or titanium dioxide is typically applied on the cell. This ensures that a minimum amount of light is reflected off the surface of the cell, so reflection losses can be significantly reduced. Silicon nitride also has the effect of inactivating any crystal defects on the surface. This prevents charge carrier pairs from recombining. The anti-reflective coating causes the originally grey crystalline wafers to take on a blue (polycrystalline cells) or dark blue to black (mono-crystalline cells) coloring. With yield-optimizing anti-reflective coating, it is possible to create different color tones by varying the coating thickness. The colors are caused by the reflection of a different part of the spectrum of light in each case. Currently, the colors green, gold, brown and violet can be produced. However, the optical effect comes at the expense of lowering cell efficiency. It is also possible to leave out the AR coating completely and have the wafers in their original silver grey (polycrystalline cells) or dark grey (mono-crystalline cells). At the same time, it is accepted that up to 30 per cent of the sunlight will be reflected off the surface of the solar cell. ***The panels tilted at about 30^o above the horizontal will not reflect any light that would cause hazard to drivers.***

Electrical Performance Factors
The electrical performance of a solar cell is substantially reduced when conditions deviate from the standard conditions (STC 25°C for cell temperature, 1000 W/m^2 for the solar insolation, and 1.5 AM (air mass) defining Spectral distribution). The reduction in performance is attributable to the following effects:

1. **Angular Distribution of Light**. Because of the movement of the sun and the diffuse nature of radiation, light does not fall perpendicular to the module, as would be the case when laboratory measurements are performed to determine the nominal efficiency.

2. **Spectral Content of Light**. For the same power content, different spectra produce different cell photocurrents according to the spectral response. Furthermore, the solar spectrum varies with the sun's position, weather, pollution and other variables, and never exactly matches the AM 1.5 standard.

3. **Irradiance Level**. For a constant cell temperature, the efficiency of the module decreases with diminished irradiance levels. This is primarily due to the logarithmic dependence of open-circuit voltage on photocurrent. At very low illumination the efficiency loss is faster and less predictable.

4. **Cell Temperature**. The ambient temperature changes and, because of the thermal insulation provided by the encapsulation, light makes cells in the module heat up. Higher temperatures translate into reduced performance. This is usually the most significant performance degradation mechanism.

Quantifying Temperature Effect on PV Modules
As was mentioned earlier, most of PV modules are typically rated under conditions of 25°C module temperature and 1 kW/m^2 of solar irradiance. When operating in the field, the temperature is typically higher and the irradiance is somewhat lower than standard conditions.

The **Nominal Operating Cell Temperature (NOCT)** is defined as the temperature reached by open circuited cells in a module under the conditions listed below:

- Irradiance on cell surface is 800 W/m^2
- Air temperature is 20°C
- Wind speed is 1 m/s
- Mounting is open back (rear) side.

PV data sheets often cite a group of coefficients known as temperature coefficients. Out of the different coefficients in existence, three stand out as being most relevant to a system designer.

1. **Temperature Coefficient of Current (α)**. This is a positive number for solar cells. For example, the BP Solar SX 3200 Panel (bulk type crystalline Si) has this coefficient ranging from 0.050-0.080% per °C rise in temperature of the panel. This means that there will be a 0.050-0.080% increase in the current output with a degree rise in temperature of the panel above the **Nominal Operating Cell Temperature (NOCT)**.

The module short-circuit current is assumed strictly proportional to irradiance. It increases slightly with cell temperature (due to a decrease in band gap and an improvement of minority-carrier lifetime). The coefficient 'α' gives the relative current increment per degree Celsius. By combining both assumptions, the short-circuit current for arbitrary irradiance and cell temperature is calculated from the following equation:

$$\mathbf{I_{SC}\,(T_{cell}, G) = I_{SC}\,(STC) \times [G/1\ kW{\cdot}m^2] \times [1 + \alpha\,(T_{cell} - 25°C)]}$$

For crystalline Si cells, α is around 0.4% per degree Celsius.

2. **Temperature Coefficient of Voltage (β)**. This is a negative number for solar cells. For example, BP Solar SX 3200 Panel (bulk type crystalline Si) has this coefficient ranging from -101 mV to -121 mV per °C rise in temperature. This means that there will be a 101-121 mV decrease in the voltage output of the panel with a degree rise in temperature above the **NOCT**.

The open-circuit voltage strongly depends on temperature (the main influence is that of the intrinsic concentration), decreasing linearly with it. Knowledge of the coefficient, called β, allows the open-circuit voltage to be calculated from the following equation:

$$\mathbf{V_{OC}\,(T_{cell}, G) = V_{OC}\,(STC) - \beta\,(T_{cell} - 25°C)}$$

For crystalline-Si, β is around 2 mV/°C per series-connected cell.

3. **Temperature Coefficient of Power**. This is a negative number for solar cells. For example, BP Solar SX 3200 Panel (Bulk type crystalline Si) has this coefficient ranging from -0.45% to -0.55% per °C rise in temperature. This means that there will be a 0.45-0.55% decrease in the power output with a degree rise in temperature above the **NOCT**.

Several factors affect the variation of the maximum power (or equivalently the efficiency) with irradiance and temperature. The parameter 'γ' is defined as the relative decrease in module efficiency per degree Celsius of cell temperature increase. The efficiency **η** is given by the following equation:

$$\boldsymbol{\eta\ (T_{cell}, G) = \eta\ (STC) \times [1 - \gamma\ (T_{cell} - 25°C)]}$$

Usual γ values are in the vicinity of 0.5% per degree Celsius. Figure 2.4 shows typical efficiency values for different types of solar cells.

The best module operated at a **NOCT** of 33°C, the worst at 58°C and the typical module at 48°C respectively. An approximate expression for calculating the cell temperature (T_{cell}**)** is given by (Ross and Smokler, 1986):

$$\mathbf{T_{cell} = T_{air} + [(NOCT\text{-}20)/80]\ S}$$

Or

$\mathbf{T_{cell} = T_{air} + 0.35S}$ when the typical **NOCT** value of the PV module (i.e. 48°C) is considered.

S - solar irradiance in mW/cm^2
$\mathbf{T_{cell}}$ – temperature of the cell (°C)
$\mathbf{T_{air}}$ - temperature of the ambient air (°C)

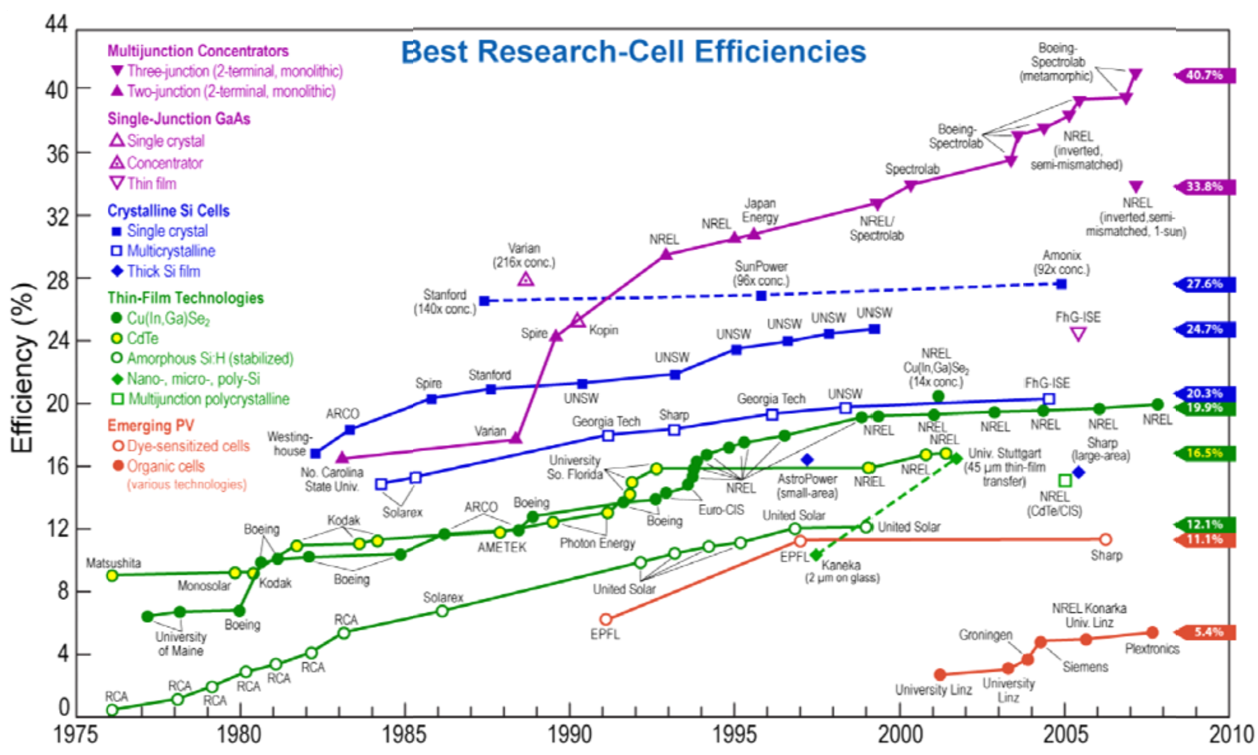

Figure 2.4 Comparison of efficiencies of various types of solar cells (Kazmerski, 2007)

Our aim is to keep the temperature difference **(T_{cell} -T_{air})** to a minimum possible value. A considerably good value can be in the range of 0-15°C. An inefficient value of the difference can be in the range of 20-45°C. A difference exceeding 45°C should be treated as a serious problem.

As seen from the above formula, there is a linear relationship between the temperature difference and solar irradiance. This means that the problem of cell heating should be taken more seriously in a high-insolation region like Florida. Since the climatic factors - 'Irradiance-**S**' and natural wind speed, our plausible rescue from serious damage to efficiency of the module is by reducing the NOCT value.

1. Measures such as using aluminum fins (aluminum finned substrate) at the rear of the module for cooling to help reduce the thermal resistance and increase the surface area for convection should be considered.

2. **Impact of Module Design on NOCT**. Module design (including module materials and packing density) has a major impact on the NOCT. For example, a rear surface with a lower packing density and reduced thermal resistance may impact the NOCT by a 5°C temperature difference or more.

3. **Impact of Mounting Conditions**. Both conductive and convective heat transfer are significantly affected by the mounting conditions of the PV module. A rear surface that cannot exchange heat with the ambient (i.e. a covered rear surface such as that directly mounted on a roof with no air gap), will effectively have an infinite rear thermal resistance. Similarly, convection in these conditions is limited to the convection from the front of the module. Roof-integrated mounting thus causes higher operating temperatures, often increasing the temperature of the modules by 10°C.

Figure 2.5 shows the relationship between the temperature difference and solar irradiance. The slope of the line is the **NOCT**.

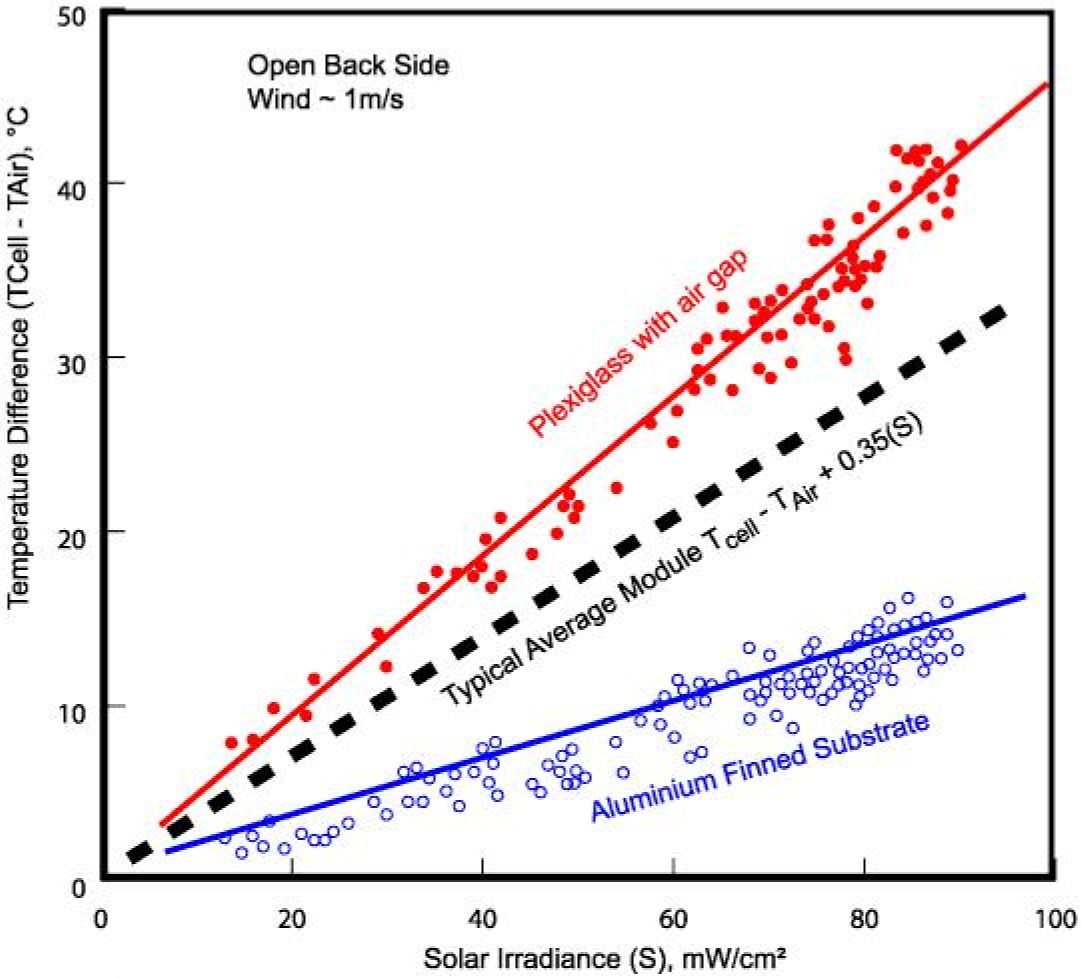

Figure 2.5 Slope of the straight lines represents the **NOCT** (Ross and Smokler, 1986)

For the region where the Turkey Lake Service Plaza is, the average insolation is 5.27 $kWh/m^2/day$, which is a reasonably higher end insolation value. The air temperature (T_{air}) in the region can reach 30-40°C in the summer. Thus, cell cooling should be seriously considered. Some of the above suggested solutions can work fairly well. Also, the manufacturers/installers typically provide their customized solutions to the problem of cell heating.

PV Market Growth and Trends in the USA

According to the "National Survey Report of PV Power Applications in the United States 2007," due to the higher prices of silicon and ramped up production, thin film manufacturers accounted for 30% of the total PV production in 2007. The total PV shipments in the United States reached 266 MW that year. The total PV installations increased by 42% from 144MW in 2006 to 205MW (ST-rated DC output) in 2007. Most of this growth occurred in grid-connected PV installations whose toll rose from 106 MW in 2006 to 148 MW (STC-rated DC output) in 2007. Table 2.1 is drawn from Poole et al. (2007) and shows the evolution of module price history from 1994-2007 in US $/Watt$_{ac}$. These prices were estimated by PV Energy Systems.

Year	1994	1995	1996	1997	1998	1999	2000
Module Price ($/Watt)	4.00	3.75	4.00	4.15	4.00	3.50	3.75
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Module Price ($/Watt)	3.50	3.25	3.00	3.50	3.60	3.75	3.75

Table 2.1 Typical Single-Crystalline and Multi-Crystalline Silicon Module Prices in US$/Watt$_{ac}$

Category/Size	Typical Applications	US $/Watt*
Off-grid up to 1 kW	Telecom, signals, lighting, highway signs, navigation aids, irrigation, cottages, etc.	10–20 depending on storage and remoteness
Off-grid >1 kW	Telecom, homes, farms, irrigation, signals, government sites, parks	10–20
Grid-connected specific case	2-5 kW roof-mounted system	7–9
Grid-connected up to 10 kW	Homes, business, schools, parking, irrigation	7–8
Grid-connected >10 kW	Government buildings, warehouses, renewable power set asides-utilities, commercial buildings	5.5–7.5

Table 2.2 Turnkey Prices of Typical Applications 2007

Table 2.2 provides turnkey prices of typical applications in 2007. Prices do not reflect add-on costs for warrantees, service contracts, and training. Additional energy storage for uninterruptible power would also increase costs.

CLASSIFICATION OF PV TECHNOLOGIES

Bulk Mono-Crystalline Solar Cells

Typical panels are generally made of a mono-crystalline Si material (also called c-Si). They have cell efficiencies between 15-20%. Manufacturers include Sanyo, BP SOLAR, Suntech Power, Sun Power, and DMsolar (see Figure 2.6).

Power Output. The power generated per panel is usually well over 200 Watts. Some companies even claim higher as much as 300-315 Watts for larger area panels. Depending on the power generated by the module, the size varies. Typically the module area ranges from 12-18 ft^2. The Wattage/ft^2 is a good decision parameter, with a value between 13-14 Watts/ft^2 or higher being considered attractive.

Cost. The initial investment cost for the panels is around 3-$3.5/Watt on average. It should be noted that this is the price of the PV panels only. It does not include other costs such as installation, electrical wiring, tracking, or mounts.

Figure 2.6 Bulk type mono-crystalline PV module
(Courtesy: http://www.lowcarboneconomy.com/Resources/UserImages/gb-sol-photovoltaic2320x320.jpg)

Weight Factor. The average weight is around 0.19 lbs/Watt. The available weight of the panels in the current market ranges from 30-50 lbs, with a typical value of about 40 lbs. This makes them attractive for applications involving both ground- and roof-mounted systems.

Electrical Specifications. Depending on the power output (Watts), the voltage generated by the panels usually falls in the range of 25-55V, while the current generated is in the range of 5-8A. However, there are occasional exceptions for both voltage and current being above or below the ranges given above.

Temperature Effects. The average power loss with respect to cell temperature rise is around 0.3-0.5 %/°C above the **NOCT** whose typical value ranges from 45-50°C. Similarly, the voltage drop associated with the panels is around 0.110-0.175V/°C above the **NOCT**. There is negligible rise in current with respect to a change in temperature, with the value often falling in the range of 1-4 mA/°C.

Warranty and Certifications. Most companies offer 20-25 years of limited power warranty. Also, UL 1703, TUV, CE, IEC-61215 approvals and certifications are considered standard, with most companies claiming that these increase the credibility of their product.

Advantages and Disadvantages

- Cell efficiencies are high enough and thereby produce better power output.

- The cost of the panels has bottomed out. Further cost reduction seems unlikely in the near future.
- Since they are primarily silicon based, the environmental effects due to Si waste are small, unlike some toxic components in thin film technology.

Bulk Multi-Crystalline Solar Cells
The panels are generally made of a multi-crystalline Si material (also called polycrystalline Si or mc-Si). They have a good cell efficiency ranging from 12-15%. Bulk multi-crystalline panel manufacturers include Bright Watts Inc., DMsolar, Sharp, GE, and Suntech Power (see Figure 2.7).

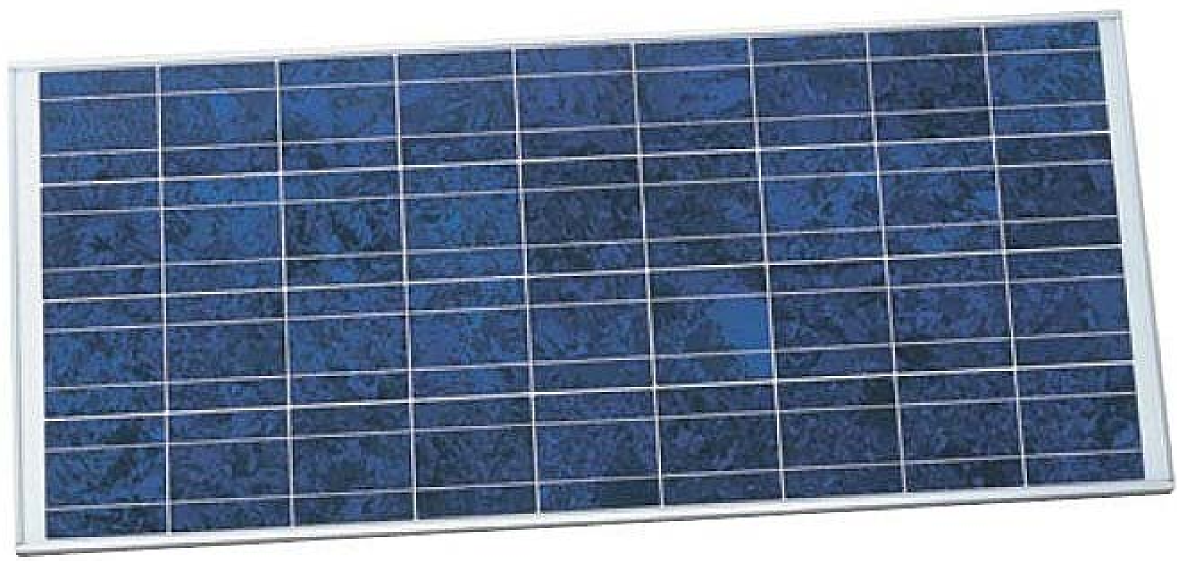

Figure 2.7 Bulk type polycrystalline PV module
(Courtesy: http://www.archiexpo.com/prod/sharp-solar/polycrystalline-photovoltaic-module-9667-18053.html)

Power Output. The power generated by the panels is usually well over 200 Watts. Some companies even claim values as high as 260-270 Watts for larger area panels. Depending on the power generated by the module, the size varies. Typically the module area is in the 15-20ft^2 range. The Watts/ft^2 is a good decision parameter, with 12-13 Watts/ft^2 or higher being a good value to shoot for.

Cost. The initial investment cost for the panels is around 3-$4/Watt on an average. It should be noted that this is the price of the PV panels only. It does not include other costs such as installation, electrical wiring, tracking, or mounts.

Weight Factor. The average weight is around 0.21 lbs/Watt. The available weight of the panels in the current market ranges from 40-60 lbs, with a typical value of about 40 lbs. This makes them attractive for applications involving both ground- and roof-mounted systems.

Electrical Specifications. Depending on the power output (Watts), the voltage generated by the panels usually falls in the range of 25-35V, while the current generated is in the range of 7-8A. However, there are occasional exceptions for both voltage and current being above or below the ranges given above.

Temperature Effects. The average power loss with respect to cell temperature rise is around 0.5 %/°C above the **NOCT** whose typical value ranges from 45-50°C. Similarly, the voltage drop associated with the panels is around 0.10-0.12V/°C above the **NOCT**. There is negligible rise in current with respect to a change in temperature, with the value often falling in the range of 4-6 mA/°C.

Warranty and Certifications. Most companies offer 20-25 years of limited power warranty. Also, UL 1703, TUV, CE, IEC-61215 approvals and certifications are considered standard, with most companies claiming that these increase the credibility of their product.

Advantages and Disadvantages

- Cell efficiencies are high enough and thereby produce better power output.
- The cost of the panels has bottomed out. Further cost reduction seems unlikely in the near future.
- Since they are primarily silicon based, the environmental effects due to Si waste are small, unlike some toxic components in thin film technology.

Thin Film Solar Cells

Thin film solar cells are generally produced from three types of materials (see Figures 2.8, 2.9, and 2.10). The materials all show promise versus those used in other cells. One key metric for solar materials is its conversion efficiency, which represents how much of the sun's energy the material can convert into electricity. Copper indium gallium selenide (CIGS) has demonstrated the highest thin film lab efficiency, and is widely seen as the most promising of thin film solar semiconductors. CIGS' lab efficiencies (19.9%) approach those of expensive silicon, and can be produced in high volume at low cost. Table 2.3 shows the different materials used in thin film solar cells and their laboratory cell efficiency. Thin film manufacturers include Kaneka Solar, EPV Solar, DMsolar, Uni-Solar, Solyndra, XsunX, Signet Solar, First Solar, Canrom Photovoltaics, and Xunlight. Table 2.4 gives a more complete listing of thin film companies in the United States.

Thin Films Material	Highest Laboratory Cell Efficiency
Amorphous Silicon Triple Junction (a-Si)	12.3%
Cadmium Telluride (CdTe)	16.5%
Copper Indium Gallium Selenide (CIGS)	19.9%

Table 2.3 Materials used in Thin Film Solar Cells

Efficiency and Power. The conversion efficiency is comparatively low and of the order of 10-12%. Nevertheless, the panels perform better in higher temperature climates than those of other technologies. The power generated by the panels is usually between 40-140 Watts. However some companies claim values as high as 200-300 Watts for larger area panels. Depending on the power generated by the module, the size varies. Typically the module area is in the 5-25ft^2 range, although there are some in the 50-60 ft^2 range. The Watts/ft^2 is a good decision parameter, with 7.5 Watts/ft^2 or higher being a good value to shoot for.

Cost. The initial investment cost for the panels is around 3-$4/Watt on an average. It should be noted that this is the price of the PV panels only. It does not include other costs such as installation, electrical wiring, tracking, or mounts. Due to the current economic downturn, the prices of thin film PV have come down to as low as 1.75-$2/Watt.

Electrical Specifications. Depending on the power output (Watts), the voltage generated by the panels usually falls in the range of 40-80V, while the current generated is in the range of 2-4A. However, there are occasional exceptions for both voltage and current being above or below the ranges given above.

Temperature Effects. The average power loss with respect to cell temperature rise is around 0.20-0.25 %/°C above the **NOCT** whose typical value ranges from 45-50°C. Similarly, the voltage drop associated with the panels is around 0.2-0.3%/°C. Although, there is negligible rise in current with respect to a change in temperature, the value is sometimes as significant as 0.1%/°C. Usually, the value is towards the lower end and close to 0.02-0.04 %/°C.

Warranty and Certifications. Most companies offer 20-25 years of limited power warranty. Most of the time, 80% of the power output is guaranteed over that period and 90% is guaranteed over a 10-12 year period. IEC certifications such as IEC 61646, IEC 61730, and UL1703, as well as CE Mark are quite often accepted as a standard of high quality panels, with most companies claiming that these increase the credibility of their product.

Figure 2.8 Thin film PV module: Copper Indium Gallium di-Selenide (CIGS - $CuInGeSe_2$) type (Courtesy: http://www.greentechmedia.com/wp-content//uploads/2009/02/tf-global-solar.jpg)

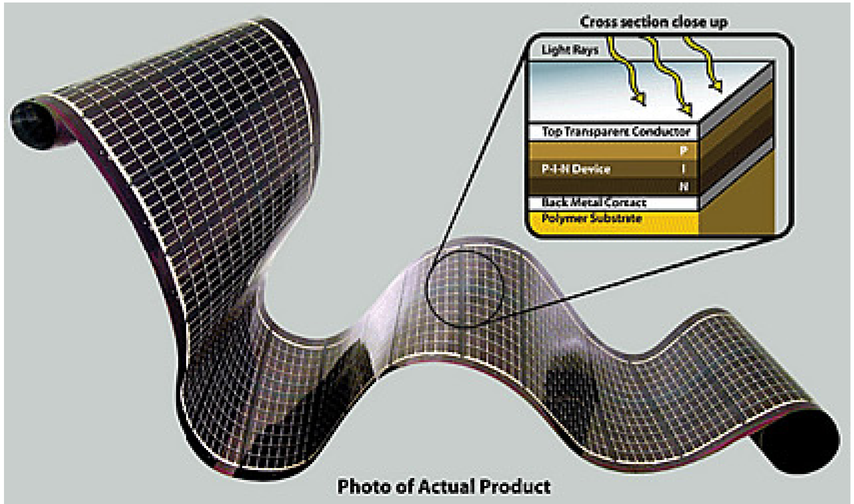

Figure 2.9 Thin film PV module: a-Si type
(Courtesy: http://www.solarstik.com/images/powerfilm-flexible-solar-panels-2.jpg)

Figure 2.10 Thin film PV module: cadmium telluride (CdTe) type
(Courtesy: http://www.pv-tech.org/images/uploads/solarcity/solarcity_fslrmodules.jpg)

Advantages and Disadvantages

- Cell efficiencies are comparatively low.
- Panels have better performance under low irradiance conditions and in hotter climates.
- The laminate production method contributes to cost reduction because expensive silicon and mounting racks are not required.

Applicability to Project Phases. This technology seems to fit Phase 2 of the project because of the lighter weight of thin film panels. These panels are typically glued straight onto the roof, with no need to penetrate the roof. This would ensure that the roof warranty is not voided. Mounting racks on the roof typically requires punching holes in it, thus taking a chance on voiding the warranty.

a-Si	CdTe	CIGS
Uni-Solar, MI	First Solar, OH	Global Solar, AZ
Applied Materials, CA	Primestar Solar, CO	Miasole, CA
Power Films, IA	AVA Solar, CO	Energy PV, NJ
Energy PV, NJ	Solar Fields, OH	Ascent Solar, CO
MV Systems, CO	Canrom, NY	ISET, CA
XsunX, CA	Ascentool, CA	ITN/ES, CO
OptiSolar, CA	Nuvo Solar Energy, CO	Daystar, NY
Signet Solar, CA	Zia Watt Solar, TX	Nanosolar, CA
Nano PV, NJ		Heliovolt, TX
MWOE Solar, OH		Solo Power, CA
Solexant, CA		Solyndra, CA
Proto Flex, CO		RESI, NJ
New Solar ventures, NM		Light Solar, NV
Innovalight, CA		Dow Chemicals, MI
Nanogram, CA		Stion, CA
Soltaix, CA		

Table 2.4 Thin Film PV Companies in the United States (Ullal and von Roedern, 2007)

Concentrated Photovoltaics (CPV)

CPV cells are typically manufactured from high efficiency III-V multi-junction material like Ge-GaAs or Ge-GaAs-GaInP. Sometimes, they use single junction mono-crystalline silicon for low-to-medium concentration cells. They are classified into three categories based on their concentration:

1. Low concentration CPV where the magnification ratio is less than 10X
2. Medium concentration CPV where the magnification ratio is between 10-100X
3. High concentration CPV where the magnification ratio is above 100X, but less than 1000X.

There are two main types of concentrating optical systems in use today:

1. Refractive that use Fresnel lenses, and
2. Reflective that use one or more mirrors.

Regardless of the chosen optical system, the result is concentrated sunlight being aimed at the sensitive face of the cell, to produce more energy from less photovoltaic materials.

Concentrating photovoltaics (CPV) manufacturers include Solar Systems, Energy Innovations, Soliant Energy, Amonix, Pyron Solar, Sol3g, Zytech Solar, and Arima Eco Energy.

Efficiency and Power. The conversion efficiency is comparatively very high and of the order of 22-35%. The downside is that the cells are costly for regular applications. CPV systems are thus better suited for locations where high solar insolation is expected. Efficiency projections through 2009 as reported by Spectrolab, Inc., are given in Figure 2.11. The power generated by the panels range from 1 to several kWs. The larger the system size, the higher the power output. Some companies manufacture larger systems (35-90 kW). Depending on the power generated by the module, the size varies. Typically, the area ranges between 10-70 ft^2, with some as high as 260-1900 ft^2 and others as low as 2.5 ft^2. The Watts/ft^2 is a good decision parameter, with 10-20 Watts/ft^2 or higher being a good value to shoot for. Market research suggests that there is a fairly even distribution of the Watts/ft^2 for different panels, with most in the 10-15 Watts/ft^2 range. Figure 2.12 shows a typical multi-junction solar cell.

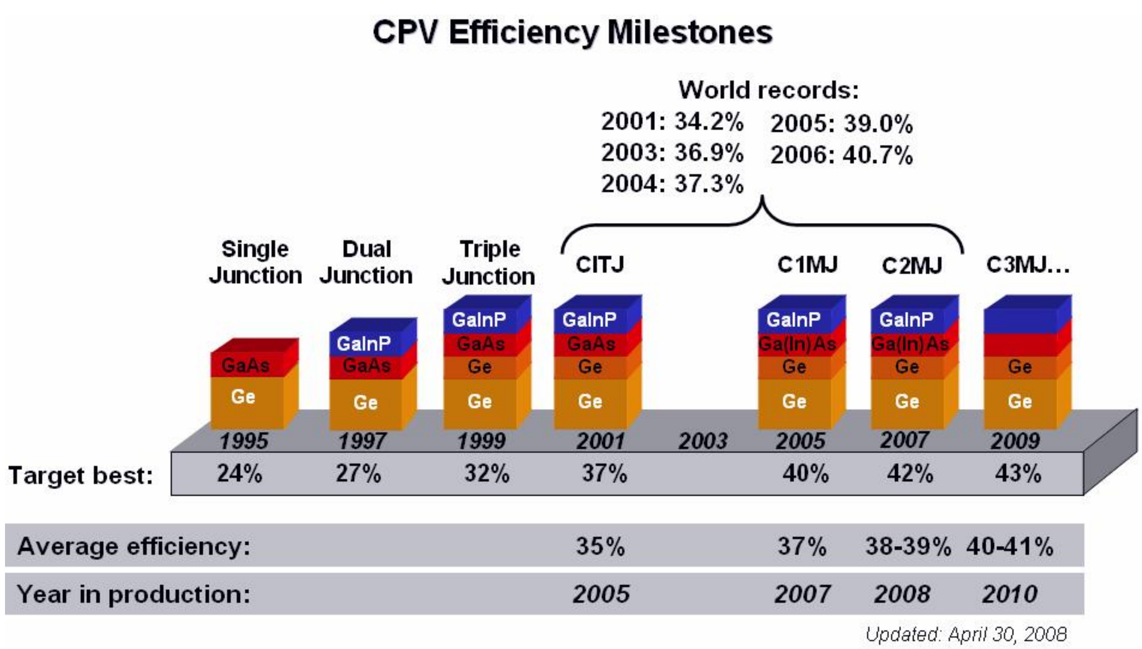

Figure 2.11 CPV efficiency milestones (courtesy of Spectrolab: (http://www.spectrolab.com/prd/terres/q4.asp)

Figure 2.12 Multi-junction solar cell
(http://www.blogcdn.com/green.autoblog.com/media/2007/06/40-percent-solarcell.jpg)

Electrical Specifications. Depending on the power output (Watts), the voltage generated by the panels usually falls in the range of 17-26V, while the current generated is in the range of 6-7A. However, there are occasional exceptions for both voltage and current being above or below the ranges given above.

Temperature Effects. The average power loss with respect to cell temperature rise is around 0.01-0.46%/K above the **NOCT** whose typical value ranges from 45-50°C. The higher end value is associated with a Si based cell material and the lower power loss factor with respect to temperature is associated with triple junction tandem cells. Similarly, the voltage drop associated with the panels is around 0.16 %/°C. There is negligible rise in current with respect to a change in temperature, with the value often falling in the range of 4-7 mA/K. Figure 2.13 displays a comparison between the performance of CPV and Si-based PV of same rated power at different temperatures.

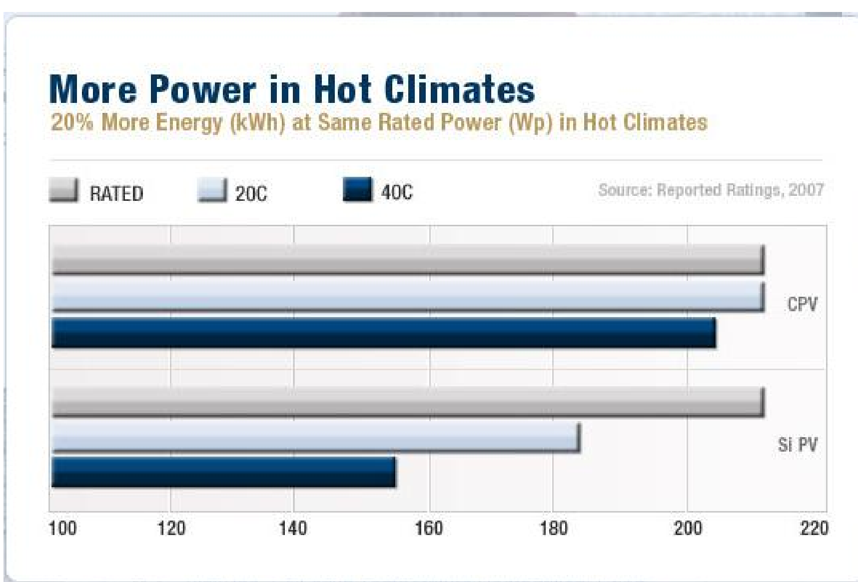

Figure 2.13 Performance of CPV and Si-based PV of same rated power at different temperatures
(courtesy of SolFocus: http://www.solfocus.com/en/images/solutions/hot_climates_chart.jpg)

Tracking. Dual-axis tracking systems are most often used with CPV in order to maximize benefit out of the inherently high cell efficiency and concentrating mechanisms. Trackers usually operate within +/- 0.5^o of tracking accuracy.

Weight Factor. CPV systems are heavier than their counterparts such as thick film or thin film. The average weight of CPV panels is 0.33 lbs/Watt of peak power. This inherent disadvantage renders CPV systems relatively un-attractive for rooftop applications.

Organic Photovoltaics (OPV)
Efficiency and Power. The conversion efficiency is very low and of the order of 5%. The power generated by the panels is usually between 0.25-26 Watts. Depending on the power generated by the module, the size varies (see Figure 2.14 and 2.15). Typically the module area is in the 0.2-17 ft^2 range. The Watts/ft^2 is substantially lower than that of other PV technologies with values of 1.56 Watts/ft^2 or lower. OPV companies include Solarmer and Konarka. Figure 2.16 shows OPV technology in flexible/non-rigid structural applications as provided by Konarka.

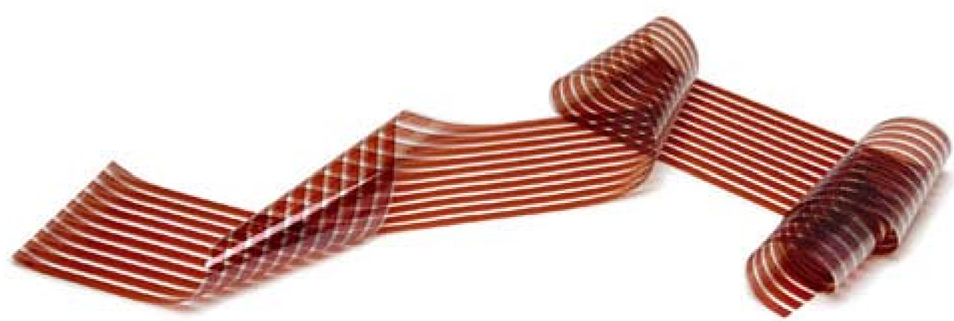

Figure 2.14 Organic photovoltaics
(Courtesy: http://www.azom.com/images/Article_Images/ImageForArticle_4528%283%29.jpg)

Electrical Specifications. Depending on the power output (Watts), the voltage generated by the panels usually falls in the range of 4-16V, while the current generated is in the range of 0.05-1.6A.

Temperature Effects. The average power loss with respect to cell temperature rise is around 0.05%/^{o}C above the **NOCT** whose typical value ranges from 45-50°C. Similarly, the voltage drop associated with the panels is around 0.27%/°C. Although, there is a small rise in current with respect to a change in temperature, its value is negligible.

Advantages and Disadvantages

- Ability to operate in high temperature and low irradiance environments.

- Low efficiency (around 5%) compared to 15% for typical PV technology.

- Many factors affect the stability and life time of OPV panels. This includes the operating temperature, light intensity, photochemistry, photo oxidation, and chemical reactions between the electrodes and the various constituents of the layers in the photovoltaic device. Performance degradation is expected every 500-1000 hours of operation.

Figure 2.15 Dye synthesized solar cells
(Courtesy: http://3gsolar.com/images/anode_plate.jpg)

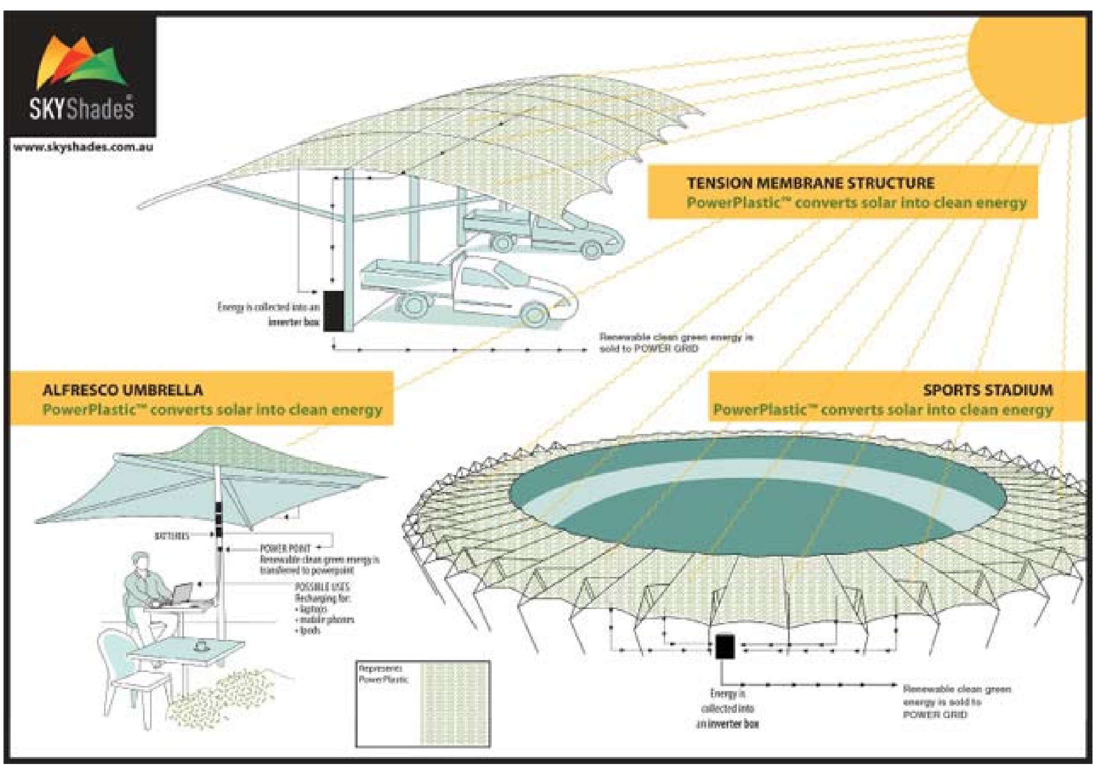

Figure 2.16 Application of OPV technology in flexible/non-rigid structural applications
(Courtesy http://www.konarka.com)

AUXILIARY COMPONENTS OF A PV SYSTEM

Inverters

Inverters convert direct current (DC) into alternating current (AC). DC has a current flow in only one direction, while AC rapidly switches the direction of current flow back and forth. Typical AC in the United States is 60 cycles per second (60 Hz). Each cycle includes the movement of current first one way, then the other. This means that the direction of current flow actually changes 120 times per second (see Figure 2.17).

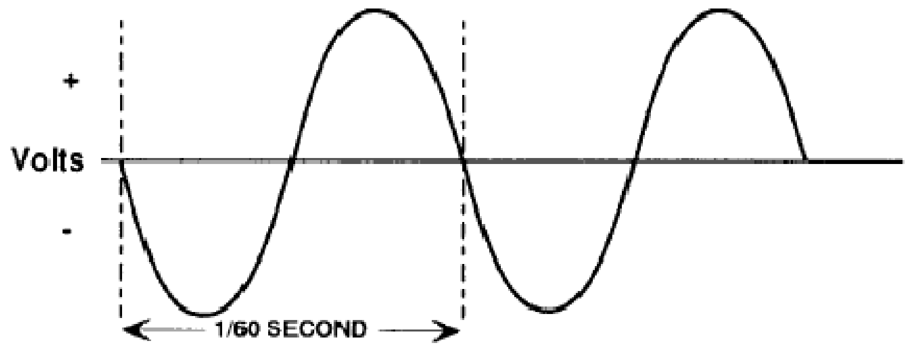

Figure 2.17 Alternating current (AC) flow and typical wave form; there are other types of wave forms like square waves, modified sine waves, etc.

Peak inverter efficiencies are in the range of 96-97%, while CEC-weighted efficiencies are in the range 95-96%. The California Energy Commission (CEC) posts specifications for hundreds of inverters that have been approved by certified testing facilities. Approval from the CEC is a stamp of certification of the quality of the Inverter based on laboratory tests. The term "weighted" here refers to time-averaged at different loads for different time intervals. On a whole if the inverter operates at different loads than the rated condition, the inverter performance can be better estimated using the weighted efficiency. The operating temperature range of the inverters is usually between -13 and 113^{o}F. So it is always recommended to operate the inverters under shaded protection from direct sunshine.

The maximum AC power output ranges from 3000-7000 Watts. The maximum DC voltage that most inverters can handle is from 500-600 V, while the AC voltage ranges from 180-305 V. Depending on the voltage value, the output AC current value is in the 13-34 A range. The nominal power factor is usually greater than 0.9.

Most of the inverters available on the market are warranted for 10 years. They also comply with technical standards IEEE-929, IEEE-1547, UL 1741, UL 1998 and FCC Parts 15A and B.

Mounts

Roof Mounts. This is the most cost effective and common type of installation for residential, commercial and industrial applications. An array of solar panels is to be placed on the roof of the property. In most cases this array is to be attached directly to the structural members of the building. The attachments must be sufficiently robust to withstand wind loading. Solar panels are typically mounted to aluminum or galvanized steel support structures. For some commercial and flat-roof applications the solar modules are installed without penetrating the roof. Roof installations are typically light weight and usually add less than 4 lb/ft^2 to the roof load. Virtually all residential and commercial roofs are able to support the additional load without the need for structural modifications.

Ground Mounts. As the name suggests, it is a mount used to support solar panels on the ground. The most common type of ground mounts is a wedge structure constructed from steel supports anchored in concrete footings. The remainder of the structure is built from aluminum or galvanized steel.

Pole Mounts. This is another type of a ground-mounted array. In this case an array is mounted on top of a single steel pole. It has the advantage of being manually adjustable, so that the system owner can change the pitch of the array at different times during the year.

Mounts manufacturers include Quick Mount, Prosolar, Sunwize, Uni-rac, Canrom, Power-Fab, and Sun Power. For additional information, the following site may be consulted: http://www.borregosolar.com/solar-power-systems/types.php

Tracking Systems

It is believed that tracking will increase the power output of PV panels by about 30-50%. Tracking systems are primarily classified into three types depending on the type of drive the tracking system uses (see Figures 2.18 and 2.19 for the cost of electricity generated with and without tracking systems, and Figure 2.20 for classification of tracking systems).

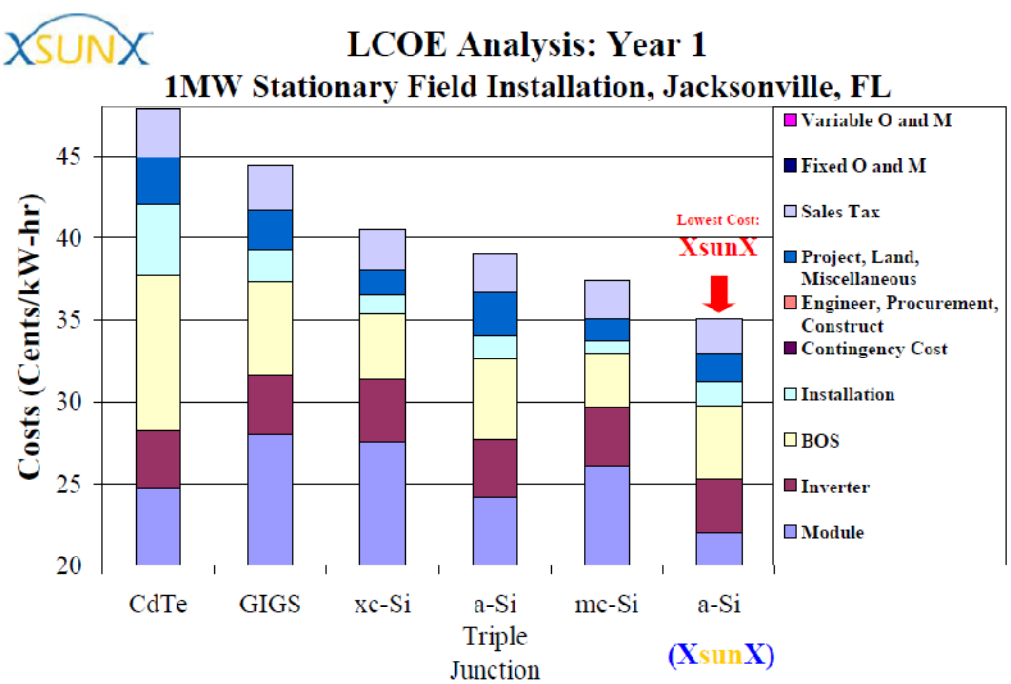

Figure 2.18 Solar Advisor model results for Jacksonville, Florida, for non-tracking PV
*BOS- Balance of System

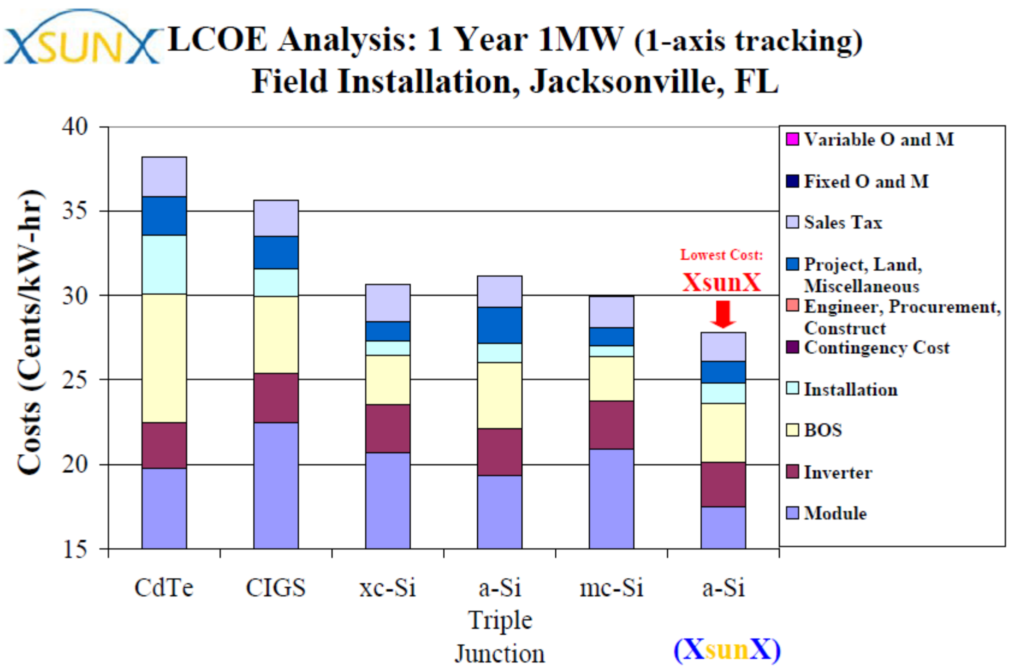

Figure 2.19 Solar Advisor model results for Jacksonville, Florida, for tracking PV
*BOS- Balance of System

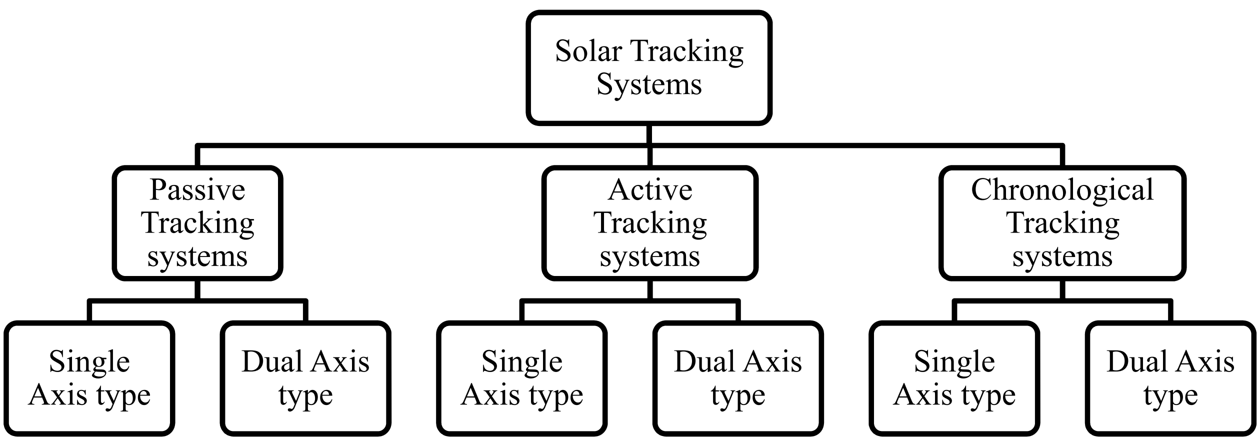

Figure 2.20 Classification of solar trackers

1. **Active Trackers**. These use a solar direction-responsive feedback control that directs the motors and thereby the gear trains of the tracker. The feedback loop comprises two light sensing devices (photosensors) such as photodiodes that generate an output pulse when there is a flux difference in the sunlight received. Depending on that difference, the feedback control activates the motor and re-orients the whole system in the direction of the Sun. Most trackers embed an intelligent feedback mechanism that would prevent

response to changes in the flux on the photosensors if light intensity falls below a threshold that renders operating the motor no longer profitable. A cloudy phase of a day is a good example where the benefit of tracking is exceeded by the electric cost of operating of the motor.

2. **Passive Trackers**. These use a low boiling point compressed gas driven to one side or the other (by the solar heat creating gas pressure) to cause the tracker to move in response to an imbalance. The precision with which this system tracks the Sun is less than that of an active system. Because of this inherent disadvantage it cannot be used for high precision solar tracking applications like CPV, hybrid solar lighting (HSL), etc. These are also relatively cheaper compared to active and chronological tracking systems.

3. **Chronological/Astronomical Trackers**. These counter the rotation of the Earth by turning in an opposite direction of its rotation with the same angular velocity of the Earth (15^{o}/hour). Knowing the time chronological position of the Sun using astronomical data, electronic control can be used to control the movement of such trackers. They are very accurate and can track the Sun to an accuracy of 0.5°.

4. **GPS-Controlled Trackers**. These use Global Positioning System (GPS) technology to find the position of the Sun and then adjust the tracker to that position.

Depending on the number of directions in which the Sun's path is followed, the trackers are classified into:

Single-axis trackers can either have a horizontal or a vertical axle. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but days can be very long. A horizontal-axis tracker consists of a long horizontal tube to which solar modules are attached. This tube is aligned in a north-south direction, is supported on bearings mounted on pylons or frames, and rotates slowly on its axis to follow the sun's motion across the sky.

Double-axis trackers have both a horizontal and a vertical axle and can track the Sun's apparent motion exactly anywhere in the World. This type of trackers is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the Sun across the sky.

As far as maintenance of trackers is concerned, seasonal adjustment like Sun synchronizing may be needed. Annual inspection and lubrication of moving parts improves their performance. In highly corrosive environments metal parts (most often mild steel) of the tracking system needs to be protected by anti-corrosive measures like paint coating. Hurricane proofing is an important issue in dealing with tracking systems. Usually most of the trackers available on the market can withstand wind loads of 130-150 km/h.

Companies that manufacture tracking systems include Wattsun Trackers, Zomeworks, Ray Trackers, Sun Power, DH Solar.

OPERATION AND MAINTENANCE OF PV PANELS

1. The most common maintenance task for solar modules is the cleaning of the glass area of the module to remove excessive dirt. PV arrays require no care other than occasional cleaning of the surfaces if they become soiled or dusty on the top surface. In most situations cleaning is only necessary during long dry periods when there is no rain to provide natural cleaning. To remove a layer of dust and dirt from the modules, simple wash of the panel with water works well. If the module has thick dirt or grime, which is harder to remove, warm water wash and a sponge will do the job. Washing the modules is similar to washing glass windows but detergents should not be used.

2. Visual inspection for defects such as broken or cracked glass covers, solar cell discoloration, bolts rusting, etc., should be routinely performed. The mounting frame should be manually checked to ensure for firmly secured mounting. All these inspection tasks should be recorded on a maintenance log sheet.

3. PV panels must be kept clear of snow, weeds, and other sources of shading to operate properly. Since the cells are connected in series, shading on even one cell in a module will appreciably decrease the output of the entire module.

4. The inverter should be checked for functioning correctly by observing LED indicators, metering and/or other displays on the inverter.

Ideally, maintenance operations are performed twice a year. The best times are in the spring and fall, before the weather extremes of summer and winter start. If maintenance is only possible once a year, it should be scheduled for fall. The system must be brought to top condition before the colder temperatures and reduced sunlight levels of winter place added demands on the system. In addition, some sites may be nearly inaccessible during the winter.

ELECTROCHEMICAL STORAGE OF GENERATED ELECTRICITY

Although there are various energy storage techniques such as capacitor storage, supra-conducting coils, medium and high speed flywheels, compressed air storage, and pumped water storage, electrochemical storage is considered one of the most promising ways to store solar energy.

An electrochemical storage system is based on the conversion of chemical energy into electrical energy and vice versa. The amount of energy that can be stored in a cell is determined by the different energy content of chemical substances that represent the charged and discharged states. Typically, all stand-alone and some grid-connected systems use battery storage. The typical size of a storage battery bank is 3-10 times the daily energy demand of the load.

Battery systems in which storage of electrical energy is done in the active mass of electrodes of the electrochemical cells are known as systems with internal storage (see Figure 2.21). The weight of these systems is directly proportional to the power storage capacity. The construction of these systems is relatively simple. Table 2.5 shows some typical examples of systems with internal storage.

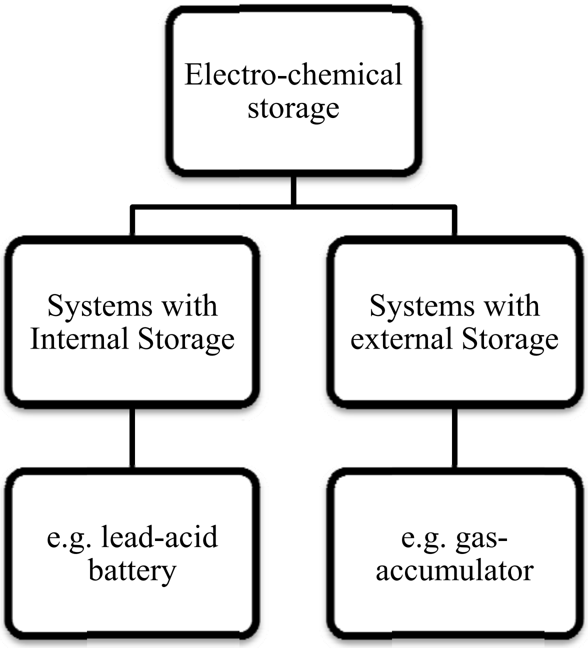

Figure 2.21 Classification of electrochemical storage systems

Gas accumulators are examples of external storage systems (see Figure 2.21). They consist of a water electrolyzer, a hydrogen storage tank, and a fuel Cell. The best storage efficiency of such systems is around 35%, which is far lower when compared to those with internal storage. It is evident that external storage systems are still in the demonstration stage.

Commonly used batteries constitute nearly all variations of the lead-acid type. These are sometimes referred to as “deep cycle” or "deep discharge" or "deep cell" batteries. Typical efficiencies of batteries are 85-95% for lead-acid and 65% for alkaline and NiCad. Efficiencies of true deep cycle AGMs (Absorbent Glass Mats) such as Concorde and Deka can approach 98%. An AGM battery is one where the electrolyte is absorbed into a mat of fine glass fibers. It is a sealed type of battery construction where there is no electrolyte leakage. Being thus non-hazardous, AGM batteries are cheaper to ship. Additionally, since there's no liquid to freeze and expand, they're practically immune from freezing damage. AGMs cost 2-3 times as much as flooded batteries of the same capacity.

Battery Type	**Specific Energy**	**Specific Power**	**Lifetime**	**Cost**
Lead-acid	25-35 Wh/kg	70-100 W/kg	250-750 cycles	50 Euro/kWh
Nickel-metal hydride	65-75 Wh/kg	120-150 W/kg	700 cycles	>600 Euro/kWh
Li systems	100-150 Wh/kg	150-250 W/kg	1000 cycles	>600 Euro/kWh

Table 2.5 Examples of Systems with Internal Storage

Practically all batteries used in PV and all but the smallest backup systems are lead-acid batteries as they offer the best price to power ratio. Some systems use NiCad, but they are not recommended except in cases where extremely cold temperatures (-50^{o}F or less) are common. They are expensive to buy and very expensive to dispose of due the hazardous nature of Cadmium.

Good practices to prolong battery life include the following:

- Store and operate batteries in a cool and dry place. For every 10°C (18°F) rise above room temperature (25°C or 77°F), battery life decreases by 50%.
- Charge batteries fully after each period of use. Allowing batteries to sit in a low state of charge for extended periods will decrease their capacity and life.
- When storing batteries for an extended period of time, they should be charged fully every 3-6 months. Lead acid batteries will self-discharge 5-15% per month, depending on the temperature and storage conditions.
- Monitor battery voltage and specific gravity of the electrolyte regularly to verify full recharging. As a general rule of thumb, the total amperage from the PV panels should be calibrated to fall between 10-20% of the total amp-hours (Ah) of the battery pack.
- Many charge controllers have equalization settings that can be adjusted to help improve battery health. It is recommended that batteries be equalized at least once a month for 2-4 hours, and for longer periods if they have been consistently undercharged.

Manufacturers of batteries for PV applications include U.S Battery, Crown Battery, Trojan Battery, Exide Battery, Surrette Battery, and Concorde Battery (Sunxtender). For additional information on thermochemical storage, the reader may consult Sauer (2003), Jossen et al. (2004) and the following web site: http://www.trojanbattery.com/Tech-Support/tips.aspx

SOLAR WATER HEATING

General Information

Solar water-heating systems for buildings have two main parts: (1) a solar collector and (2) a storage tank. The most common collector used in solar hot water systems is the flat-plate collector (see Figures 2.22 and 2.23).

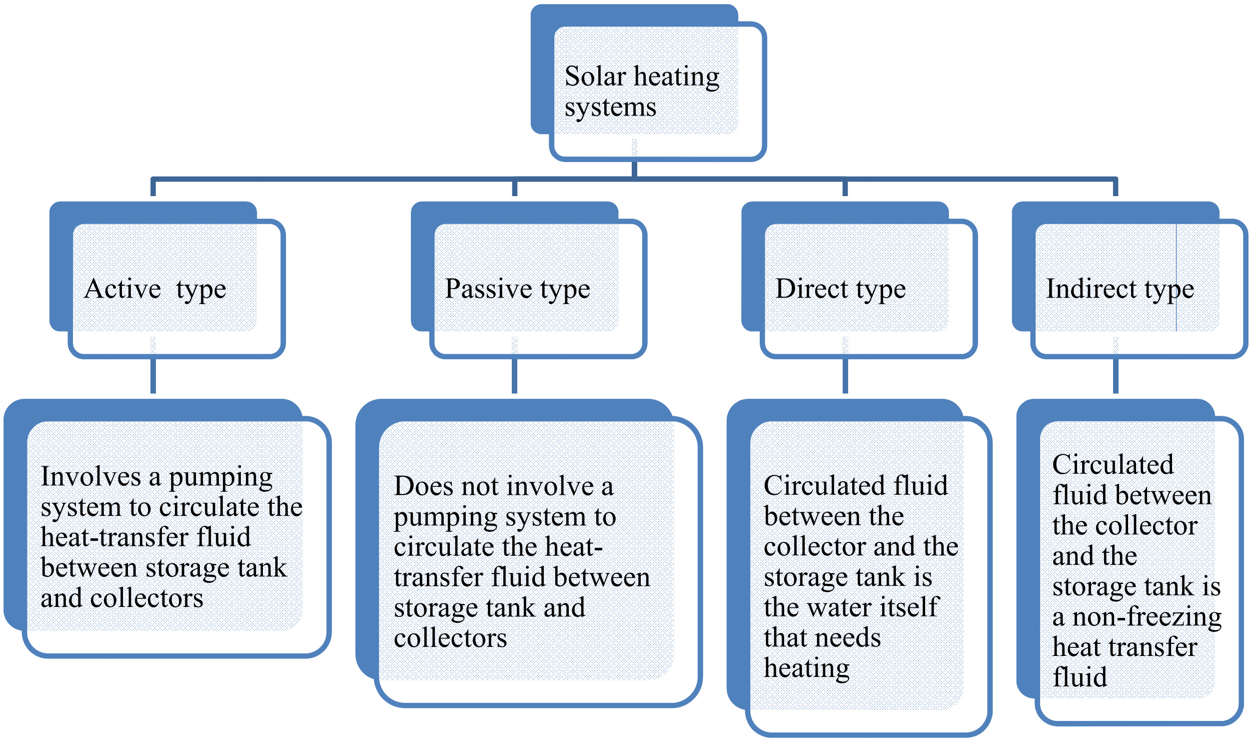

Figure 2.22 Classification of solar water heating systems

Solar collectors are the key component of active solar-heating systems. Solar collectors gather the sun's energy, transform its radiation into heat, and then transfer that heat to water, solar fluid, or air. There are several types of solar collectors:

- Flat-plate collectors
- Evacuated-tube collectors
- Integral collector-storage systems

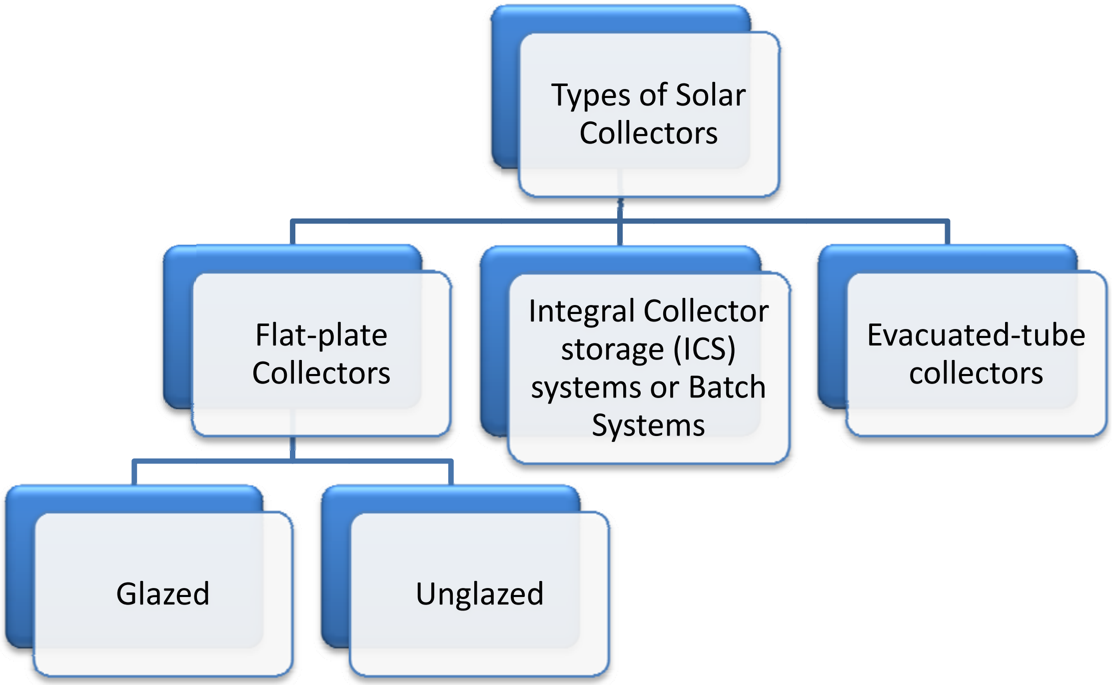

Figure 2.23 Classification of solar collectors

Residential and commercial building applications that require temperatures below 200°F typically use flat-plate collectors, whereas those requiring temperatures higher than 200°F use evacuated-tube collectors.

- Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorber plate. These collectors heat liquid or air at temperatures less than 180°F.

- Evacuated-tube collectors can achieve very high temperatures (170-350°F), making them more appropriate for cooling as well as commercial and industrial applications. However, evacuated-tube collectors are more expensive than flat-plate collectors, with unit area costs about twice that of flat-plate collectors.

- Integral collector-storage systems, also known as ICS or "batch" systems are made of one or more black tanks or tubes in an insulated glazed box. Cold water first passes through the solar collector, which preheats the water, and then continues to the conventional backup water heater. ICS systems are simple, reliable solar water heaters. However, they should be installed only in climates with mild freezing because the collector itself or the outdoor pipes could freeze in severely cold weather.

The Solar Rating and Certification Corporation (SRCC) and the Florida Solar Energy Center (FSEC) certify and rate solar thermal systems and equipment.

There are substantial federal income tax credits (30% of the cost of a solar hot water system) and State of Florida rebates ($500 for a system) for the installation of solar systems in Florida. In addition, one Florida utility, Progress Energy Florida (PEF), recently implemented a new program that offers additional utility incentives of $450 for the installation of solar water heating systems. These combine to offer a considerable buy-down for a solar water heating system. More information on solar water heating can be found at the following web sites:

http://www.fsec.ucf.edu/ and http://www1.eere.energy.gov/solar/sh_basics_collectors.html

Solar Water Heating Costs

Solar water heaters for commercial applications are typically available in the 80-120 gallon range by most companies (see the MS Access file available electronically as one of the deliverables to this project). A solar water heating system for hot water usage of an application requiring 200 gallons/day would be sized with three solar collectors accounting for a total collector area of around 97 ft^2 (9.01 m^2). Such a system would be priced anywhere from $6,800 to $10,200 depending on variations in the cost of installation. The expected cost range for one- and two-solar collector systems would be $3,600 to $5,400 and $5,200 to $7,800, respectively. It should be noted that the storage capacity of the system will need to be scaled down proportionally depending on the collector area. Passive solar water heating systems are cheaper than active systems. In all cases, there are usually financial incentives that would cover a substantial amount of the investment cost (e.g. federal tax credits typically cover 30% of the installation costs). There are other incentives such as the Florida Solar Rebate Program and the Solar Hot Water Rebate Program, etc. Solar hot water heating systems have a life expectancy of 15 or more years. Typical payback periods for a good solar-rated area (for Ocoee, FL, it is 5.28 $kWh/m^2/day$) is around 5-6 years. The approximate net savings over a 15-year period is typically $8,000 to $8,500. Yearly savings in utility bills should be around $600 to $700. The lifetime operating cost over a period of 15-30 years is around $1,000. Passive systems generally require less maintenance compared to active ones. On average, maintenance should be conducted every 3-5 years.

Rules of Thumb for Sizing Solar Water Heating Systems

The following are general rules of thumb established by the industry for sizing solar water heating systems:

- In the Sunbelt region, use 1 ft^2 (0.09 m^2) of collector area per 2 gallons (7.6 liters) of tank capacity (daily household usage)
- In the Southeast and Mountain states, use 1 ft^2 of collector per 1.5 gallons (5.7 liters) of tank capacity
- In the Midwest and Atlantic states, use 1 ft^2 of collector per 1.0 gallon (3.8 liters) of tank capacity
- In New England and the Northwest states, use 1 ft^2 of collector per 0.75 gallon (2.8 liters) of tank capacity.

For additional information, the reader is advised to consult the following resources:

- www.flaseref.org

- www.flaseia.org
- www.fsec.ucf.edu
- www.floridaenergy.org
- http://www.fsec.ucf.edu/en/industry/pdf/SolarContractor.pdf
- http://www.solar-estimate.org/

SOLAR LIGHTING
According to the US DOE (http://buildingsdatabook.eren.doe.gov/?id=view_book&c=1) lighting energy consumption comprises 24% of the total energy usage of a commercial building. Therefore, savings made by using solar energy for lighting needs can be substantial.

Eco-friendly, commercial/industrial grade solar-powered LED lighting systems and alternative solutions are used for applications such as streets and roadways, parking lots, billboards and signs, paths and trails, perimeters and security, bus shelters, remote operations, university campuses, temporary sites, and parks and recreation areas. The fastest growing and highly preferred solar lighting system is known as Hybrid Solar Lighting (HSL).

Hybrid Solar Lighting
Rather than using solar panels, which collect solar energy as electricity, store that electricity, and use it to power lights throughout a building, hybrid solar lighting instead transmits the solar energy directly into the structure using optical fibers. Bypassing this intermediate step is one reason why Hybrid Solar Lighting has a much higher efficiency.

Traditional solar panels are able to utilize approximately 15% of the sunlight they receive, while standard light bulbs lose the bulk of their energy in the form of heat — the end result is a total efficiency of about 2% of the original sunlight. By contrast, Hybrid Solar Lighting systems are able to utilize as much as 50% of the original sunlight.

Additional benefits include the fact that Hybrid Solar Lighting systems generate much less heat than traditional bulbs (the optical fibers are cold enough to be touched with no danger of burning), thus saving on cooling costs. They also yield indirect sunlight. This means that the light received is full-spectrum rather than the narrow band found in most light bulbs. The IR and UV wavelengths are stripped out before the visible light is sent into the building. The system must track the sun with an accuracy of one-eighth of an angular degree, regardless of sky conditions, and must concentrate the sunlight (400 times) into a focused beam that is narrow enough to enter the numerical aperture of the optical fibers.

Pricing for hybrid solar lighting is dropping dramatically, with one group aiming to get the price down to $3,000 for 10,000 ft^2 (930 m^2) within a few years. Currently a full setup costs $40,000 for 10,000 ft^2, but advancing technology and switching to plastic optical fibers should make it possible for prices to drop a full order of magnitude.

Solar Light Tube Technology
This is a day-lighting technology that works with the principle of transmitting the available daylight into the building space that needs illumination. This technology is classified into three major zones:

1. **Capture Zone**. This is where sunlight is captured by the dome mounted on the rooftop of the building and directed down into the tube. The dome design is such that it will reject any direct solar radiation and will allow diffused or low-angle sunlight to pass through it. Thus it maintains a consistent daylight throughout the day. The dome on the top can be mounted by a wide variety of ways according to the roof design. For example, a shingle/shake type mount is used for asphalt tile roofs, and a tile type mount is used for tile roofs, etc.

2. **Transfer Zone**. The transfer of the captured sunlight to the space to be illuminated is achieved by 99.7% reflective tubing in this tubular day-lighting device (TDD). This tubing can be designed to run a length of 20-30 ft. The tubing will fit between rafters and will install easily with no structural modifications.

3. **Delivery Zone**. This is the zone that ends in the ceiling of the room space to be illuminated. At the ceiling level, an attractive diffuser spreads the light evenly throughout the room. A dual lens array technology employed in this zone helps customize the room end light. A diffusion lens of this dual lens array technology controls the light diffusion, while a lens adjusts the light and gives the end user the option to soften or warm the light color.

These systems can illuminate an area ranging between 150-500 ft^2 depending on the type of system used. They can carry light to a length of 20-30 ft or more downwards from the rooftop. The optional Solatube Daylight Dimmer can also be installed to allow control of the light output.

Manufacturers include Sol Inc., Silicon Solar Inc., Sunlight Direct, Oak Ridge National Laboratories (ORNL), Sunflower Corporation, and Solatube.

SOLAR TECHNOLOGY FOR EDUCATION

The purpose of this section is to identify innovative solar technologies that the Turnpike Enterprise can use for education and showcasing purposes. These include powerbrellas, solar trees, canopy systems, solar shades, transparent solar cells, solar power towers, solar space cooling, solar bags, and hybrid solar flash lights.

Powerbrellas, Solar Trees, Canopy Systems and Solar Shades

Powerbrellas, solar trees, canopy systems, and solar shades can be made to utilize solar panels to power laptops, cell phones and lights without a standard electrical hookup. This technology is a collaborative effort between SKYshades and Konarka. They claim that enough power could be generated that customers might be able to sell electricity back to the grid. SKYshades designs and builds all types of fabric structures using HDPE, PVC, PTFE, and ETFE fabrics. Konarka, on the other hand, is a leading OPV cell manufacturer. Currently, manufactured solar canopies (OPV technology bonded to PVC canopies) and powerbrellas are being evaluated for performance.

Transparent Solar Cells
Transparent solar cells in their most common design are standard crystalline cells with a transparent back cover. Another design employs thin film transparent amorphous modules. Transparent solar modules arguably offer one of the most attractive solutions to Building Integrated Photovoltaics (BIPV). Modules with different transparency rates and/or different technologies are available on the market. Transparent modules can be used as window glazing in usual windows, sunspaces, and can be integrated into roofs. Quite often they can also be part of shading devices in both movable and stationary applications. Such systems are also known as "shadow-voltaic" systems.

Solar Power Towers
A solar power tower or central receiver generates electricity from sunlight by focusing concentrated solar energy on a tower-mounted heat exchanger (receiver). This system uses hundreds to thousands of flat sun-tracking mirrors called heliostats to reflect and concentrate the Sun's energy onto a central receiver tower. The energy can be concentrated to as much as 1500 times that of the energy coming in from the Sun. Energy losses from thermal-energy transport are minimized as solar energy is directly transferred by reflection from the heliostats to a single receiver, rather than being moved through a transfer medium to one central location, as with parabolic troughs. Power towers must be large to be economical. This is a promising technology for large-scale grid-connected power plants.

Solar Space Cooling
Solar-assisted space cooling can be accomplished using thermally-activated cooling systems (TACS) driven by solar energy. Because of their relatively high initial cost, TACS are not very widespread. The two most commonly available systems are solar-assisted absorption and solar-assisted desiccant systems. The former uses thermal energy to vaporize a binary-fluid mixture in an absorption-refrigeration unit. The latter uses solar energy to regenerate either solid or liquid desiccant materials in a vapor-compression refrigeration system to help offset a portion of the space latent load. Solar-assisted desiccant systems are particularly suited for hot and humid climates where the latent load is high.

Solar Bags
The company Noon Solar markets bags that incorporate flexible, light weight OPV solar panels to keep cell phones and iPods charged. Each bag is designed to be able to sit in a window at work or in the car to collect solar energy. Energy is stored in a lithium-ion battery pack, weighing about 4oz inside the bag. Because solar power is stored inside a battery pack, cell phones and iPods can be charged day or night (see http://noonsolar.com/).

Hybrid Solar Flash Light
"Hybrid Solar Lite" is a hybrid solar flash light that has photovoltaic cells which captures both sunlight and room light, converting them directly to electrical energy powering a 1-Watt LED bulb. When the solar charge is completely spent, there is a lithium backup battery providing up to 50 hours of light. The unit is waterproof in up to 80 ft of water. For additional information, the reader is referred to http://www.hybridlite.com/.

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CHAPTER 3
SYSTEM SELECTION AND DESIGN ALTERNATIVES

The solar system design and layout for Turkey Lake Plaza encompasses seven areas within the Plaza and the noise walls one mile north and south of the Plaza. These eight areas correspond to the major Phases within the scope of the project that have good potential for solar installation. Each Phase requires a different approach to system design and layout in, for example, the type of solar system or the support structure.

The system design and layout is presented in the following eight sections, Phase 1 through Phase 8. Each Phase has a written description, an estimate of the maximum solar panel area that could be installed in the area, and a color coded aerial view location map showing the area or areas in the Phase. The Phase description is followed by a summary of selected alternatives for design and layout. Each alternative, called a Scenario, has a synopsis of the assumptions in terms of solar panel type and mounting system, an estimate of the installed power range and annual energy generation given the type of technology. Additional Scenarios and details are provided in Appendix B. The system design and layout is schematic and would require more detailed analysis in order to determine, for example, the electrical interconnect, the panel mounting system, the orientation, and the specific performance of the panel type.

The system design and layout is intended as a guide for the solar system installation for Turkey Lake Plaza. The design criteria include not only energy generation but also education, public awareness, and financial considerations which will influence the Phases and scenarios selected for development.

The concluding section in this chapter includes two example solar installations for Turkey Lake Plaza. The first is an example of how a combination of the scenarios can be used to create a Net Zero Energy Plaza, in other words, a system that is estimated would generate enough electricity to offset the Plaza's annual consumption. This proposal consists of selected technologies in Phase 1, Phase 2, and Phase 4 and may not represent the full implementation of any individual scenario in a Phase. The second is the Maximum Energy Case which estimates the energy generation if all areas available in all scenarios were fully utilized using the highest efficiency equipment. This case is included primarily as an estimate of the potential for generation and may not be the most desirable or likely approach.

SUMMARY OF SCENARIOS

Scenario	MW	kWh/yr	$/kWh	System Cost
PHASE 1 - Open Areas				
A: Rail Mounted Crystalline	1.97 MW	3,221,000 kWh	$ 0.18	$ 9,835,000.00
B: Passive Tracking Crystalline	1.97 MW	3,804,000 kWh	$ 0.15	$ 9,835,000.00
C: Single-Axis Tracking Crystalline	1.97 MW	3,804,421 kWh	$ 0.16	$ 10,818,500.00
D: Dual-Axis Tracking Crystalline	1.97 MW	4,142,664 kWh	$ 0.16	$ 11,802,000.00
E: Enclosed/Mounted Thin Film	1.07 MW	1,744,151 kWh	$ 0.14	$ 4,260,000.00
F: Concentrating PV	1.81 MW	2,960,962 kWh	$ 0.25	$ 12,656,000.00
PHASE 2 - Roof Mounted				
A: Solyndra	0.21 MW	350,468 kWh	$ 0.14	$ 856,000.00
B: Flat Thin Film	0.20 MW	291,855 kWh	$ 0.12	$ 585,000.00
C: SunPower	0.45 MW	732,052 kWh	$ 0.14	$ 1,788,000.00
PHASE 3 - Employee Parking				
A: Crystalline Engineered Structure	1.34 MW	2,199,431 kWh	$ 0.21	$ 8,058,000.00
B: Thin Film Engineered Structure	0.73 MW	1,192,246 kWh	$ 0.18	$ 3,640,000.00
C: Envision Solar Grove	1.65 MW	2,700,567 kWh	$ 0.21	$ 9,894,000.00
PHASE 4 - Visitor Parking				
A: Crystalline Engineered Structure	0.75 MW	1,225,000 kWh	$ 0.21	$ 4,488,000.00
B: Thin Film Engineered Structure	0.41 MW	663,269 kWh	$ 0.18	$ 2,025,000.00
C: Envision Solar Grove	0.92 MW	1,503,409 kWh	$ 0.21	$ 5,508,000.00
PHASE 5 - Truck Parking				
A: Crystalline Engineered Structure	0.51 MW	838,502 kWh	$ 0.21	$ 3,072,000.00
B: Thin Film Engineered Structure	0.28 MW	455,281 kWh	$ 0.18	$ 1,390,000.00
C: Envision Solar Grove	0.63 MW	1,030,113 kWh	$ 0.21	$ 3,774,000.00
PHASE 6 - Noise Walls				
A: Dual-Vertical Row Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
B: Dual-Horizontal Row Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
C: Two Rows of Vertical Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
D: Two Rows of Horizontal Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
E: Two Rows of Vertical Crystalline PV - South	0.82 MW	1,341,276 kWh	$ 0.19	$ 4,504,500.00
F: Top Mounted Crystalline PV	0.68 MW	1,054,018 kWh	$ 0.21	$ 3,751,000.00
G: Flush Thin Film	0.95 MW	1,468,207 kWh	$ 0.17	$ 4,275,000.00
PHASE 7 - Retention Ponds				
A: Floating Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00
B: Mounted Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00

Notes:
Summary uses the mean performance numbers for each scenario.
$/kWh includes gross first cost based on the cost/Watt installed with a production life of 20 years.

Table 3.1 Summary of Scenarios and Phases

PHASE 1: OPEN AREAS

Figure 3.1 Aerial View of Phase 1: Open Areas

The Open Areas specified in Phase 1 refer to the grassy areas at the North and South sides of the Turkey Lake property as shown in Figure 3.1. This includes land extending up to paved or improved surfaces, but not beyond. These areas can be used for field-mounted types of PV systems, but changes to the landscaping may be necessary to accommodate the system. The sloped grassy areas near the retention pond are not included as locations for the PV systems due to the need to keep them for maintenance purposes. This was chosen as Phase 1 due to ease of installation and high levels of visibility.

Phase 1 allows for approximately 142,000 square feet of panel area.

Figure 3.2 Scenario A: Rail Mounted Crystalline (Base Case)

Phase 1- Scenario A: Rail Mounted Crystalline (Base Case)

This scenario utilizes crystalline panels that are rail-mounted directly to the ground in a fixed position facing directly south- at the optimum angle of 27 degrees from horizontal. (See Figure 3.2)

Peak Power Range: 1.25 – 2.54 MW

Energy Generation Range: 2,504,000 – 5,088,000 kWh/yr

Installed Cost Range: $6,270,000 – $12,735,000

Phase 1- Scenario B: Passive Tracking Crystalline

This scenario utilizes crystalline panels that are pole-mounted off the ground to passively track the sun in one direction. This represents higher generation efficiency than the fixed Scenario A.

Peak Power Range: 1.25 – 2.54 MW

Energy Generation Range: 3,150,000 – 6,401,000 kWh/yr

Installed Cost Range: $6,270,000 – $12,735,000

Phase 1- Scenario C: Single-Axis Tracking Crystalline

This scenario utilizes crystalline panels that are pole-mounted off the ground to actively track the sun in one direction. This represents higher generation efficiency than the fixed Scenario A.

Peak Power Range: 1.25 – 2.54 MW
Energy Generation Range: 3,150,032 – 6,400,704 kWh/yr
Installed Cost Range: $6,897,000 – $14,008,500

Phase 1- Scenario D: Dual-Axis Tracking Crystalline

This scenario utilizes crystalline panels that are pole-mounted off the ground to actively track the sun in two directions. This represents higher generation efficiency than the fixed Scenario A and the Single-Axis Scenarios B & C.

Peak Power Range: 1.25 – 2.54 MW
Energy Generation Range: 3,255,200 – 6,614,400 kWh/yr
Installed Cost Range: $7,524,000 – $15,282,000

Phase 1- Scenario E: Enclosed/Mounted Thin Film

This scenario would be exactly like Scenario A except for exchanging crystalline panels with an encased thin film material to allow for rail mounting on the ground. This system has a lower efficiency compared to crystalline.

Peak Power Range: 0.70 – 1.70 MW
Energy Generation Range: 1,402,000 – 3,404,000 kWh/yr
Installed Cost Range: $2,804,000 – $6,816,000

Phase 1- Scenario F: Concentrating Photovoltaics (CPV)

The final scenario utilizes CPV throughout the open areas. This CPV system would be pole-mounted. CPV would be the heaviest and most complicated system, but could potentially represent a higher efficiency due to solar concentration as outlined in the Technology portion of this report.

Peak Power Range: 1.39 – 2.67 MW
Energy Generation Range: 2,774,000 – 5,534,000 kWh/yr
Installed Cost Range: $9,723,000 – $19,390,000

PHASE 2: BUILDING ROOFS

Figure 3.3 Aerial View of Phase 2: Building Roofs

The Building Roofs specified in Phase 2 refer to the roof areas on four Turkey Lake buildings: Law Enforcement, Operations, Sunwatch/Trades, and Turnpike Headquarters. The space excludes roof parapets and mechanical equipment areas on the roof. Additional buildings were not included in the total roof area as structures are likely to change with the new concessionaire contract for the current Service plaza. This space can be used for flat and angled panels with limited mounting options to prevent voiding current roof warranties.

Phase 2 allows for approximately 26,000 square feet of panel area.

Phase 2- Scenario A: Solyndra (Base Case)

This base case utilizes Solyndra's proprietary self-ballasting tubular panel system. This system would be custom made for the Turkey Lake roofs and would lay in rows along the roof surfaces without voiding the roof warranties. This is the base case because it is the most easily removed and reinstated when the roof needs replacing.
Peak Power Range: 0.19 – 0.25 MW
Energy Generation Range: 372,000 – 496,000 kWh/yr
Installed Cost Range: $736,000 – $984,000

Phase 2- Scenario B: Flat Thin Film

This scenario proposes thin film adhered to the roof surface. This should not void the roof warranty, but would most likely have to be removed when the roof is replaced. This case may have the lowest peak power of the three scenarios.

Peak Power Range: 0.13 – 0.32 MW

Energy Generation Range: 260,000 – 630,000 kWh/yr

Installed Cost Range: $384,000 – $936,000

Figure 3.4 Scenario C: SunPower Roof Tile System

Phase 2- Scenario C: SunPower Roof Tile System

This scenario is based on SunPower's own roof tile system and would also not void the roof warranty. SunPower panels are positioned in a south-facing direction at a slight angle in rows along the roof surface. This represents the highest peak power of the three scenarios. (See Figure 3.4)

Peak Power Range: 0.42 – 0.47 MW

Energy Generation Range: 844,000 – 942,000 kWh/yr

Installed Cost Range: $1,668,000 – $1,864,000

PHASE 3: EMPLOYEE PARKING

Figure 3.5 Aerial View of Phase 3: Employee Parking

The Employee Parking specified in Phase 3 refers to the total paved area of the large employee parking lot north of the Turnpike Headquarters building. Landscaping and current lighting systems may need to be redesigned to maximize energy generation while minimizing intrusions and shading. All proposed systems will allow for ventilation and varying degrees of natural light within the structure. This represents the largest single parking area for solar power generation. The parking structures will have a clearance of 10-12 feet.

Phase 3 has approximately 97,000 square feet of panel area.

Figure 3.6 Scenario A: Crystalline Engineered Structure (Base Case)

Phase 3- Scenario A: Crystalline Engineered Structure (Base Case)

The base case scenario is comprised of an engineered structure designed to support a truss-mounted crystalline panel system in the south-facing direction. The supports would span between the islands of the parking lots and would not have a solid roof in order to allow for ventilation and natural light. (See Figure 3.6)
Peak Power Range: 0.86 – 1.74 MW
Energy Generation Range: 1,710,000 – 3,474,000 kWh/yr
Installed Cost Range: $5,142,000 – $10,440,000

Phase 3- Scenario B: Thin Film Engineered Structure

This scenario would involve an engineered structure similar to the above but designed to support a flat array of thin film PV panels. This would reduce energy generation as well as ventilation and natural light.
Peak Power Range: 0.48 – 1.16 MW
Energy Generation Range: 956,000 – 2,324,000 kWh/yr
Installed Cost Range: $2,395,000 – $5,820,000

Figure 3.7 Scenario C: Envision Solar Grove

Phase 3- Scenario C: Envision Solar Grove

This scenario is based on Envision's Solar Grove covered parking systems. Envision designs variations of its Solar Tree system to accommodate any type of parking layout or facility. This scenario would leave large gaps between rows of vaulted solar "trees" throughout each parking lot. (See Figure 3.7)

Peak Power: 1.65 MW

Energy Generation: 3,292,000 kWh/yr

Installed Cost: $9,894,000

PHASE 4: VISITOR PARKING

Figure 3.8 Aerial View of Phase 4: Visitor Parking

The Visitor Parking specified in Phase 4 refers to the total paved area of the visitor parking lots on either side of the Service plaza buildings. Landscaping and current lighting systems may need to be redesigned to maximize energy generation while minimizing intrusions and shading. All proposed systems will allow for ventilation and varying degrees of natural light within the structure. The parking structures will have a clearance of 10-12 feet.

Phase 4 has approximately 54,000 square feet of panel area.

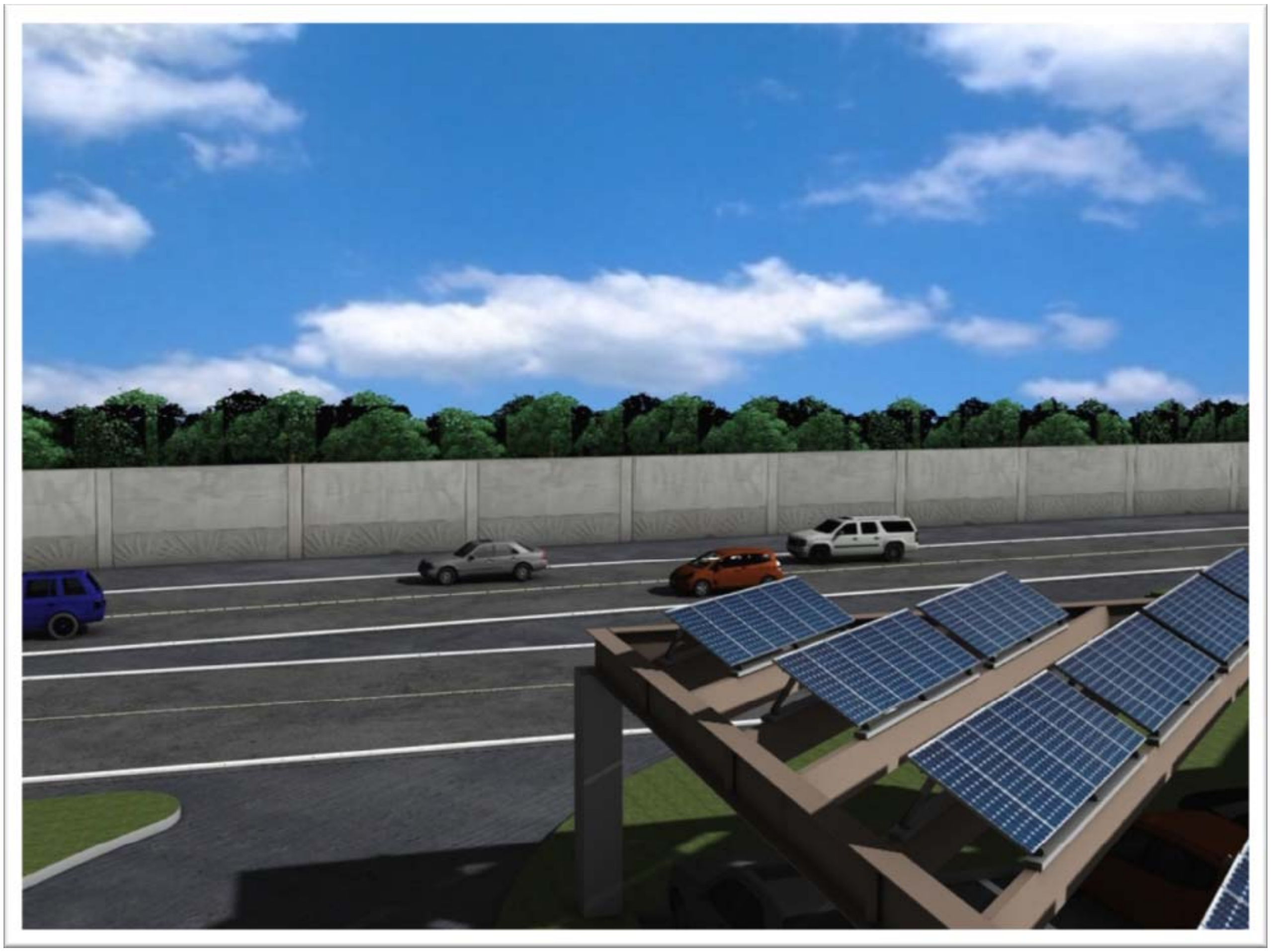

Figure 3.9 Scenario A: Crystalline Engineered Structure (Base Case)

<u>**Phase 4- Scenario A**: Crystalline Engineered Structure (Base Case)</u>

Refer to P3-A (See Figure 3.9)
Peak Power Range: 0.48 – 0.98 MW
Energy Generation Range: 960,000 – 1,952,000 kWh/yr
Installed Cost Range: $2,862,000 – $5,814,000

<u>**Phase 4- Scenario B**: Thin Film Engineered Structure</u>

Refer to P3-B
Peak Power Range: 0.27 – 0.65 MW
Energy Generation Range: 538,000 – 1,306,000 kWh/yr
Installed Cost Range: $1,335,000 – $3,240,000

<u>**Phase 4- Scenario C**: Envision Solar Grove</u>

Refer to P3-C
Peak Power: 0.93 MW
Energy Generation: 1,850,000 kWh/yr
Installed Cost: $5,508,000

PHASE 5: TRUCK PARKING

Figure 3.10 Aerial View of Phase 5: Truck Parking

The Truck Parking specified in Phase 5 refers to the total paved area of the truck parking lots on either side of the Service plaza buildings. Landscaping and current lighting systems may need to be redesigned to maximize energy generation while minimizing intrusions and shading. All proposed systems will allow for ventilation and varying degrees of natural light within the structure. Structures will be identical to those in Phase 4 and 5, but will be raised from 10-12 feet to 16-22 feet high to allow for full truck clearance.

Phase 5 has approximately 37,000 square feet of panel area.

Figure 3.11 Scenario A: Crystalline Engineered Structure (Base Case)

Phase 5- Scenario A: Crystalline Engineered Structure (Base Case)

Refer to P3-A (See Figure 3.11)
Peak Power Range: 0.33 – 0.66 MW
Energy Generation Range: 654,000 – 1,326,000 kWh/yr
Installed Cost Range: $1,962,000 – $3,984,000
Note: Structure height would be raised from 10-12 feet to 16-22 feet high.

Phase 5- Scenario B: Thin Film Engineered Structure

Refer to P3-B
Peak Power Range: 0.18 – 0.44 MW
Energy Generation Range: 366,000 – 888,000 kWh/yr
Installed Cost Range: $915,000 – $2,220,000
Note: Structure height would be raised from 10-12 feet to 16-22 feet high.

Phase 5- Scenario C: Envision Solar Grove

Refer to P3-C

Peak Power: 0.63 MW

Energy Generation: 1,258,000 kWh/yr

Installed Cost: $3,774,000

Note: Structure height would be raised from 10-12 feet to 16-22 feet high.

PHASE 6: NOISE WALLS

Figure 3.12 Aerial View of Phase 6: Noise Walls

The Noise Walls specified in Phase 6 refer to the wall on the north side of the highway from mile marker 262 to mile marker 264. Several scenarios are proposed for this Phase representing different aesthetic and power generation options. All scenarios cover only the top 12-foot panel and do not cover the graphics on the lower section of wall. All scenarios are only being considered for the north wall as trees along the south wall would shade top mounted panels and the wall mounted systems would not receive enough sunlight.

Phase 6 has a range of approximately 49,000– 127,000 square feet of panel area.

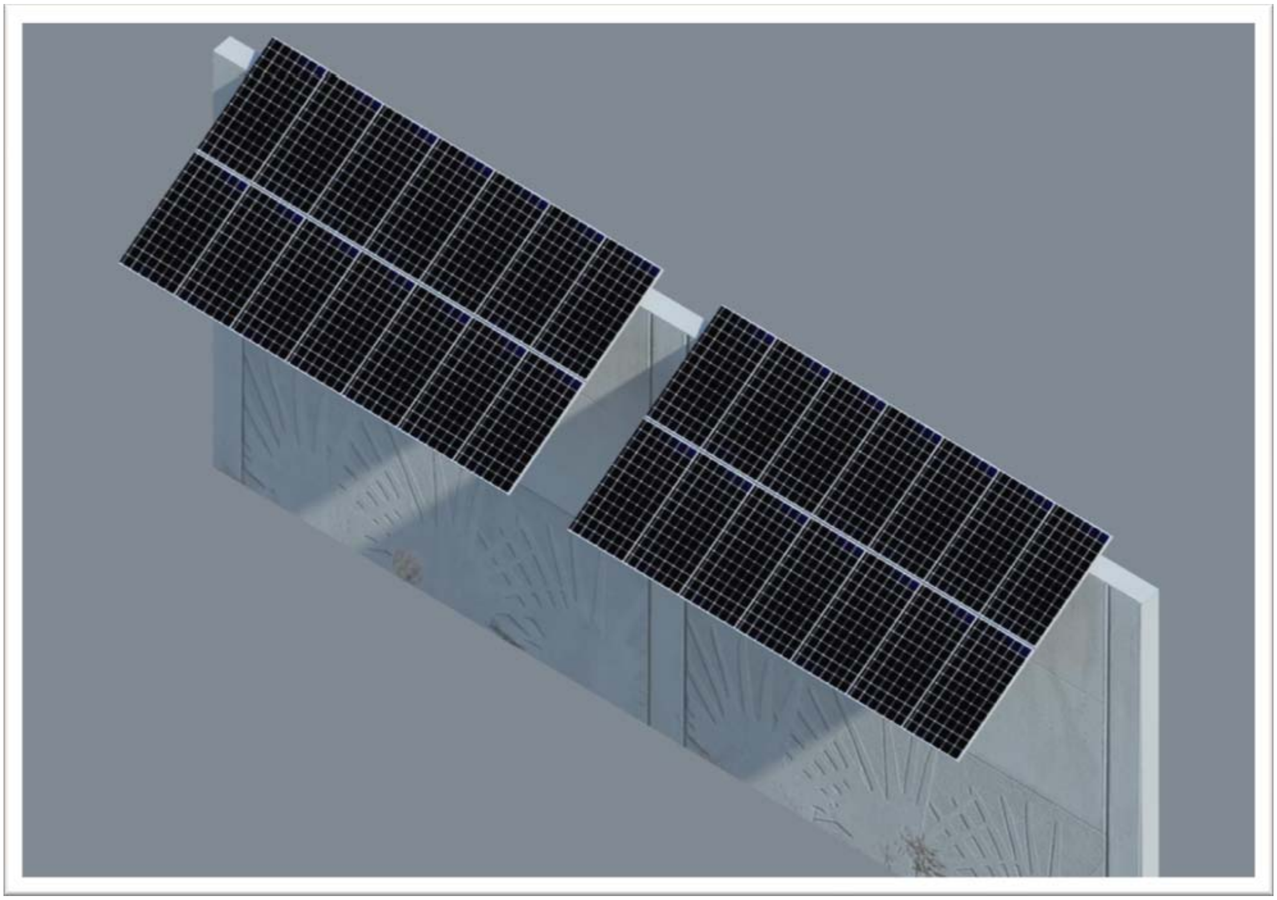

Figure 3.13 Scenario A: Dual-Vertical Row Crystalline Photovoltaics (Base Case)

Phase 6- Scenario A: Dual-Vertical Row Crystalline Photovoltaics (Base Case)

This scenario utilizes fourteen (14) crystalline panels per wall panel mounted vertically. The panel faces are aligned in the same plane to avoid self-shading at any time throughout the day. The panels are fixed and tilted at the optimum 27 degrees from horizontal. (See Figure 3.13)

Peak Power Range: 0.91 – 1.86 MW

Energy Generation Range: 1,826,000 – 3,712,000 kWh/yr

Installed Cost Range: $5,021,500 – $10,208,000

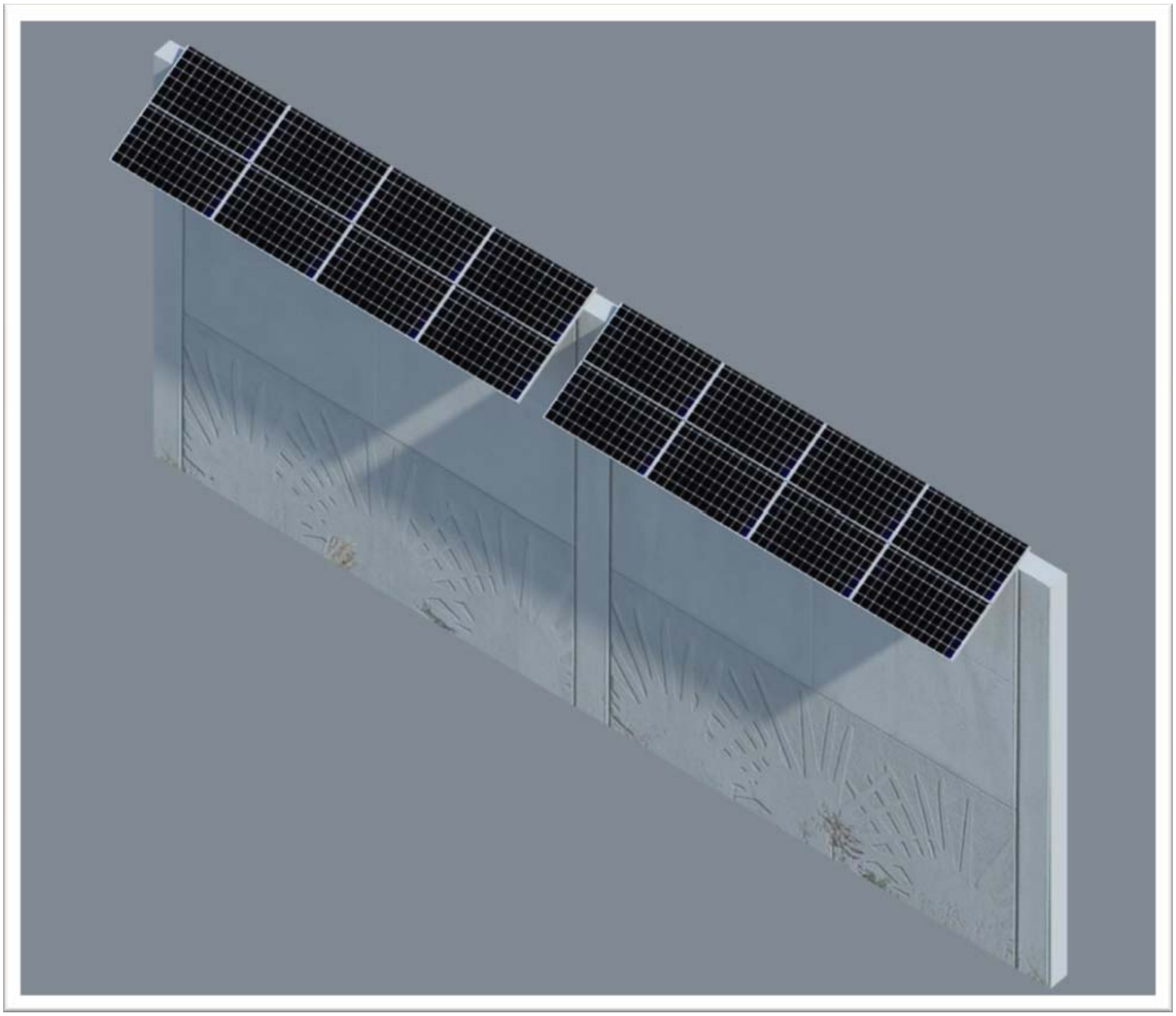

Figure 3.14 Scenario B: Dual-Horizontal Row Crystalline Photovoltaics

Phase 6- Scenario B: Dual-Horizontal Row Crystalline Photovoltaics

This scenario utilizes eight (8) crystalline panels per wall panel mounted horizontally. The panel faces are aligned in the same plane to avoid self-shading at any time throughout the day. The panels are fixed and tilted at the optimum 27 degrees from horizontal. (See Figure 3.14)

Peak Power Range: 0.52 – 1.06 MW

Energy Generation Range: 1,044,000 – 2,120,000 kWh/yr

Installed Cost Range: $2,871,000 – $5,830,000

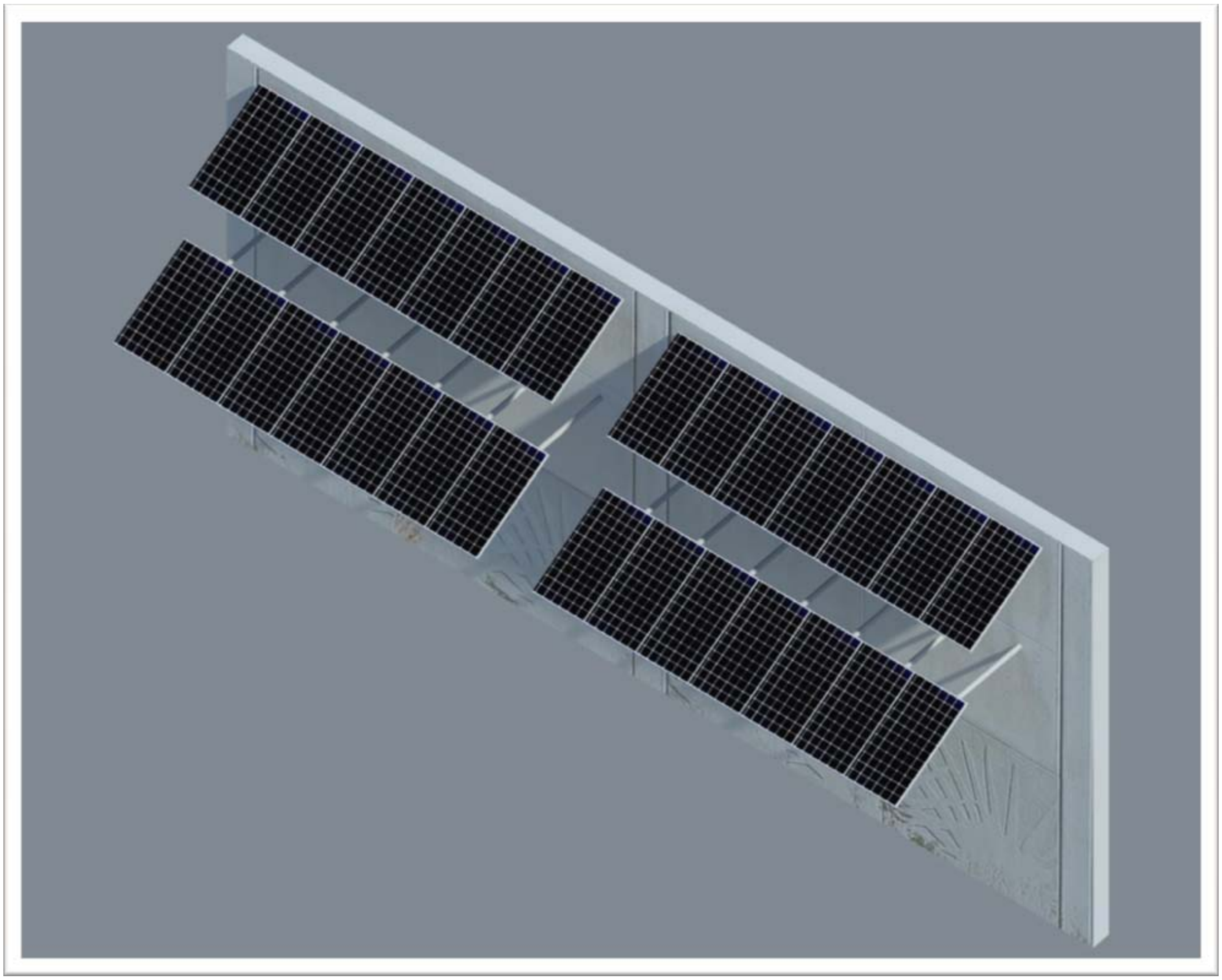

Figure 3.15 Scenario C: Two Rows of Vertical Crystalline Photovoltaics

Phase 6- Scenario C: Two Rows of Vertical Crystalline Photovoltaics

This scenario utilizes fourteen (14) crystalline panels per wall panel mounted vertically. The panels are grouped together into two rows of seven (7) panels and are free of self-shading from 10:00am to 4:00pm. The panels are fixed and tilted at the optimum 27 degrees from horizontal. (See Figure 3.15)

Peak Power Range: 0.91 – 1.86 MW

Energy Generation Range: 1,826,000 – 3,712,000 kWh/yr

Installed Cost Range: $5,021,500 – $10,208,000

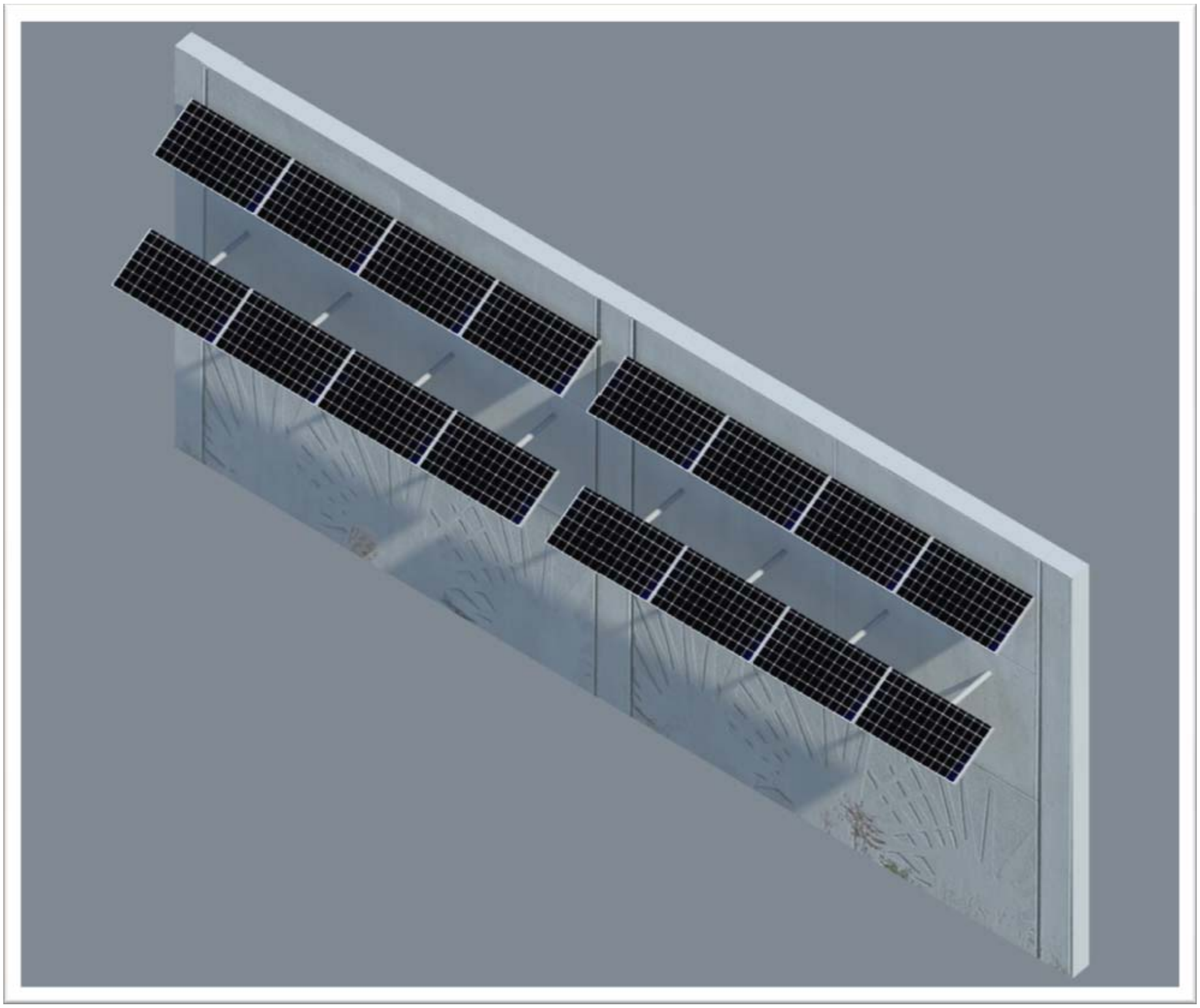

Figure 3.16 Scenario D: Two Rows of Horizontal Crystalline Photovoltaics

Phase 6- Scenario D: Two Rows of Horizontal Crystalline Photovoltaics

This scenario utilizes eight (8) crystalline panels per wall panel mounted horizontally. The panels are grouped together into two rows of four (4) panels and are free of self-shading from 10:00am to 4:00pm. The panels are fixed and tilted at the optimum 27 degrees from horizontal. (See Figure 3.16)

Peak Power Range: 0.52 – 1.06 MW

Energy Generation Range: 1,044,000 – 2,120,000 kWh/yr

Installed Cost Range: $2,871,000 – $5,830,000

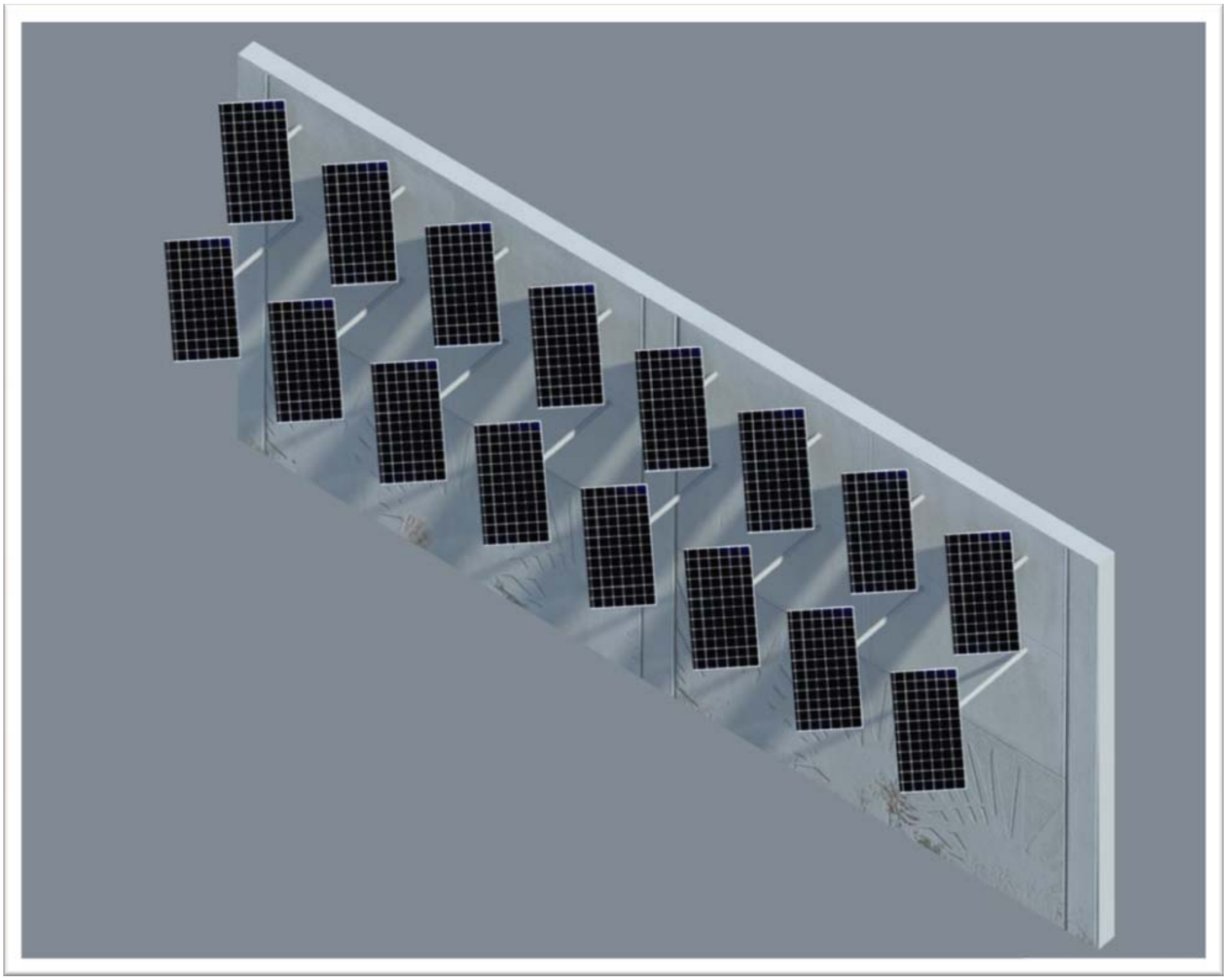

Figure 3.17 Scenario E: Two Rows of Vertical Crystalline Photovoltaics Facing South

Phase 6- Scenario E: Two Rows of Vertical Crystalline Photovoltaics Facing South

This scenario utilizes eight (8) crystalline panels per wall panel mounted vertically. These panels are grouped together into two rows of four (4) panels and are free of self-shading from 10:00am to 4:00pm. The panels are fixed, optimally oriented south and optimally tilted 27 degrees from horizontal. (See Figure 3.17)

Peak Power Range: 0.52 – 1.06 MW

Energy Generation Range: 1,108,726 – 2,251,440 kWh/yr

Installed Cost Range: $2,871,000 – $5,830,000

Figure 3.18 Scenario F: Top Mounted Crystalline

Phase 6- Scenario F: Top Mounted Crystalline

This scenario utilizes six (6) crystalline panels per wall panel mounted vertically. These panels are grouped together into two rows of three (3) panels and are free of self-shading from 10:00am to 4:00pm. The panels are fixed atop the walls, optimally oriented south and optimally tilted 27 degrees from horizontal. This scenario may not be feasible due to weather and maintenance issues. Refer to Chapter 4 for more information. (See Figure 3.18)

Peak Power Range: 0.44 – 0.88 MW

Energy Generation Range: 870,000 – 1,768,000 kWh/yr

Installed Cost Range: $2,392,500 – $4,862,000

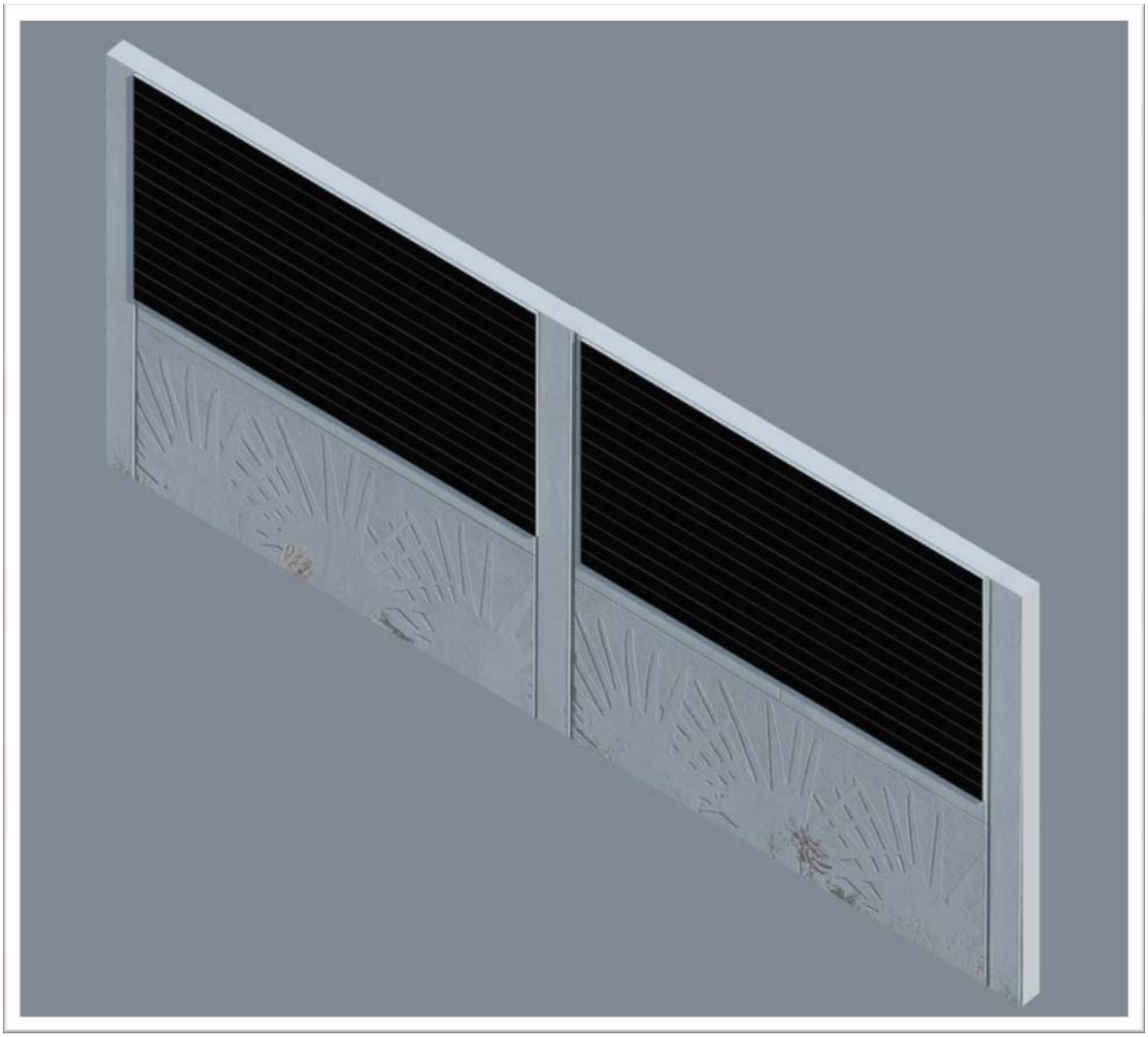

Figure 3.19 Scenario G: Flush Thin Film

Phase 6- Scenario G: Flush Thin Film

The final scenario utilizes thin-film panels and is free from self-shading at any time throughout the day. The panels are fixed and mounted flush to the wall face. This reduces the efficiency while increasing surface area, thus achieving a comparable power generation to other scenarios. (See Figure 3.19)

Peak Power Range: 0.63 – 1.52 MW

Energy Generation Range: 1,252,000 – 3,042,000 kWh/yr

Installed Cost Range: $2,817,000 – $6,844,500

PHASE 7: RETENTION PONDS

Figure 3.20 Aerial View of Phase 7: Retention Ponds

The Retention Ponds specified in Phase 7 refer to the two large retention ponds on the north and south ends of the Turkey Lake site. Both proposed scenarios include the use of crystalline panels to cover the entire area of water. Both scenarios would allow for the rise and fall of pond water levels. The other ponds on the site are not included in this Phase.

Phase 7 has approximately 85,000 square feet of panel area.

Figure 3.21 Scenario A: Floating Crystalline

Phase 7- Scenario A: Floating Crystalline

This scenario is a series of crystalline panels atop floating rafts supported by cables and pilings to account for changing water levels. (See Figure 3.21)
Peak Power Range: 0.75 – 1.53 MW
Energy Generation Range: 1,504,000 – 3,054,000 kWh/yr
Installed Cost Range: $4,881,500 – $9,912,500

Phase 7- Scenario B: Mounted Crystalline

This scenario is a serious of crystalline panels permanently mounted in a fixed position around the retention ponds.
Peak Power Range: 0.75 – 1.53 MW
Energy Generation Range: 1,504,000 – 3,054,000 kWh/yr
Installed Cost Range: $4,881,500 – $9,912,500

PHASE 8: EDUCATION/MARKETING

Figure 3.22 Aerial View of Phase 8: Education/Marketing

The Education/Marketing specified in Phase 8 refers to highly visible educational systems that could be implemented throughout the Turkey Lake site. Scenarios A, B, and C could be utilized simultaneously in multiple places around the site to generate high amounts of interest in various types of solar technology. Power output, however, is low.

Figure 3.23 Scenario A: SKYShadesCovered Walkway

Phase 8- Scenario A: SKYShades Covered Walkway

This scenario utilizes thin-film panels integrated into a SKYShades covered walkway. The proposed installation would span the length of the walkway from the Headquarters building to the Law Enforcement and Operations buildings. (See Figure 3.23)

Figure 3.24 Scenario B: SKYShadesPowerBrella

Phase 8- Scenario B: SKYShadesPowerBrella

This scenario utilizes thin-film panels integrated into a SKYShades umbrella. The proposed installation would allow visitors to charge cell phones and power electronic devices while visiting the plaza. (See Figure 3.24)

Figure 3.25 Scenario C: Solar/Photovoltaic Sculpture

Phase 8- Scenario C: Solar/Photovoltaic Sculpture

The final scenario utilizes any number or combination of photovoltaic technologies. The proposed installation could be designed by artists selected through a local, regional, or national competition. (See Figure 3.25)

NET ZERO ENERGY CASE

The following case is one example of achieving net zero energy through utilizing only a few of the proposed systems. The open areas and building roofs are utilized at 100% of their capability. The employee and visitor parking areas are 75-80% utilized. The number used to achieve net zero energy is 3.8 MW, which may vary slightly depending on the efficiency of the panels. The scenarios used below are the mean value of the base case for each of the three Phases: Open Areas, Building Roofs, Employee Parking, and Visitor Parking. While visitor parking represents the same cost as employee parking, it is more visible and accessible to the public and so considered more of a priority. (See Table 3.2)

Phase	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production (kWh)
1	Open Area System	A. Rail Mounted Crystalline	100%	1.97	$ 9,835,000.00	3,221,000
2	Building Roofs	A. Solyndra	100%	0.21	$ 856,000.00	350,468
3	Employee Parking	A. Crystalline Engineered Structure	76%	1.02	$ 6,124,080.00	1,671,568
4	Visitor Parking	A. Crystalline Engineered Structure	80%	0.60	$ 3,590,400.00	980,000
5	Truck Parking		0%	0.00	$ 0.00	0
6	Noise Walls		0%	0.00	$ 0.00	0
7	Retention Ponds		0%	0.00	$ 0.00	0
8	Education/Marketing					
Total				**3.80**	**$ 20,405,480**	**6,223,036**
Average $/Watt					**$ 5.37**	

Table 3.2 Net Zero Energy Scenario using four of the eight Phases, peak power production of 3.8 MW

SHOWCASE ENERGY CASE

The following case is one example of a showcase energy option. This case is intended for education purposes and accounts for only 100kW. For this example, Powerbrellas are the main visual focus with a small percentage of Phases 1, 4, 6, and 7 pulling together this energy case. (See Table 3.3)

Phase	Description	Scenario	Percentage of Scenario	System Size (kW)	System Cost	Production (kWh)
1	Open Area System	A. Rail Mounted Crystalline	2%	39.34	$ 196,700.00	64,420
2	Building Roofs		0%	0.00	$ 0.00	0
3	Employee Parking		0%	0.00	$ 0.00	0
4	Visitor Parking	A. Crystalline Engineered Structure	2%	14.96	$ 89,760.00	24,500
5	Truck Parking		0%	0.00	$ 0.00	0
6	Noise Walls	A. Dual Vertical Row Crystalline	2%	21.52	$ 118,340.72	33,253
7	Retention Ponds	A. Floating Crystalline	2%	23.54	$ 153,010.00	38,551
8	Education/Marketing	B. SkyShades Powerbrellas	100%	0.64	$ 50,000.00	1,048
Total				**100.00**	**$ 607,811**	**160,726**
Average $/Watt					**$ 6.08**	

Table 3.3 Showcase Energy Scenario using five of the eight Phases to produce 100 kW of peak power

MAXIMUM ENERGY CASE

The following case is representative of the maximum energy production. This is achieved by selecting the best performing technologies and utilizing 100 percent of the areas allotted. The maximum energy production equates to 9.15 MW, which may vary slightly depending on the weather conditions and efficiency of the panels. The scenarios used below are the maximum values derived from the base case for all Phases. (See Table 3.4)

Phase	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production (kWh)
1	Open Area System	D. Dual-Axis Tracking Crystalline	100%	2.55	$ 15,282,000.00	5,364,191
2	Building Roofs	C. SunPower	100%	0.47	$ 1,864,000.00	763,168
3	Employee Parking	A. Crystalline Engineered Structure	100%	1.34	$ 8,058,000.00	2,199,431
4	Visitor Parking	A. Crystalline Engineered Structure	100%	0.75	$ 4,488,000.00	1,225,000
5	Truck Parking	A. Crystalline Engineered Structure	100%	0.66	$ 3,984,000.00	1,087,433
6	Noise Walls	A. Dual-Vertical Row Crystalline PV	100%	1.86	$ 10,208,000.00	2,868,413
7	Retention Ponds	A. Floating Crystalline	100%	1.53	$ 9,912,500.00	2,497,493
8	Education/Marketing					
Total				**9.15**	**$ 53,796,500**	**16,005,129**
Average $/Watt					**$ 5.88**	

Table 3.4 Maximum Power Scenario using all Phases to produce 9.15 MW of peak power

SCALING THE SYSTEMS

The information in this section can be used to determine the size in MW of a PV system for any particular annual energy requirement in kWh at Turkey Lake Service Plaza. The Net Zero Energy scenario (Table 3.2) indicates that a 3.80 MW peak power PV system with the mix of technologies shown in the table can produce approximately 6,223,000 kWh on an annual basis at the Turkey Lake Service Plaza. This result means that about 1.64 million kWh can be generated annually per 1 MW peak power PV system installed. This ratio can be used to estimate the system size needed for a specific energy generation requirement. For example, if one of the buildings at the Turkey Lake Service Plaza were to be made a Net Zero Energy building, and the annual energy consumption of the building were 1 million kWh, the following calculation would determine the size of the PV system with the mix of technologies shown in Table 3.2 in MW required to produce 1 million kWh of electricity in a year:

$$Peak\ Power[MW] = \frac{Annual\ energy\ generation[kWh]}{1{,}640{,}000\frac{kWh}{MW}}$$

$$Peak\ Power[MW] = \frac{1{,}000{,}000\,kWh}{1{,}640{,}000\frac{kWh}{MW}}$$

$$Peak\ Power = 0.61\,MW$$

Thus a building or area requiring 1,000,000 kWh of electricity annually in Turkey Lake Plaza could meet its requirements with a 0.61 MW PV system with the mix of technologies shown in

Table 3.2. By using the System Size (MW) column in Table 3.2, one possible solution is to use the Phase 4 system, Visitor Parking, which has a maximum power of 0.60 MW. Another solution would be to use about 30% of Phase 1, Open Area System, which has a peak power output of 1.97 MW, to install a 0.61 MW system. This approach provides an approximation for determining the size of the system required for a given purpose. In a similar fashion, the costs can be extrapolated using the information in Tables 3.2 and 3.4. For example, Phase 1 in Table 3.2 is a ground mounted crystalline system with a cost of about $2.60 per watt. For the 1.0 MW peak power system in this example, the system cost would be about $2,600,000.

The annual kWh energy generation per MW installed peak power approach can be calculated for the specific technologies as well. The approach is geographically limited as incident solar energy varies with latitude. Generally, incident solar will increase further south and decrease further north of Turkey Lake Service Plaza making this performance estimating approach less accurate the further one moves away from Turkey Lake Service Plaza.

CHAPTER 4
SITE ENERGY AND INFRASTRUCTURE ISSUES

This chapter discusses items related to the physical infrastructure necessary to install the PV panels and connect them into the existing electrical system. Structural issues will be discussed first, followed by electrical connection issues. The impact of Progress Energy's regulations on a large solar installation are reviewed. Finally, the results of a solar simulation of a fixed panel installation at the Turkey Lake Service Plaza are compared to the historical energy consumption records.

STRUCTURAL ISSUES

The following sections are written assuming that the solar power systems described therein are implemented. Structural items are discussed along with cost estimates for installations on the noise walls, ground, a raised structure over the parking areas, and floating structures on the ponds. Each section seeks to address the concerns and to predict the results of choosing the option described. The concerns and results discussed in each section are described in the section's subheading.

Noise Wall Mounting

The noise walls are installed with a maximum of 40 lineal feet (LF) between vertical supports. Most walls are placed in 20-lineal-foot sections. Calculations for the 40-foot scenario (the largest and therefore most risky) indicate that for 130 mph wind with 3-second gusts, the wall currently located at the Turkey Lake Service Plaza can withstand an additional 300 square feet (sf) per 40 LF section at the top of the wall without tipping the wall over. A system was proposed that, in its worst-case scenario, would act as a two-foot tall continuous panel, mounted on top of the noise wall. Calculations show that this option would add an additional 80sf per section. This grants a 3.75 factor of safety.

Mounting the panels on top of the walls also introduces the threat of the bending moment generated by the wind hitting the panels, potentially causing the concrete on the edges of the wall to crack and spall off, exposing the reinforcement steel in the wall. Based on the results of this evaluation, top mounting the PV panels on the noise walls as shown in Figure 4.1 is not recommended.

Standard panels themselves can withstand a wind load of 50 psf. This is just above the pressure from 130 mph wind with 3-second gusts (49.7 psf). Note that both the Florida Building Code and the ASCE Design Standards indicate that the design wind load for the Turkey Lake area is 110 mph or less. The pressure from a 110 mph wind is 35.6 psf, well within the safe range. (Sunpower 2009)

Representatives of Unirac and Direct Power & Water have indicated that their more advanced mounting systems could withstand winds of 130 mph with 3-second gusts. Preliminary analysis indicates that a noise wall mount could be constructed to withstand the 130 mph wind with 3-second gusts. Suffice to say it is feasible to mount the largest commercially available solar panel so that the panel mounts do not fail due to design wind loads.

Figure 4.1 Although providing a flexible orientation for PV panels, top-mounting of the panels on the noise walls is not recommended due to a high bending moment that could result from high winds.

Also, even if all shop drawings, standards, and specifications warrant that the hardware will not fail under the design wind load, care must be taken by the designer to design the steel rods connected to the hardware supporting the panels deep enough into the wall to prevent the wind from blowing the hardware off the wall.

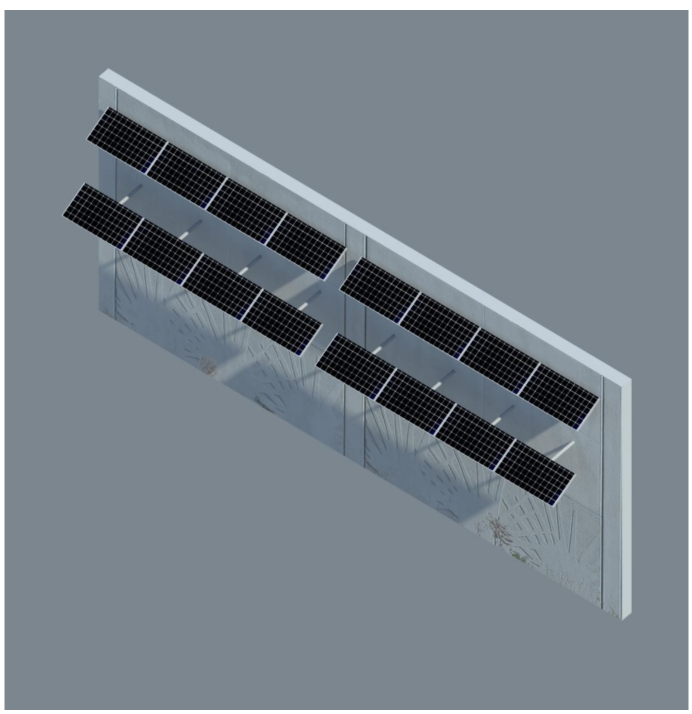

Figure 4.2 Side of Noise Wall Mounting

Cost of Mounting Hardware for Panels Mounted on Noise Walls
The mounting system which would be used for the noise wall (side mounting) would be much the same as the mounting system used for the ground panels. There would be an added cost for different fasteners which would be needed to go through or into the wall itself. There would also be an added cost for the increase in the size of the mounting system for the second row of panels due to the fact that they would be farther away from the wall to avoid shading from the first row of panels. The cost of the mounting system for the noise wall would be in the range of 1.2 to 1.5 times that of the ground mounted. This assumes no tracking system. The cost of the top-mounting system for the noise wall would be in the range of 1.8 times that of the ground mounted. This also assumes no tracking system and requires reinforcing steel through the wall.

Cost of Mounting Hardware for Ground Panels
Mounting hardware for ground panels would have a cost of about $1.00 per watt. This is based on a simple mounting system. Addition of a tracking system would also raise that cost of the system. All other mounting systems costs will be listed as a multiple of this (baseline) cost.

Cost of Thin-Film Panels
The thin film which would be used on the roof of any of the building would not need any mounting hardware, but this would not have a reduction in the cost of the over all system.
The cost of the thin-film mounting system would be about the same per watt as that of the ground mounted. The savings for using this system on the building roofs is that it can be applied with no mechanical fasteners. This will not affect the warranty on the roof.

Cost of Mounting Hardware for Truck and Car Parking
For truck and car parking, it is recommended that FDOT use the same structure which is used at the fueling areas of typical truck stops. A cost for these structures was found to be $7.00 per square foot of top surface (roof) space. Fashion, Inc., a contractor from Kansas, was contacted; they have done a large amount of similar work at different truck stop areas in Florida.

They suggest that the span between the sub structures be bridged with open web joists, which would then have the same style of solar panels as ground mounting hardware attached to them. This comes with a cost of approximately $5.00 per liner foot. This design would allow for air movement and daylight. Each panel will require a footprint of about 23 square feet to allow for shading. This assumes no tracking system.

Cost of Mounting Hardware for Floating Panels
For the water retention ponds a floating sub structure would be required. These structures would consist of an open web joist spanning floating dock boxes. The solar panels would then be mounted to the top of the web joist and the whole structure would be attached to piles at the end of each row as needed. There are a range of different dock boxes which could be sized to support that weight of the panels and joist. Due to the unknown weight of both the panels and the web, joist sizing for the dock boxes cannot be determined exactly. However, assuming a conservative joist size, the estimated cost of the mounting system on floating panels would be in the range of 1.75 times that of the ground mounted. This assumes no tracking system. Table 4.1 shows a mounting hardware cost comparison for the viable solar panel options.

Option	Cost ($/watt)
Ground Panels	1.00
Panels Side-mounted on Noise Walls	1.20 – 1.50
Thin Film Panels	0.00
Panels mounted on Truck and Car Parking	1.80
Floating Panels	1.75

Table 4.1 Mounting Hardware Cost Comparison

ELECTRICAL ISSUES

As part of this study, an inspection was completed of the Turkey Lake facilities. The Turkey Lake campus has several buildings serving different functions. There are the Headquarters building, Operations building, Florida Highway Patrol (FHP) building, Maintenance building, and the Service Plaza. The electricity for the facilities are supplied from Progress Energy. Progress has three separate services at Turkey Lake. There is one for the Headquarters building, one for Operations, FHP, and Maintenance, and one for the Service Plaza. The Headquarters, Operations, FHP, and Maintenance buildings were built in 2000, and are of modern construction. The electric distribution uses Square D components that are readily available, and has adequate space for connecting in feeds from a photovoltaic system. The Service Plaza facilities are very old; however, the Service Plaza is about to undergo a major remodeling and the interconnection of a photovoltaic system could be coordinated with the renovation.

Table 4.2 depicts a Net Zero Energy system which is also shown in Table 3.2. This system will be used to discuss the regulatory issues that will impact this solar study. Note that only Phases 1 through 4 are needed to supply the 3.8 MW peak power system needed to meet all the energy needs of the Plaza. In fact there are many combinations of Phases and fractions of Phases that could produce 3.8 MW of peak power.

Phase	Description	Scenario	System Size (MW)
1	Open Area System	A. Rail Mounted Crystalline	2.00
2	Building Roofs	A. Solyndra	0.20
3	Employee Parking		1.00
4	Visitor Parking	A. Engineered Structure (Crystalline)	0.60
5	Truck Parking		0.00
6	Noise Walls		0.00
7	Retention Ponds		0.00
8	Education/Marketing		0.00
Total			**3.80**

Table 4.2 A Net Zero Energy scenario for the Turkey Lake Service Plaza

Progress Energy Issues

There are two considerations when choosing the method of grid connection. One method is to connect the PV system behind the meter. In this configuration, the PV system will reduce the amount of power consumed, reducing purchased energy and reducing demand. If, at any time, the amount of produced power exceeds consumption, then the electric utility will purchase the excess energy. The purchase price of that energy will be either through net metering or based on the avoided cost of production. Net metering is by far more favorable. Although energy prices vary, for the Turkey Lake facilities, the average cost for kWh was approximately $0.08/kWh in 2008, and was $0.097/kWh in April of 2009, whereas the avoided cost of production is about $0.03/kWh. Progress Energy allows net metering installations up to 2 MW. There are three electrical service points at Turkey Lake, which would allow up to 6 MW of standby capacity to be installed.

In order to keep within Progress Energy's net metering requirements, the overall size of the installation would need to be no larger than 3.8 MW. Considering that there are three meter installations at Turkey Lake, this would limit the maximum installed size to 6 MW. Net metering allows the customer to offset the purchased energy. This means that during the monthly billing cycle, the total photovoltaic generated energy should not exceed the total consumed energy. Figure 4.3 shows the historical usage for all buildings at Turkey Lake for 2008. Table 4.4 shows the monthly consumption for all facilities at Turkey Lake compared with the output of a 3.8 MW fixed panel PV installation. The data is based on simulated results using recorded weather data from Orlando International airport. For a 3.8 MW PV system, the monthly energy output exceeds the historical consumption for 6 out of the 12 months. For these months, the expense column shows the estimated cost of purchasing energy from Progress Energy at $0.104/kWh. For the six months where production exceeded consumption, the revenue column shows the estimated revenue from selling the excess energy to Progress Energy at their cost of production, which is currently about $0.035/kWh.

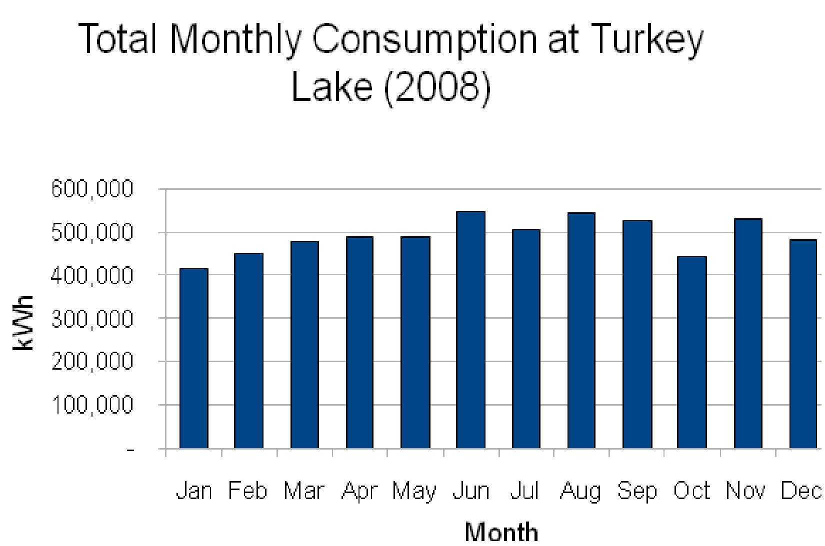

Figure 4.3 2008 Total Monthly Consumption Compared with a 3.8 MW Fixed Panel PV Installation

	Turkey Lake Consumption (kWh)	3.8 MW PV Output (kWh)	Purchased Energy (kWh)	Sold Energy (kWh)	Expense	Revenue
January	415,500	430,203		14,703		$ 515
February	450,180	443,916	6,264		$ 651	
March	476,760	582,180		105,420		$ 3,690
April	486,840	641,481		154,641		$ 5,412
May	488,160	628,112		139,952		$ 4,898
June	545,940	527,481	18,459		$ 1,920	
July	504,960	534,316		29,356		$ 1,027
August	542,160	505,060	37,100		$ 3,858	
September	524,940	493,354	31,586		$ 3,285	
October	443,820	499,525		55,705		$ 1,950
November	530,340	480,146	50,194		$ 5,220	
December	482,280	454,139	28,141		$ 2,927	
	5,891,880	***6,219,912***			***$ 17,861***	***$ 17,492***

Table 4.3 Energy Consumption for the Turkey Lake Service Plaza in 2008 Compared with the 3.80 MW PV System Output

Firm Standby Charges

If the PV system fails, there are two options to provide backup power. Progress Energy can provide this through a firm standby agreement. Under this agreement, Progress will keep excess capacity in its system to support the backup needs of the Turkey Lake Plaza. Based on the recent billings and a net-zero scheme shown in figure 4.3, the firm standby charge would be approximately $3,000/month. A second option is to use the existing standby diesel generators. The other option is to use the three existing1-MW generators. Each of these has more than adequate capacity for the load, and provide backup power in the event of total or partial failure in the PV system.

Equipment Discussions

The major components of a grid-connected photovoltaic system are the PV panels, inverters, and the interconnection wiring. The PV panels convert solar energy into DC electrical power. Inverters are used to convert the DC electrical power to AC electrical power.

The PV panels have no moving parts, and are very reliable and durable. Manufacturers offer these panels with 25 year warranties. Inverters have improved in recent years, and now have efficiencies of about 95%. However, the inverters have a shorter lifespan than the PV panels due to transients from the grid or photovoltaic (PV) generator, component aging, and operation beyond the designed limits (Ireland 2009). Currently, inverters have a mean time between failure (MBTF) of five to ten years (Navigant 2006). An independent failure analysis of the Xantrex inverters reported a predicted MTBF of 68,960 Hours (7.9 years) for the 500 kW model, and 52,400 Hours (6.0 years) for the 100 kW and 250 kW models (West 2008).

Table 4.3 shows the estimated costs of installing an inverter for the Xantrex models. The inverters are NEMA 3R rated and designed to be installed outdoors. The price estimate includes the cost of installing a concrete pad, unloading and connecting the inverter.

Schematic Drawings

Based on a site review and the findings of this feasibility study, a set of schematic electrical drawings were prepared to describe the infrastructure items related to the electrical installation. These drawings are included in Appendix C. Drawing E1 provides an overview of the site, and drawings E2 and E3 give additional details.

The Turkey Lake facilities are connected to the grid at three separate points. There is one near the back of the SunWatch Building, the Operations Building, and the Law Enforcement Building. The second point is slightly north of the Service Plaza, which serves the Service Plaza, Toll Operations, and the gas station. The third point is on the south side of the Headquarters Building, which serves the Headquarters Building. The schematic details of the suggested modifications to each of these service points is shown on sheet E2. At each of these points, there is an existing Cutler-Hammer externally mounted service switch that feeds a paralleling switch in an existing 1 MW standby generator. The feed then continues from the standby generator to the buildings served. The suggested change is to add the PV connection between the existing Cutler-Hammer service switch and the existing standby generator. As the PV capacity is similar to the capacity of the standby generator, the existing infrastructure should be capable of sustaining this connection provided that controls are installed to ensure that PV system and generator cannot operate at their combined maximum outputs.

Detail 3 on sheet E2 shows the connection for the Headquarters Building. This detail is different in that it includes a connection to PV mounted noise walls. If the TPE elects to install PVs on the noise walls, a feed from to the north bound lane would need to be bored under the highway. Detail 3 shows the additional equipment necessary to make this connection. The detail notes the recommendation of using step-up and step-down transformers to raise the distribution voltage from 480V to 4,160V. This is needed to keep distribution losses below 3%.

Sheet E3 shows the details required to tie the individual PV panels to the inverter. Two details are shown for a 100kW and a 250kW inverter, which represent commercially available PV inverters for a large scale PV installation.

Lighting Protection

The fundamental principle in providing lightning protection is to provide a means where lightning can enter or leave the ground without resulting in damage or loss of life. If the current from a lightning strike flows through high impedance materials such wood, brick, stone, or concrete, then the resulting heat and mechanical forces can damage the material. An effective lightning protection system provides a means to direct the current through a low impedance material. Metallic structures are unlikely to be damaged by the heat and mechanical forces if there is sufficient metal to carry the current.

The parts of structures most likely to be struck by lightning are the highest points, such as chimneys, ventilators, flagpoles, towers, gables, ridges, and parapets. The edges and corners of the roof are the parts most likely to be struck for flat and low slope roof. The roofs of the buildings at the Turkey Lake facilities are currently protected with lightning air terminals and a system of conductors to connect the terminals to the earth. For the photovoltaic cells installed on the roofs at the Turkey Lake facilities, care should be exercised if the cells are installed higher than the parapet walls, as these will now be the highest points and most likely to be struck.

Photovoltaic cells, like all electrical components, will be damaged as a result of a direct lighting strike. The standard approach for mitigating this damage is to have an effective grounding system and to employ surge suppressors on the DC connection to the inverters, and on the AC connections from the inverters back to the grid. There is some anecdotal evidence that the installation of lightning air terminals on masts higher than the array of ground mounted photovoltaic arrays will provide some additional protection by attracting lightning strikes and directing the resulting current flow away from the photovoltaic cells. However, facilities using this approach still have occasional photovoltaic cell damage due to lightning strikes. For additional information on effective lightning protection, please refer to NFPA 780 – Standard for Installation of Lightning Protection Systems.

Cost Estimates

The layout on drawings E1, E2, and E3 in Appendix C indicate a 3.8 MW PV system, which is large enough to make the entire service plaza Net Zero Energy. The cost of the various types of PV panels are covered in Chapter 2, whereas this chapter presents estimates for the additional infrastructure. The electrical system would require the addition of inverters to convert the DC output of the PV panels to AC power, electrical switchgear to safely connect the PV system to the existing electrical infrastructure, and the conduit and wire to connect all of these devices. Inverter pricing for Xantrex inverters are shown in Table 4-4. For a 3.8 MW installation of inverters with a 10 year warranty, the cost would be approximately $1.75 million. The additional switchgear, conduit, and wire would add an additional $950K. This would bring the total estimated cost to $2.7 million.

Inverter Costs	*Installed Cost*
Xantrex GT-100-480, 100kW, 3-ph 480 Vac	$ 64,100
Xantrex GT 100 Warranty Extension, from 5 years to 10 years	$ 4,900
Xantrex GT-250-480, 250kW, 3-ph 480 Vac	$ 102,400
Xantrex GT-250 Warranty Extension, from 5 years to 10 years	$ 7,300

Table 4.4 Installed Cost of Inverters

SUMMARY

The costs of physically mounting PV panels within the service plaza site show that the least expensive option is to use a roof mounted system. However, the roof area is not large enough to meet the annual energy needs. Also, the roof area is not visible to the public, and does not meet the criteria of making the Turkey Lake plaza a showcase for the traveling public. If a net-zero of larger sized system is installed, the roof areas should be considered due to the lower cost of installation. For a smaller showcase installation, the open areas on the ground would be preferable as they are highly visible. Ground mounted systems are also a good alternative due to the lower mounting costs. The mounting cost for other areas such as the noise walls, parking areas, and retention ponds are provided if additional PV capacity is desired.

Using Progress Energy's existing rate structure, a PV system of up to 6 MW of total capacity could be installed and operate under net-metering. A 3.8 MW system is recommended for net-metering, as this would meet the annual energy consumption. Producing power beyond consumption is not recommended for a net-metering installation as the purchase price for power produced above consumption is very low. For larger systems, a power purchase agreement or developer owned installation should be pursued.

The lifespan of the PV system components are not the same. Whereas the PV panels have a warranted lifespan of 25 years, the inverters have an average MBTF of 6 to 8 years. Inverters are available with 5 or 10 year warranties. As the inverters are a significant portion of the cost of the infrastructure, the cost of replacing these over the 25 year lifespan of the PV panels should be included. Based on a fixed panel system, a 3.8 MW PV installation would meet the annual energy consumption of the plaza. The electrical infrastructure for such a system would have an estimated cost of $2.7 million plus the cost of the PV panels.

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CHAPTER 5
INNOVATIVE FINANCING OPTIONS

A thorough review of financing options for the Turnpike Enterprise Plaza Solar Research Project was conducted during the course of research into the technical options. The primary goal of this effort was to determine how to minimize the initial capital cost to the FTE in the execution of the project. Three major options were analyzed:

(1) Ownership
The FTE would fund, own, insure, operate, and maintain the solar equipment, controls, and electrical connections that would be installed on the Turkey Lake Complex and adjacent noise walls. It would call for the FTE to fund the installation using one or more mechanisms: a bond or loan that would be repaid based on the stream of energy savings, corporate sponsorships, funding from the FTE budget, funding by a State appropriation, and revenue derived from Carbon Credits and/or Green Power Sales. FTE ownership of the solar energy infrastructure on the Turkey Lake Service Plaza, with financing via a combination of the following:

- (a) Bond/loan, repaid by electricity savings
- (b) Corporate sponsorship
- (c) Carbon credits
- (d) Green Power sales
- (e) State appropriation
- (f) Turnpike Enterprise budget or allocation

(2) Leasing
This would be a contractual arrangement between the FTE and a utility or other entity in which the FTE would provide its property and buildings as areas where solar installations would be located. The capital cost to the FTE would be negligible and the responsibility for maintaining and operating the solar energy power system would be that of the utility or other entity. The entity owning the solar energy equipment would benefit by having an addition to their renewable energy portfolio, from tax credits, from providing green power to green building projects, and from carbon credits. The FTE would benefit through leasing fees or reduced energy rates, including but not limited to open areas, parking lots, and building rooftops. This option could include electric car recharging stations and infrastructure. The developer of the solar project would preferably have a Purchased Power Agreement (PPA) in place with Progress Energy or with another utility. The developer can then take advantage of a wide range of options for financing the project:

- (a) ARRA 2009 grant
- (b) Accelerated depreciation of the property
- (c) Carbon credits
- (d) Green Power sales

(3) A combination of (1) and (2)
A possible combination for the FTE is for a developer to come in and finance the installation. The developer would take advantage of the following:

- (a) ARRA 2009 grant
- (b) Accelerated depreciation of the property

Once the property is depreciated out in 6 years, the developer could turn over the property to the FTE. During the 6 years where the developer owns the property they could sell the power to the FTE at a lower rate, which would allow the FTE to have a net revenue from energy savings.

COST PER WATT ANALYSIS

The cost of solar is measured in dollars per Watt. As the cost of the installed system rises so does the dollars per Watt. Figure 5.1 shows the correlation between the total cost of the system and dollars per Watt installed. The figure is based on a net zero scenario of 3.80 Megawatts (MW). The target range for a cost per Watt is between $4.50 and $6.00. This would put the total cost of the system between $15,200,000 and $22,800,000.

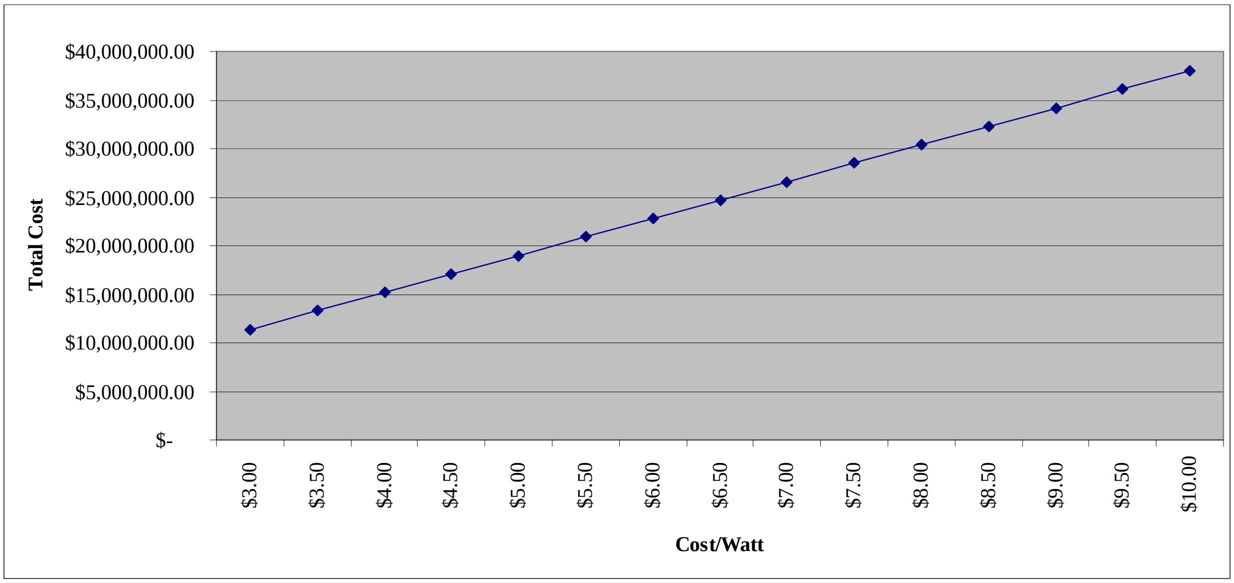


Figure 5.1 Cost/Watt vs. Total Cost of PV for 3.80MW

Figure 5.2 examines the net cost per Watt of installed solar. The net cost is the total cost minus the funds raised via the either the ownership option or lease option. The more money brought in to offset the initial cost, the less the cost per Watt. The dollars in Figure 5.2 represent the capital that would need to be secured to finance the new cost basis. The new cost basis would be the capital needed after initial fundraising from Options 1 and 2. As shown in Figure 5.2, if the net initial cost/Watt was $0.80, then the net initial cost of the 3.80MW system would be $3,040,000.00. The equation for this is (cost/Watt) x (number of Watts) = Total Cost

$$(\$0.80 \times 3{,}800{,}000) = \$3{,}040{,}000.00$$

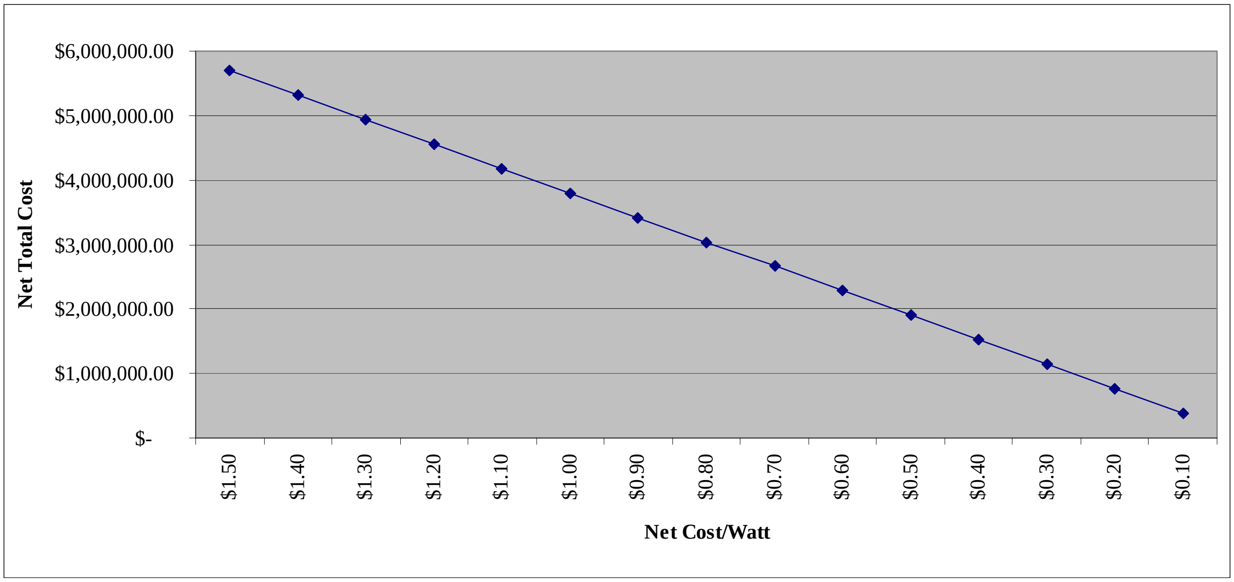


Figure 5.2 Net Cost/Watt vs. Net Total Cost of PV for 3.80MW

OWNERSHIP OPTION

The FTE can own and operate the solar installation at Turkey Lake Service Plaza and directly reap the benefits of generating the electricity produced by the solar installation. The financing for this option would be a combination of low interest loans, bonds, and income derived from carbon credits and green power sales.

Bond/Loan

The annual savings in electricity, or the net revenue of the Plaza, will be the payment of the bond/loan. The maturity term can be up to 20 years. The greater the term, the less money from other sources is needed to finance the project. Table 5.1 and Figure 5.3 show the cumulative net revenue generation during a 20 year study for a 3.80MW system. The amount is based on the simulated production from the PV minus the historical consumption data from the Turkey Lake Service Plaza. As either result changes so does the Net Revenue. As consumption is reduced the net revenue would increase. These numbers also reflect the following assumptions: 3.0% energy inflation, 1.5% general inflation, 2.0% discount rate, and net metering of the 3.80MW system.

Bond Issue Amounts based on Years					
Years		PW Net Revenue	Years		PW Net Revenue
1	$	523,277.74	11	$	5,468,830.95
2	$	1,041,170.34	12	$	5,935,827.98
3	$	1,553,733.21	13	$	6,398,019.07
4	$	2,061,021.21	14	$	6,855,453.67
5	$	2,563,088.62	15	$	7,308,180.73
6	$	3,059,989.16	16	$	7,756,248.69
7	$	3,551,776.02	17	$	8,199,705.51
8	$	4,038,501.81	18	$	8,638,598.63
9	$	4,520,218.61	19	$	9,072,975.03
10	$	4,996,977.99	20	$	9,502,881.19

Table 5.1 Net Revenue from energy savings

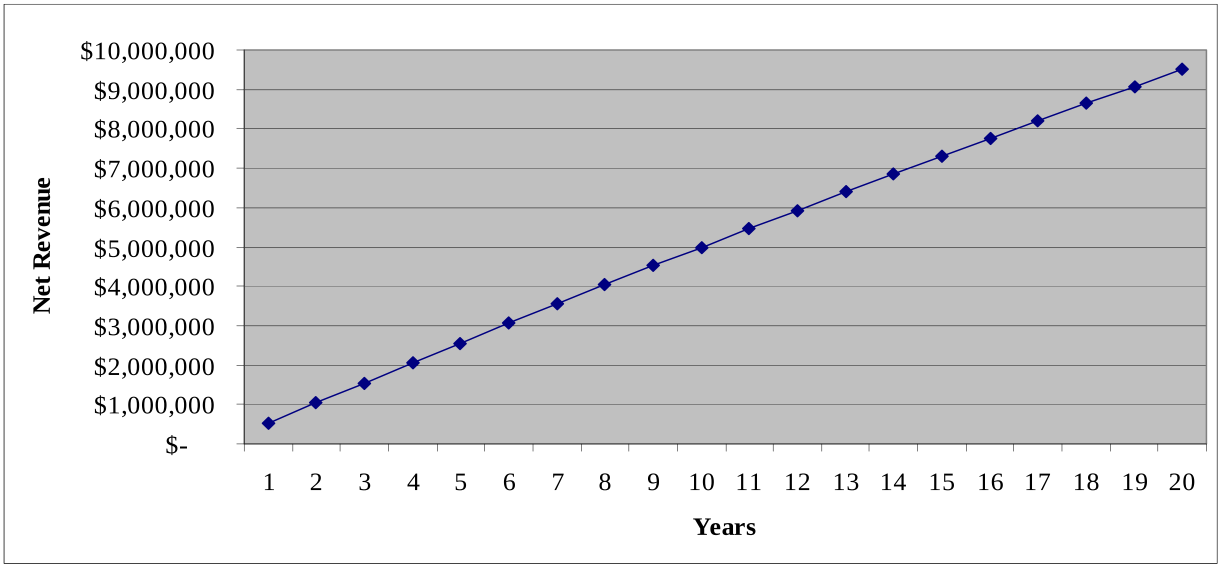


Figure 5.3 Net Revenue Generated from the Energy Savings for the life of the system

Corporate Sponsorship

Corporate Sponsorship is where companies/manufacturers/vendors set forth a certain amount of support for the project, whether it is a monetary sponsorship or an in-kind donation. The donations can include equipment and labor. The greater the sponsorship level, the lower the amount of the bond required to finance the system. Also, the greater the sponsorship the lower the cost basis will be due to the decrease in initial cost for the system.

Carbon Credits

The value of Carbon is based on a market in which carbon is traded. The value is calculated by taking the life cycle cost (LCC) of the Net Energy Cost and multiplying that number by the dollar value of carbon/kilowatt hour (kWh). That number is then divided by the 2000 lbs/ton to determine the value of carbon over the life of the system. Since the value of carbon fluctuates with the market, the projected value could change, so with that, the value could be taken annually as the fluctuation in the market occurs.

Green Power Sales

Renewable Energy Credits (RECs) are credits that are sold, traded, or bartered from the production of renewable energy. A single REC is recorded after 1,000 kWh or 1 MWh has been produced. The current rate for a REC is valued below $0.01/kWh and is projected to be between $0.014 and $0.019/kWh. At $0.01/kWh, 1 MWh of production would be worth $10.00, and at $0.014 and $0.019/kWh that is $14.00 and $19.00 respectively. Some states have a Renewable Portfolio Standard (RPS), which sets guidelines which require a certain level of the total electrical energy in the state be generated from renewable resource within a specific period of time. At this point Florida does not have a RPS.

State Appropriation

A state appropriation to support renewable energy projects for state facilities is a potential sources of revenue for a project of the type described in this report. As of December 2009, there has not been a request for proposal for a solar installation of this type or size.

Turnpike Enterprise Budget or Allocation

One additional source of funding for a solar energy system at the Turkey Lake Service Plaza is funding obtained through the budgetary process by FTE and FDOT. In the event that substantial funding is obtained through bonds and sponsorship, a modest investment by the State to support this project could be requested.

NET ZERO ENERGY AND MAXIMUM POWER SCENARIOS

The solar energy system costs depend on the PV technology as well as the mounting system required for installation. The building roofs are the least expensive because they require the solar PV panels and only minimal mounting hardware. The open areas, parking, noise wall, and retention ponds are more expensive per watt because they require fabricated mounting systems.

Phases	Cost/Watt
Phase 1: Open Areas	\$4.00 - \$7.00
Phase 2: Building Roofs	\$3.00 - \$4.00
Phase 3: Employee Parking	\$5.00 - \$6.00
Phase 4: Visitor Parking	\$5.00 - \$6.00
Phase 5: Truck Parking	\$5.00 - \$6.00
Phase 6: Noise Walls	\$4.50 - \$5.50
Phase 7: Retention Ponds	\$6.50

Table 5.2 Cost/Watt range for each phase

Tables 5.3 and 5.4 below depict the Net Zero Energy scenario with FTE Ownership. For the Net Zero Energy scenario, there are many ways to produce the 3.80 MW peak power that would be required and Table 5.3 shows just one approach. In this approach Phase 1, 2, 3 and 4 are employed while the other phases are not required to contribute to the electrical energy needs of the Turkey Lake Service Plaza. Note also that only 76% of Phase 3 (employee parking) and 80% of the Phase 4 (visitor parking).

Tables 5.5 and 5.6 below depict the Maximum Energy scenario with FTE Ownership. In this scenario, all seven Phases are employed at 100% to produce a peak power of 9.15 MW.

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production
PHASE 1	Open Area System	Scenario A Mean	100%	1.97	$ 9,835,000.00	3,221,000
PHASE 2	Building Roofs	Scenario A Mean	100%	0.21	$ 856,000.00	350,468
PHASE 3	Employee Parking	Scenario A Mean	76%	1.02	$ 6,124,080.00	1,671,568
PHASE 4	Visitor Parking	Scenario A Mean	80%	0.60	$ 3,590,400.00	980,000
PHASE 5	Truck Parking		100%	0.00	$ 0.00	0
PHASE 6	Noise Walls		100%	0.00	$ 0.00	0
PHASE 7	Retention Ponds		100%	0.00	$ 0.00	0
PHASE 8	Education/Marketing					
Total				**3.80**	**$ 20,405,480**	**6,223,036**
Average $/Watt					**$ 5.37**	

Table 5.3 Ownership Option (Net Zero Energy Case)

OWNERSHIP OPTION				
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA				
Annual Energy Cost	$ 495,432			
Annual Energy Consumption	5,891,880	kWh		
Utility Rate	**$ 0.08**			
SYSTEM COST				
Average Cost/Watt	System Size, kW	System Cost		
$ 5.37	3,800	$ 20,405,480		
SYSTEM OUTPUT				
kWh/year	Electricity Cost/kWh	Annual Value		
6,223,036	$ 0.08	$ 523,278		
CARBON MITIGATION				
Lbs Carbon/kWh	Carbon Value, $/ton	Annual Mitigation		
1.33	$ 20.00	$ 82,766		
FINANCING OPTIONS				
General Inflation	1.5%			
Energy Inflation	3.0%			
Discount Rate	2.0%			
Bond Term, years	20			
REC Premium (until 2017)	$ 0.01	per kWh		
Sources				
Sponsorships	25%	$ 5,101,370		
Bond		$ 9,502,881		
Carbon and REC Value		$ 2,741,823		
Total Funding				**$ 17,346,074**
Difference				$ (3,059,406)
$/kWh				**$ 0.0439**

Table 5.4 Ownership Option (Net Zero Energy Case – Initial Cost Example)

The historical data was provided by the FTE. The system cost numbers were derived from Table 5.3, and the costs change as Table 5.3 is altered. The kWh/year under system output is the result of a PV simulation and that number was used to determine the annual value of the production. The carbon value is based on the present rate at which Carbon trades for on Carbon exchange markets. It is a number that fluctuates. The financing option assumptions are shown and if altered will affect the total funding and the difference.

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production
PHASE 1	Open Area System	Scenario D Maximum	100%	2.55	$ 15,282,000.00	5,364,191
PHASE 2	Building Roofs	Scenario C Maximum	100%	0.47	$ 1,864,000.00	763,168
PHASE 3	Employee Parking	Scenario A Mean	100%	1.34	$ 8,058,000.00	2,199,431
PHASE 4	Visitor Parking	Scenario A Mean	100%	0.75	$ 4,488,000.00	1,225,000
PHASE 5	Truck Parking	Scenario A Maximum	100%	0.66	$ 3,984,000.00	1,087,433
PHASE 6	Noise Walls	Scenario A Maximum	100%	1.86	$ 10,208,000.00	2,868,413
PHASE 7	Retention Ponds	Scenario A Maximum	100%	1.53	$ 9,912,500.00	2,497,493
PHASE 8	Education/Marketing					
Total				**9.15**	**$ 53,796,500**	**16,005,129**
Average $/Watt					**$ 5.88**	

Table 5.5 Ownership Option (Max Energy Case)

OWNERSHIP OPTION					
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA					
Annual Energy Cost	$	495,432			
Annual Energy Consumption		5,891,880	kWh		
Utility Rate	**$**	**0.08**			
SYSTEM COST					
Average Cost/Watt		System Size, kW	System Cost		
$ 5.88		9,149	$ 53,796,500		
SYSTEM OUTPUT					
kWh/year		Electricity Cost/kWh	Annual Value		
16,005,129	$	0.08	$ 1,345,827		
CARBON MITIGATION					
Lbs Carbon/kWh		Carbon Value, $/ton	Annual Mitigation		
1.33	$	20.00	$ 212,868		
FINANCING OPTIONS					
General Inflation		1.5%			
Energy Inflation		3.0%			
Discount Rate		2.0%			
Bond Term, years		20			
REC Premium (until 2017)	$	0.01	per kWh		
Sources					
Sponsorships		25%	$ 13,449,125		
Bond			$ 24,440,619		
Carbon and REC Value			$ 7,051,741		
Total Funding				**$**	**44,941,484**
Difference				$	(8,855,016)
$/kWh				**$**	**0.0380**

Table 5.6 Ownership Option (Max Energy Case – Initial Cost Example)

The initial cost of the system jumps from $20,405,480 to 53,796,500, but the cost per kWh only increases $0.01 over the 20 year study of the system using the variables in the table. Again should those change the cost per kWh would change. In looking at the net cost, it increases a little more than double. This is meant to show that with the larger system at a similar $/Watt, $5.37 and $5.88, the larger system is feasible. Figures 5.4 and 5.5 show the discounted payback for the net zero system and the max power system.

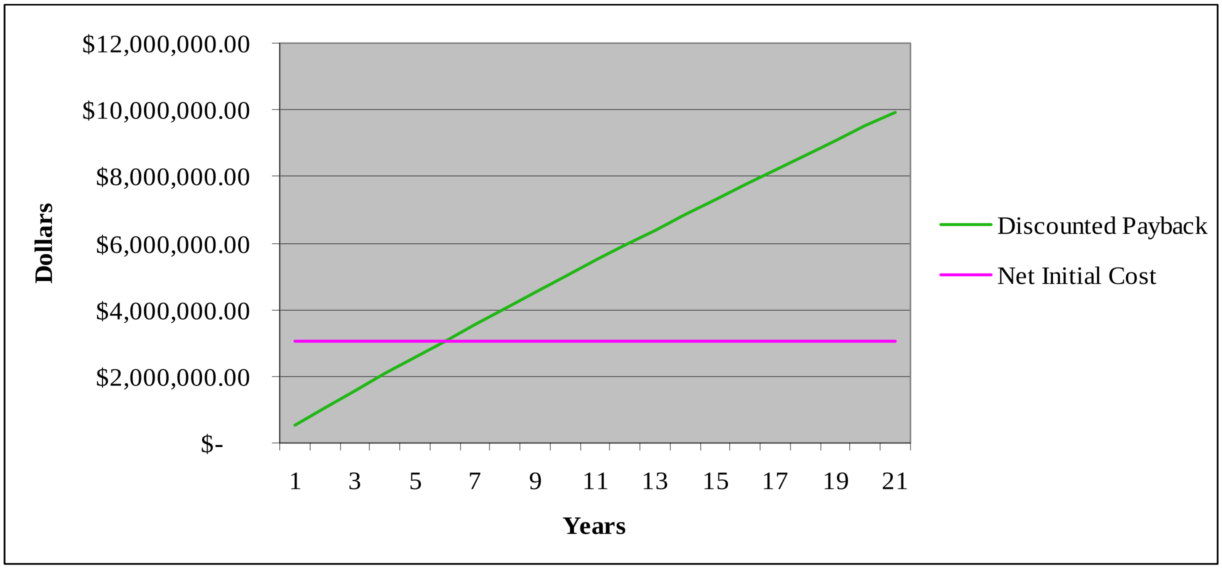


Figure 5.4 Ownership Option - Discounted Payback of the 3.80MW Net Zero Energy Case

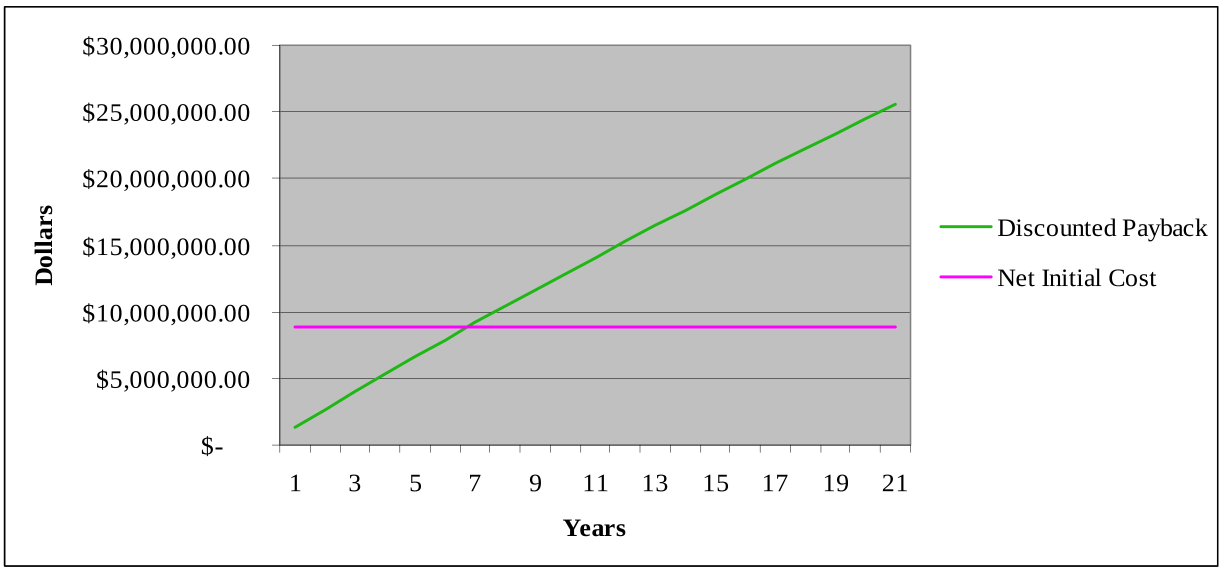


Figure 5.5 Ownership Option - Discounted Payback of the 9.15MW Max Energy Case

The Figures show that the two cases, using 20 year bonds from net revenue and 25% sponsorship. The difference in years for payback of the net zero and max energy cases are 6 and 7 years respectively.

LEASE OPTION

A private developer can own and operate the solar installation at the Turkey Lake Complex and directly reap the benefits of generating the electricity produced by the solar installation. The financing for this option would be a combination of ARRA grants or tax credits, income derived from carbon credits and green power sales, accelerated depreciation, and a PPA.

ARRA 2009 Overview
As part of the American Recovery and Reinvestment Act that was signed into law February 17, 2009, 30% cash grants can be taken instead of 30% Investment Tax Credits (ITC). Section 1603 of the Act's tax title, the American Recovery and Reinvestment Tax Act, appropriates funds for payments to persons who place in service specified energy property during 2009 or 2010 or after 2010 if construction began on the property during 2009 or 2010 and the property is placed in service by a certain date known as the credit termination date. The credit termination date for solar projects is January 1, 2017. The U.S. Treasury will make Section 1603 payments to qualified applicants in an amount generally equal 30% of the basis of the property. Applications will be reviewed and payments made within 60 days from the later of the date of the complete application or the date the property is placed in service. Applicants who receive payments for property under Section 1603 are not eligible for the ITC under sections 45 and 48 of the Internal Revenue Code (IRC) with respect to the same property for the taxable year of the payment or subsequent years. In addition, any credit under section 48 previously allowed with respect to progress expenditures for the property will be recaptured. At this point the grant is guaranteed with respect to the termination dates and guidelines. For detailed information regarding the program guidance, terms and conditions, and application for the grant refer to Appendix D.

Modified Accelerated Cost Recovery System
Accelerated Depreciation
Accelerated Depreciation is a six year depreciation where the property is depreciated based on the original or adjusted cost basis. Accelerated Depreciation is a percentage taken off of taxes annually over six years. Table 5.7 shows the Modified Accelerated Cost Recovery System (MACRS) depreciation schedule is as follows:

MACRS	
Year	Depreciation Rate
1	20.00%
2	32.00%
3	19.20%
4	11.52%
5	11.52%
6	5.76%

Table 5.7 MACRS Accelerated Depreciation Schedule

The depreciation rate is multiplied by the original cost basis and is fully depreciated in 6 years. The cost basis will be adjusted depending on grants and other incentives that may lower the initial cost of the property. Table 5.8 shows the 1st year breakdown of a 3.80MW installation and Table 5.9 shows the 6 year depreciation. The depreciation is calculated from the cost basis not the initial cost of the property. Depreciation is taken after rebates, credits, and other incentives have been deducted.

MACRS Regular Depreciation		
Initial Cost		$ 20,405,480.00
ITC Grant		$ 6,121,644.00
New Cost Basis		**$ 14,283,836.00**
20%	1st Year Depreciation	$ 2,856,767.20
Net Initial Cost		**$ 11,427,068.80**

Table 5.8 First Year Depreciation for 3.80MW System

MACRS		
Year	Depreciation Rate	Annual Depreciation
1	20.00%	$ 2,856,767.20
2	32.00%	$ 4,570,827.52
3	19.20%	$ 2,742,496.51
4	11.52%	$ 1,645,497.91
5	11.52%	$ 1,645,497.91
6	5.76%	$ 822,748.95
Total		**$ 14,283,836.00**

Table 5.9 Accelerated Depreciation Schedule and Costs (3.80MW)

50% Bonus Depreciation

The federal Economic Stimulus Act of 2008, enacted in February 2008, included a 50% bonus depreciation (26 USC § 168(k)) provision for eligible renewable-energy systems acquired and placed in service in 2008. This provision was extended (retroactively to the entire 2009 tax year) under the same terms by The American Recovery and Reinvestment Act of 2009, enacted in February 2009. Currently there is no sign of extending the bonus depreciation past 2009, but through legislation it could. To qualify for bonus depreciation, a project must satisfy these criteria:

- the property must have a recovery period of 20 years or less under normal federal tax depreciation rules;
- the original use of the property must commence with the taxpayer claiming the deduction;
- the property generally must have been acquired during 2008 or 2009; and
- the property must have been placed in service during 2008 or 2009

If the property meets these requirements, the owner is entitled to deduct 50% of the adjusted basis of the property in 2008 and 2009. The remaining 50% of the adjusted basis of the property is depreciated over the ordinary depreciation schedule. The bonus depreciation rules do not override the depreciation limit applicable to projects qualifying for the federal business energy tax credit. Before calculating depreciation for such a project, including any bonus depreciation, the adjusted basis of the project must be reduced by one-half of the amount of the energy credit for which the project qualifies. With this depreciation option the 30% cash grant is reduced to 15%, and then the 50% bonus is taken from the 85% cost basis. Once the new cost basis has been established and the 50% has been taken, then the regular MACRS schedule is put into action. Table 5.10 shows the first year depreciation of the installation with the 50% bonus, and Table 5.11 shows the schedule. The net initial cost difference favors the 50% bonus option but both scenarios have the system depreciated out in 6 years.

MACRS 50% Bonus Depreciation		
Initial Cost		$ 20,405,480.00
ITC Grant		$ 3,060,822.00
New Cost Basis		**$ 17,344,658.00**
50%	Bonus Depreciation	$ 8,672,329.00
20%	1st Year Depreciation	$ 1,734,465.80
Net Initial Cost		**$ 6,937,863.20**

Table 5.10 First Year Depreciation with 50% Bonus Depreciation for 3.8MW System

MACRS 50% Bonus Depreciation		
Year	Depreciation Rate	Annual Depreciation
1	50%	$ 8,672,329.00
1	20.00%	$ 1,734,465.80
2	32.00%	$ 2,775,145.28
3	19.20%	$ 1,665,087.17
4	11.52%	$ 999,052.30
5	11.52%	$ 999,052.30
6	5.76%	$ 499,526.15
Total		**$ 17,344,658.00**

Table 5.11 Accelerated Depreciation with 50% Bonus for 3.8MW System

Carbon Credits

The value of carbon is based on a market in which carbon is traded. The value is calculated by taking the life cycle cost (LCC) of the Net Energy Cost and multiplying that number by the dollar value of carbon/kilowatt hour (kWh). That number is then divided by the 2000lbs/ton to get the value of carbon over the life of the system. Since the value of carbon fluctuates with the market, the projected value could change, so with that, the value could be taken annually as the fluctuation in the market occurs.

Green Power Sales

Renewable Energy Credits (RECs) are credits that are sold, traded, or bartered from the production of renewable energy. A single REC is recorded after 1,000 kWh or 1 MWh has been produced. The current rate for a REC is valued below $.01/kWh and is projected to be between $.014 and $.019/kWh. At $.01/kWh, 1 MWh of production would be worth $10.00, and at $.014 and $.019/kWh that is $14.00 and $19.00 respectively. Some states have a Renewable Portfolio

Standard (RPS), which sets guidelines to which states have to produce a certain percentage of renewable power by certain years. At this point Florida does not have a RPS.

Purchase Power Agreements

In general for a lease option, a Power Purchase Agreement (PPA) is desirable so that the developer will have an assured contract for sale of the electricity produced by the photovoltaic system. A PPA is a legal contract between an electricity generator and a host site owner or lessor. The host site owner or lessor purchases energy or capacity (power or ancillary services) from the PPA Provider (the electricity generator). Such agreements play a key role in the financing of electricity generating assets. Under the terms of a PPA, the PPA provider (the electricity generator) typically assumes the risks and responsibilities of ownership when it purchases, operates, and maintains the turnkey facility.

The PPA provider secures funding for the project, maintains and monitors the energy production, and sells the electricity to the host at a contractual price for the term of the contract. The term commonly ranges between 5 to 25 years. In some renewable energy contracts, the host has the option to purchase the generating equipment from the PPA provider at the end of the term, may renew the contract with different terms, or can request that the equipment be removed.

By clearly defining the output of the generating assets (such as a solar electric system) and the credit of its associated revenue streams, a PPA can be used by the PPA Provider to raise non-recourse financing from a bank or other financing counterparty.

Commercial PPA providers can enable businesses, schools, governments, and utilities to benefit from predictable, renewable energy.

In the United States, the solar power purchase agreement (SPPA) depends heavily on the existence of the solar investment tax credit. The SPPA relies on financing partners with a tax appetite who can benefit from the federal tax credit. Typically, the investor and the solar services provider create a special purpose entity that owns the solar equipment. The solar services provider finances, designs, installs, monitors, and maintains the project. As a result, solar installations are easier for customers to afford because they do not have to pay upfront costs for equipment and installation. Instead, customers pay only for the electricity the system generates.

Solar PPAs are now being successfully utilized in the California Solar Initiative's (CSI) Multifamily Affordable Solar Housing (MASH) program. This aspect of the successful CSI program was just recently opened for applications.

FINANCIAL ANALYSIS

The analyses shown in Tables 5.12 to 5.19 depict the net zero energy case and the max energy case. The two cases are split between the 50% bonus plus the MACRS and the MACRS only option. The variables are all the same throughout the analyses as to get a true reading for the net initial costs. The depreciation was not taken into account in the discounted payback period. It was only taken in to account for the net initial cost in the first year.

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production
PHASE 1	Open Area System	Scenario A Mean	100%	1.97	$ 9,835,000.00	3,221,000
PHASE 2	Building Roofs	Scenario A Mean	100%	0.21	$ 856,000.00	350,468
PHASE 3	Employee Parking	Scenario A Mean	76%	1.02	$ 6,124,080.00	1,671,568
PHASE 4	Visitor Parking	Scenario A Mean	80%	0.60	$ 3,590,400.00	980,000
PHASE 5	Truck Parking		100%	0.00	$ 0.00	0
PHASE 6	Noise Walls		100%	0.00	$ 0.00	0
PHASE 7	Retention Ponds		100%	0.00	$ 0.00	0
PHASE 8	Education/Marketing					
Total				**3.80**	**$ 20,405,480**	**6,223,036**
Average $/Watt					**$ 5.37**	

Table 5.12 Lease Option (Net Zero Energy Case)

LEASE OPTION				
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA				
Annual Energy Cost	$ 495,432			
Annual Energy Consumption	5,891,880 kWh			
Utility Rate	**$ 0.08**			
SYSTEM COST				
Cost per watt	System Size, kW	System Cost		
$5.37	3,800	$ 20,405,480		
SYSTEM OUTPUT				
kWh/year	Electricity Cost per kWh	Annual Value		
6,223,036	$ 0.08	$ 523,278		
CARBON MITIGATION				
Lbs Carbon.kWh	Carbon Value, $/ton	Annual Mitigation		
1.33	$ 20.00	$ 82,766		
FINANCING OPTIONS				
General Inflation	1.5%			
Energy Inflation	3.0%			
Discount Rate	2.0%			
Term of Analysis, years	8			
REC Premium (until 2017)	$ 0.01 per kWh			
Financing Sources				
PW of Net Revenue		$ 4,038,502		
Depreciation (1st Year)	20%	$ 2,856,767		
ARRA 2009 Grant	30%	$ 6,121,644		
Carbon and REC Value		$ 2,741,823		
Total Funding				**$ 15,758,736**
Difference				$ (4,646,744)
$/kWh				**0.043**

Table 5.13 Lease Option (Net Zero Energy Case – Initial Cost Example)

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production
PHASE 1	Open Area System	Scenario D Maximum	100%	2.55	$ 15,282,000.00	5,364,191
PHASE 2	Building Roofs	Scenario C Maximum	100%	0.47	$ 1,864,000.00	763,168
PHASE 3	Employee Parking	Scenario A Mean	100%	1.34	$ 8,058,000.00	2,199,431
PHASE 4	Visitor Parking	Scenario A Mean	100%	0.75	$ 4,488,000.00	1,225,000
PHASE 5	Truck Parking	Scenario A Maximum	100%	0.66	$ 3,984,000.00	1,087,433
PHASE 6	Noise Walls	Scenario A Maximum	100%	1.86	$ 10,208,000.00	2,868,413
PHASE 7	Retention Ponds	Scenario A Maximum	100%	1.53	$ 9,912,500.00	2,497,493
PHASE 8	Education/Marketing					
Total				**9.15**	**$ 53,796,500**	**16,005,129**
Average $/Watt					**$ 5.88**	

Table 5.14 Lease Option (Max Energy Case)

LEASE OPTION				
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA				
Annual Energy Cost	$ 495,432			
Annual Energy Consumption	5,891,880 kWh			
Utility Rate	**$ 0.08**			
SYSTEM COST				
Cost per watt	System Size, kW	System Cost		
$5.88	9,149	$ 53,796,500		
SYSTEM OUTPUT				
kWh/year	Electricity Cost per kWh	Annual Value		
16,005,129	$ 0.08	$ 1,345,827		
CARBON MITIGATION				
Lbs Carbon.kWh	Carbon Value, $/ton	Annual Mitigation		
1.33	$ 20.00	$ 212,868		
FINANCING OPTIONS				
General Inflation	1.5%			
Energy Inflation	3.0%			
Discount Rate	2.0%			
Term of Analysis, years	8			
REC Premium (until 2017)	$ 0.01 per kWh			
Financing Sources				
PW of Net Revenue		$ 10,386,690		
Depreciation (1st Year)	20%	$ 7,531,510		
ARRA 2009 Grant	30%	$ 16,138,950		
Carbon and REC Value		$ 7,051,741		
Total Funding				**$ 41,108,891**
Difference				$ (12,687,609)
$/kWh				**0.046**

Table 5.15 Lease Option (Max Energy Case – Initial Cost Example)

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost		Production
PHASE 1	Open Area System	Scenario A Mean	100%	1.97	$	9,835,000.00	3,221,000
PHASE 2	Building Roofs	Scenario A Mean	100%	0.21	$	856,000.00	350,468
PHASE 3	Employee Parking	Scenario A Mean	76%	1.02	$	6,124,080.00	1,671,568
PHASE 4	Visitor Parking	Scenario A Mean	80%	0.60	$	3,590,400.00	980,000
PHASE 5	Truck Parking		100%	0.00	$	0.00	0
PHASE 6	Noise Walls		100%	0.00	$	0.00	0
PHASE 7	Retention Ponds		100%	0.00	$	0.00	0
PHASE 8	Education/Marketing						
Total				**3.80**	**$**	**20,405,480**	**6,223,036**
Average $/Watt					**$**	**5.37**	

Table 5.16 Lease Option with the 50% Bonus (Net Zero Case)

LEASE OPTION (with 50% Bonus Depreciation)						
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA						
Annual Energy Cost	$	495,432				
Annual Energy Consumption		5,891,880	kWh			
Utility Rate	**$**	**0.08**				
SYSTEM COST						
Cost per watt		System Size, kW		System Cost		
$5.37		3,800	$	20,405,480		
SYSTEM OUTPUT						
kWh/year		Electricity Cost per kWh		Annual Value		
6,223,036	$	0.08	$	523,278		
CARBON MITIGATION						
Lbs Carbon.kWh		Carbon Value, $/ton		Annual Mitigation		
1.33	$	20.00	$	82,766		
FINANCING OPTIONS						
General Inflation		1.5%				
Energy Inflation		3.0%				
Discount Rate		2.0%				
Term of Analysis, years		8				
REC Premium (until 2017)	$	0.01	per kWh			
Financing Sources						
PW of Net Revenue			$	4,038,502		
Bonus Depreciation		50%	$	8,672,329		
Depreciation (1st Year)		20%	$	1,734,466		
ARRA 2009 Grant		15%	$	3,060,822		
Carbon and REC Value			$	2,741,823		
Total Funding					**$**	**20,247,942**
Difference					$	(157,538)
$/kWh						**0.001**

Table 5.17 Lease Option with the 50% Bonus (Net Zero Case – Initial Cost Example)

Phases	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production
PHASE 1	Open Area System	Scenario D Maximum	100%	2.55	$ 15,282,000.00	5,364,191
PHASE 2	Building Roofs	Scenario C Maximum	100%	0.47	$ 1,864,000.00	763,168
PHASE 3	Employee Parking	Scenario A Mean	100%	1.34	$ 8,058,000.00	2,199,431
PHASE 4	Visitor Parking	Scenario A Mean	100%	0.75	$ 4,488,000.00	1,225,000
PHASE 5	Truck Parking	Scenario A Maximum	100%	0.66	$ 3,984,000.00	1,087,433
PHASE 6	Noise Walls	Scenario A Maximum	100%	1.86	$ 10,208,000.00	2,868,413
PHASE 7	Retention Ponds	Scenario A Maximum	100%	1.53	$ 9,912,500.00	2,497,493
PHASE 8	Education/Marketing					
Total				**9.15**	**$ 53,796,500**	**16,005,129**
Average $/Watt					**$ 5.88**	

Table 5.18 Lease Option with the 50% Bonus (Max Energy Case)

LEASE OPTION (with 50% Bonus Depreciation)				
TURKEY LAKE SERVICE PLAZA HISTORICAL DATA				
Annual Energy Cost	$ 495,432			
Annual Energy Consumption	5,891,880 kWh			
Utility Rate	**$ 0.08**			
SYSTEM COST				
Cost per watt	System Size, kW	System Cost		
$5.88	9,149	$ 53,796,500		
SYSTEM OUTPUT				
kWh/year	Electricity Cost per kWh	Annual Value		
16,005,129	$ 0.08	$ 1,345,827		
CARBON MITIGATION				
Lbs Carbon.kWh	Carbon Value, $/ton	Annual Mitigation		
1.33	$ 20.00	$ 212,868		
FINANCING OPTIONS				
General Inflation	1.5%			
Energy Inflation	3.0%			
Discount Rate	2.0%			
Term of Analysis, years	8			
REC Premium (until 2017)	$ 0.01 per kWh			
Financing Sources				
PW of Net Revenue		$ 10,386,690		
Bonus Depreciation	50%	$ 22,863,513		
Depreciation (1st Year)	20%	$ 4,572,703		
ARRA 2009 Grant	15%	$ 8,069,475		
Carbon and REC Value		$ 7,051,741		
Total Funding				**$ 52,944,121**
Difference				$ (852,379)
$/kWh				**0.003**

Table 5.19 Lease Option with the 50% Bonus (Max Energy Case – Initial Cost Example)

Figures 5.6 to 5.9 show the discounted payback of their respective scenarios. Both lease options use 8 years for the Present Worth (PW) of net revenue. Figures 5.8 and 5.9 depict the discounted payback of the lease option with the 50% bonus. In these examples the net initial cost is $157,538.00 and $852,379.00 respectively. Figures 5.6 and 5.7 show the lease option, the option with the regular MACRS applied. At 8 years, the options have a net initial cost of $4,646,744.00

and $12,687,609.00. The years for the PW of net revenue could be increased, but it was important to show the two options with every variable the same except for the 50% bonus.

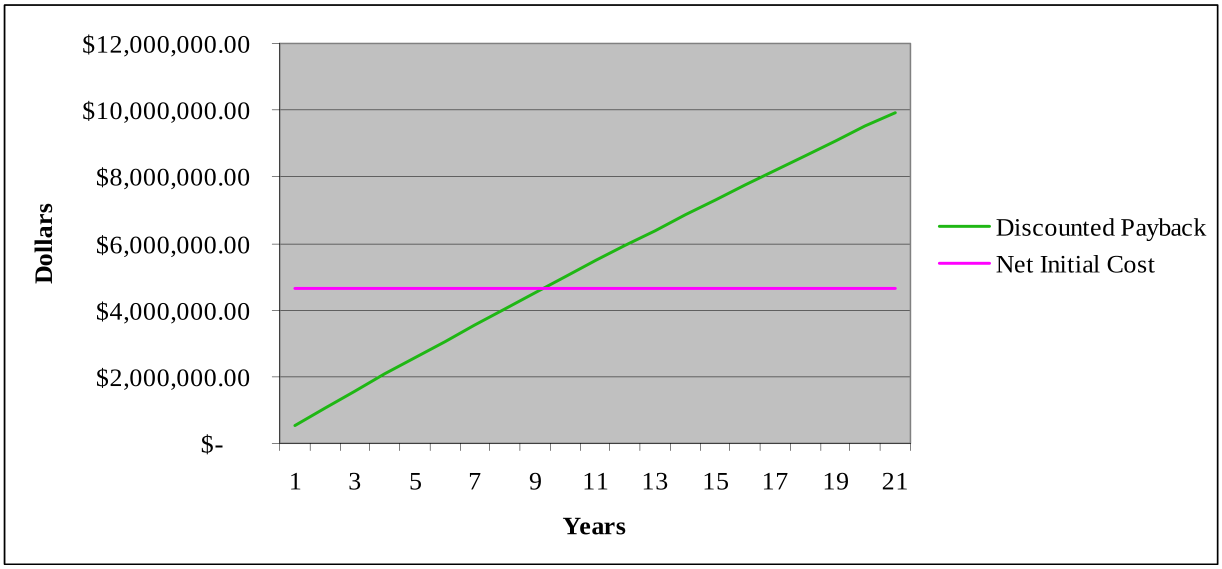


Figure 5.6 Lease Option - Discounted Payback of the 3.80MW Net Zero Energy Case

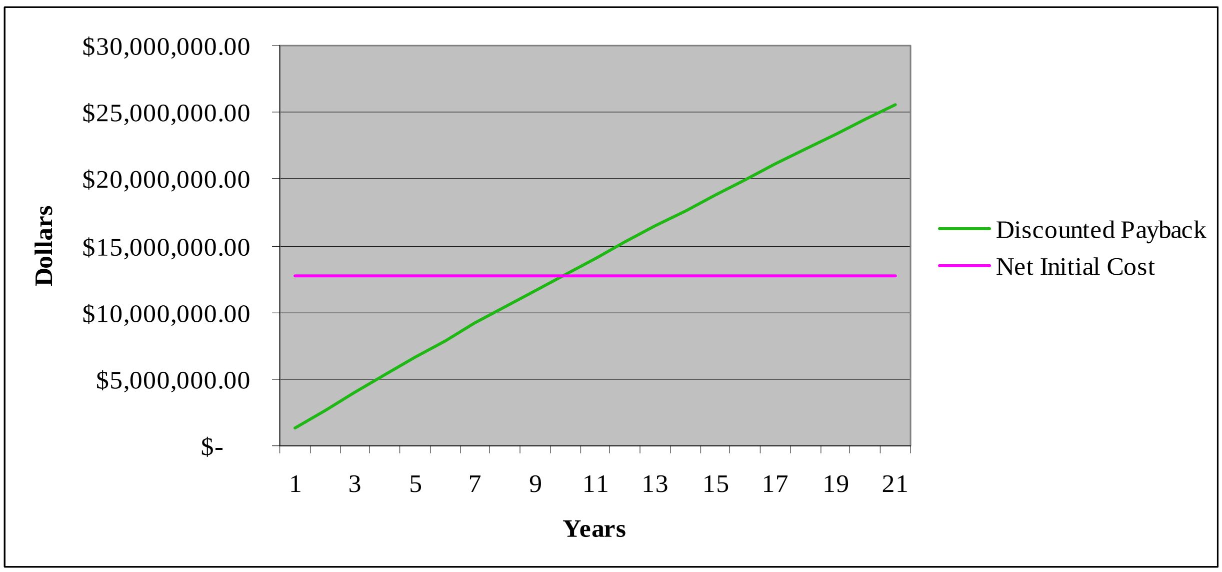


Figure 5.7 Lease Option – Discounted Payback of the 9.15MW Max Energy Case

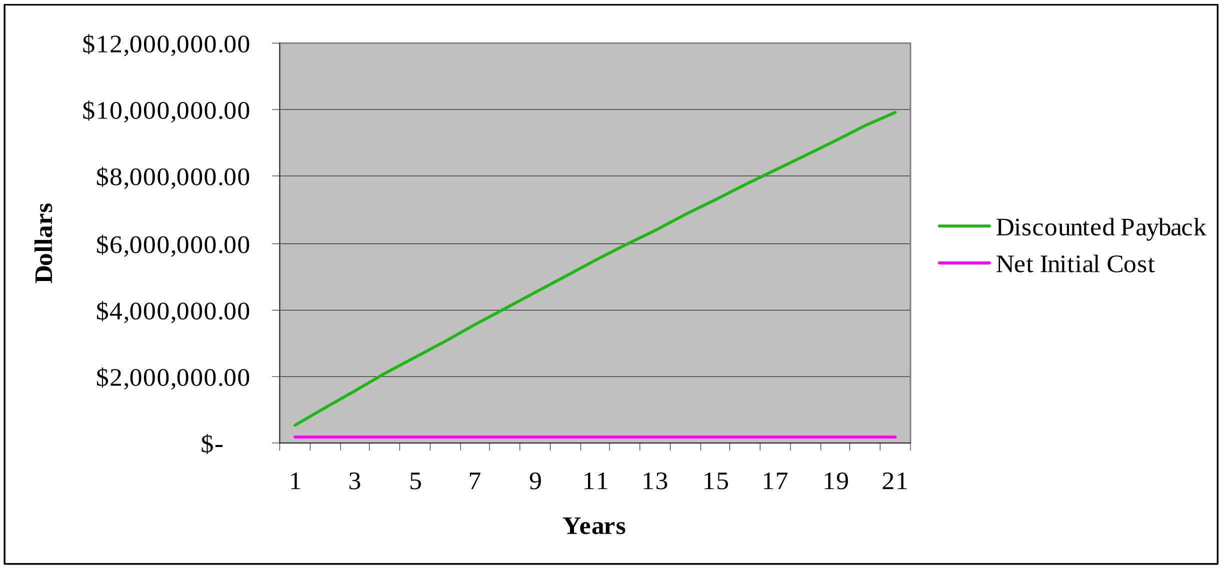


Figure 5.8 Lease Option with 50% Bonus – Discounted Payback of the 3.80MW Net Zero Energy Case

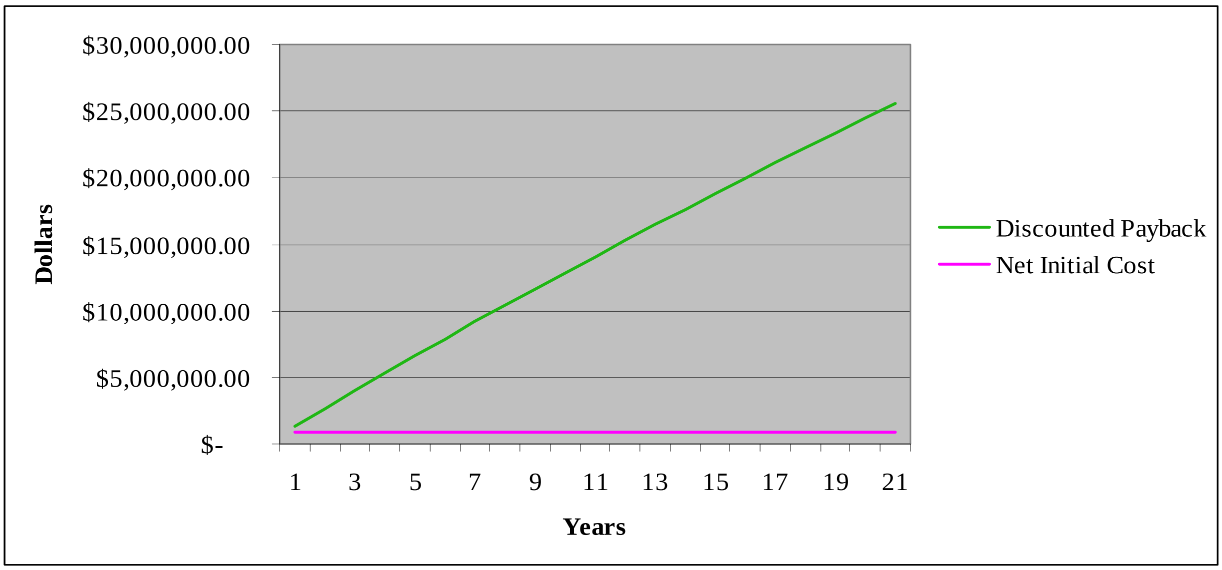


Figure 5.9 Lease Option with 50% Bonus – Discounted Payback of the 9.15MW Max Energy Case

Figures 5.10 and 5.11 are an analysis of the discounted payback for both the Ownership and Lease Options. The figures examine the discounted payback of the two options within the Net Zero and Max Energy Case. Each of the cases use a 2% discount rate.

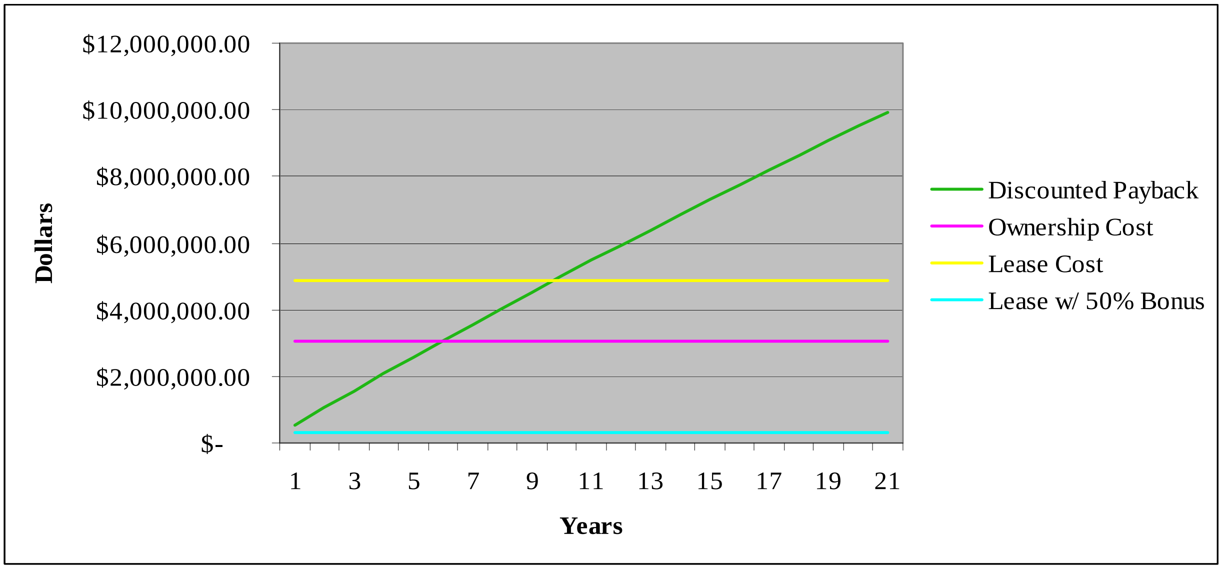


Figure 5.10 Cost Analysis for Net Zero Energy Case

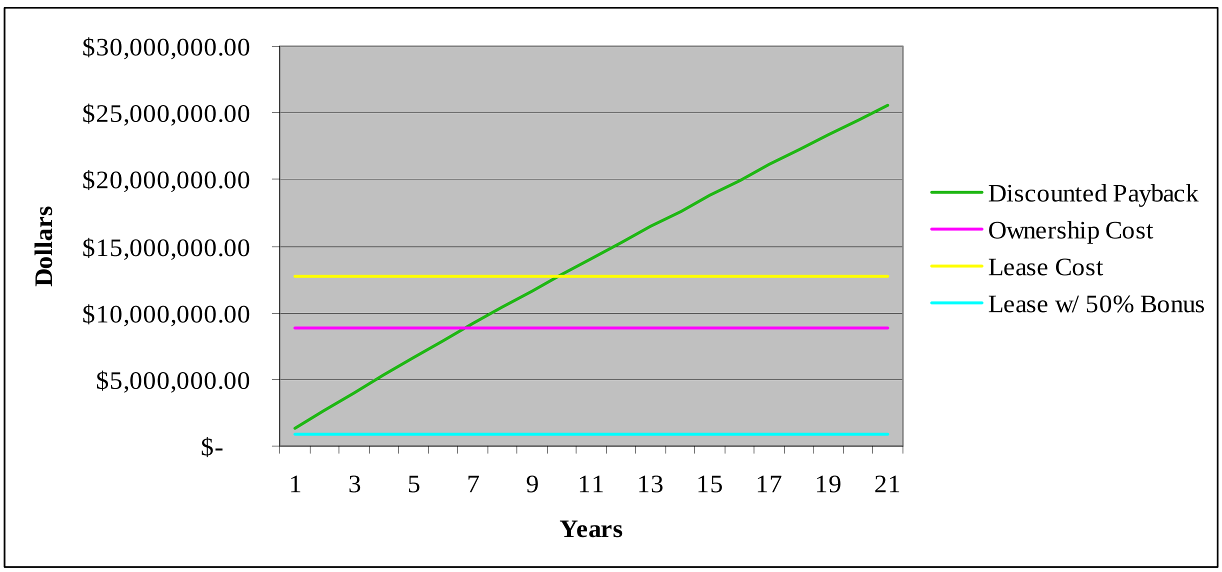


Figure 5.11 Cost Analysis for Max Energy Case

In both Figure 5.10 and 5.11, the scenario with the 50% bonus depreciation allows for the least initial cost. The lease cost appears to have a longer payback period, but again, it is because the net revenue term was 8 years, instead of 20 years like the bond term.

Figures 5.12 and 5.13 show the discounted payback of the two options using a 4% discount rate. Figure 5.12 analyzes the Net Zero Case and Figure 5.13 analyzes the Max Energy Case.

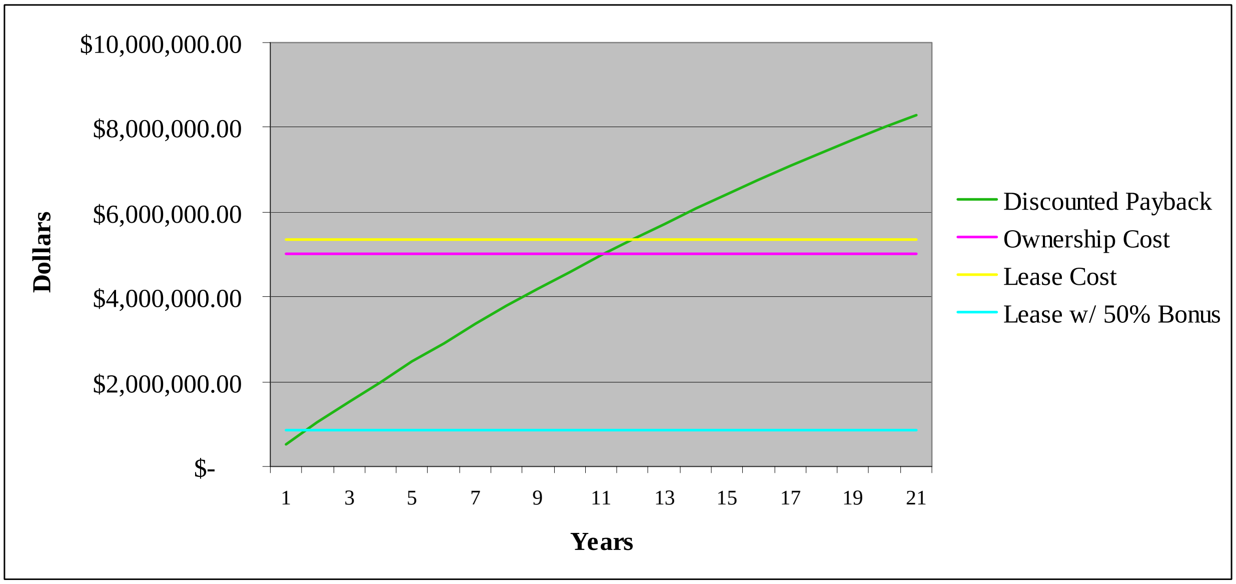


Figure 5.12 Cost Analysis for Net Zero Energy Case with 4% Discount Rate

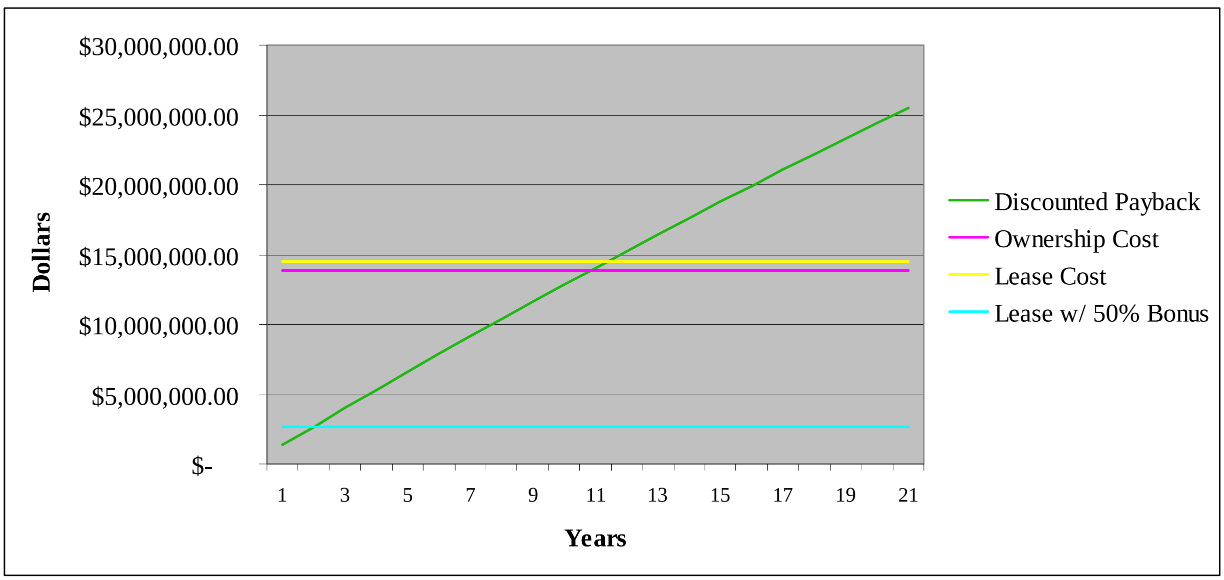


Figure 5.13 Cost Analysis for Max Energy Case with 4% Discount Rate

SENSITIVITY ANALYSIS

The result of using a 4% discount rate is an extended payback for the net zero and max energy systems. Table 5.20 shows the year in which the system is paid for, examining both 2% and 4% discount rates. In both cases the lease option with the 50% bonus depreciation is the most feasible. But as stated previously it is due to expire at the end of 2009, with no plan to continue or reinstate it, although it could be reinstated at a later date. The next most feasible option is the lease option. The bond term that was used for the ownership option was 20 years, and the term for the lease option was 8. Again the longer the term, the more electricity is generated and saved. If the lease term is 20 years, the payback occurs before the payback for the ownership option. Table 5.21 shows the payback for both the ownership and the lease option with a term of 20 years.

Net Zero Energy			
Discount Rate	Ownership Option	Lease Option	Lease w/ 50% Option
2%	6	10	1
4%	12	12	2
Max Energy			
Discount Rate	Ownership Option	Lease Option	Lease w/ 50% Option
2%	7	10	1
4%	11	12	2

Table 5.20 Sensitivity Analysis for 2% and 4% Discount Rate and the resulting payback for the system for each option.

Net Zero Energy		
Discount Rate	Ownership Option	Lease Option
2%	6	1
4%	12	3
Max Energy		
Discount Rate	Ownership Option	Lease Option
2%	7	1
4%	11	3

Table 5.21 Sensitivity Analysis for 2% and 4% Discount Rate and the resulting payback for the system (both with a term of 20 years)

SUMMARY

The Ownership Option and the Lease Option are feasible for both the Net Zero Energy and the Maximum Energy scenarios. In evaluating these Options, it is important to examine and analyze the value of the energy production for each of the scenarios in addition to the first cost for each system. A system may cost more initially, but the production of that system may result in a lower cost per kWh than a less expensive scenario, allowing for a greater return over the life of the system.

The Ownership Option would require a high level of sponsorship and a bond term of about 20 years to become as feasible as the Lease Option. The sponsorship could come in the form of cash or as product donations by manufacturers in exchange for displaying and advertising their products. Operation and maintenance costs, as well as repair and replacement of the equipment, must be taken into account in the financial analysis. For the Ownership Option, the maintenance and upkeep of the system would more likely be the responsibility of the FTE.

The Lease Option would guarantee the installation of the system at no cost to the FTE. In this case, the owner is a utility or solar energy developer and they would be able to take advantage of depreciation and tax credits not available to the public sector. Additionally the FTE would simply provide space for the solar energy systems while the owner would be responsible for the operation and maintenance of the system.

Net metering configurations will have an effect on the ownership structure, tax, implementation, and financing. Also the private operations of the Turkey Lake Service Plaza facilities will a role in the configuration. Careful consideration must be taken into account when sizing of financing of the system the system come about. The Ownership and Lease Option examples use a net metering scenario for total generation. Thus, the discounted payback reflects that scenario. The payback would change as the $/kWh changes.

CHAPTER 6
MARKETING AND EDUCATION

In addition to the technical program proposed for the Turkey Lake Service Plaza Solar Project, a Marketing and Educational Plan was included in the project scope. The hope was that such a campaign could enhance the impact of the project and make it more relevant to visitors at the Turkey Lake Service Plaza.

After initial conversations with Florida's Turnpike Enterprise (FTE) and Florida Department of Transportation (FDOT) staff, it became clear to the project team that the opportunity for education and marketing of solar power at the Turkey Lake Service Plaza was exponentially larger than previously thought. Extremely high visitor counts, a broad variety of visitor types (homeowners, business owners, etc.), and the diverse geographic origins of those visitors (state, regional, national and international) make the Turkey Lake Service Plaza one of the most visible and desirable locations for solar marketing and education in the state.

This new vision has guided the development of this plan to capitalize on this opportunity and make the most of it to push solar energy to the forefront in Florida and give the state a much-needed boost in support of solar energy initiatives.

Figure 6.1 Turkey Lake Service Plaza has the potential for a highly visible renewable energy education campaign.

Objectives
The following were the Objectives for this part of the overall plan:

A. Marketing and Educational Plan Objectives

(1) Create a concept for creating project awareness for the general public, before, during and after the installation of the solar systems.

(2) Develop a concept for a solar trail for use in educating the general public.

(3) Integrate innovative technologies into the marketing plan to capture the imagination of the public (e.g. solar umbrellas, solar trees, solar shades, solar electric vehicles and solar charging stations.)

(4) Develop a plan for integrating marketing and advertising from solar manufacturers, and installers for education of the public about the availability of solar energy systems.

B. Other Relevant Objectives from the Project

(1) Contact potential public and private partners whose in-kind contributions, branding opportunities, or other interest to become part of this effort would offset FDOT construction costs.

(2) Identify and assess corporate sponsorship options and potential revenue from advertising using the Turkey Lake Plaza as a destination to capitalize on this opportunity.

(3) Assess the Collateral Impacts of the Project by assessing the potential for attracting solar business into Florida based on projects such as Turkey Lake Service Plaza.

(4) Provide recommendations for incorporating solar strategy elsewhere. (Note: This is addressed by showing how an integrated Marketing and Educational Plan could be extended beyond Turkey Lake Service Plaza and solar to the other FTE service plazas' themes. It may also be possible to move some of the proposed projects to other locations in the system, but evaluating this option was outside the scope of this report.)

(5) Provide recommendations to assist in accelerating the uptake of solar power in FDOT context and generally throughout the state of Florida.

(6) Increase public awareness of solar energy applications.

Figure 6.2 A Solar Walk covered with flexible PV materials can demonstrate the practical and aesthetic appeal of solar energy.

(7) Integrate innovative solar artwork, solar shades, and other devices to provide opportunities for the public to interact with solar power technology.

(8) Propose plans for one mile north and south of plaza.

The remaining sections of the report present a detailed plan for achieving these stated objectives.

The team identified five key steps in the process of developing the Marketing and Educational Plan for the Turkey Lake Service Plaza Solar Project:

Step 1: Define Objectives
The initial step was to identify and clarify the objectives of the FTE and the Florida Department of Transportation (FDOT) in the project. This was accomplished through a series of interviews with key stakeholders and extensive review of documents published by both agencies over the past three years. Four key objectives emerged and are discussed in detail in the Objectives section of this chapter.

Step 2: Define Audiences
The second step of the process was to define what stakeholder groups might be relevant and important to reach with the Marketing and Educational Plan. This was accomplished by reviewing the education, marketing, and general communications plans and campaigns of a number of major solar and sustainable energy initiatives across the US. Seven major stakeholder groups emerged from four distinct geographic scopes. These are discussed in detail (including demographics, needs, and barriers to action) in the Audiences section of this chapter.

Step 3: Define Goals
The third step in the process was to look for synergies between the sponsoring agencies' objectives and the determined stakeholders' goals. Pairing these is critical to ensuring that the proposed messages and chosen tools will serve both sides. The specific goals of the Marketing and Educational Plan as they relate to the identified stakeholders and target audiences are discussed in the Goals section of the chapter.

Step 4: Establish Messages
The fourth step in developing an effective plan for the Turkey Lake Solar Project was to use the audience information, combined with their goals, and determine the most effective overall messages and specific themes to focus on in the campaign. This was done through a series of informal interviews and focus groups, with the end goal of developing a campaign slogan that could inspire multiple target audiences and scale across the FDOT system. The results of this research are discussed in the Messages section of this chapter.

Step 5: Choose Tools
The final step in preparing the Marketing and Educational Plan was to develop tools and specific projects that would reach all of the intended audiences with targeted messages to achieve the project's marketing and educational objectives. These proposed projects are discussed in detail in the Tools section of the chapter. The proposals are also ranked according to a variety of criteria to allow the FTE and FDOT to choose those options that best fit their established goals, chosen audience, timeline, available space, sponsorship opportunities, budget, and staffing plans.

Underlying these five steps is an assumption that the goal of the Marketing and Educational Plan must be to go beyond merely informing visitors to the Turkey Lake Service Plaza Solar Project about the potential of solar. The ultimate goal of the plan must be to change the thinking and behavior of the stakeholder groups to result in the expansion of solar power uptake in Florida and to boost the state's economy through green job growth into the future. To accomplish this, the team sought a theoretical framework that could inform the process and improve the outcomes of the final plan.

FRAMEWORK

Problems with Sustainability Education and Marketing
What might seem on the surface to be a straightforward problem— find a way to educate the public on the potential of solar and they will act on the information— is actually more difficult to solve through simple education and marketing than one might think. Dr. Doug McKenzie-Mohr, an environmental psychologist who has worked extensively on developing effective marketing campaigns to influence the sustainable behaviors of stakeholder groups, described the challenge in his book Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing (available at http://www.cbsm.com/), pp 2-5**:**

“Most programs to foster sustainable behavior rely upon large-scale information campaigns. These campaigns are usually based on one of two perspectives regarding changing behavior. The first perspective assumes that changes in behavior are brought about by increasing public knowledge about an issue, such as decreasing landfill capacity, and by fostering attitudes that are supportive of a desired activity, such as recycling. Accordingly, programs based on this perspective attempt to alter behavior by providing information, through media advertising, and frequently the distribution of brochures, flyers and newsletters...

The second perspective assumes that individuals systematically evaluate choices, such as whether to install additional insulation to an attic or purchase a low-flow shower head, and then act in accordance with their economic self-interest. This perspective suggests that in order to affect these decisions, an organization, such as a utility, need only provide information to the public that something is in their financial best interest and consequently the public will behave accordingly. As with information campaigns that focus on altering knowledge and attitudes, efforts that have concentrated on pointing out the financial advantages of a sustainable activity, such as installing a low-flow shower head or adding insulation, have also been largely unsuccessful...

The failure of mass media campaigns to foster sustainable behavior is due in part to the poor design of the messages, but more importantly to an underestimation of the difficulty of changing behavior."

Solution: Community-Based Social Marketing

Dr. McKenzie-Mohr has developed a very effective process for dealing with the challenges of changing individual attitudes to result in more sustainable behaviors, and this process underlies the findings and suggestions contained in the Marketing and Educational Plan for the Turkey Lake Service Plaza Solar Project.

The system is called Community-Based Social Marketing and is based on the following stages:

Identifying Barriers

If any form of sustainable behavior is to be widely adopted, the critical first step is to identify what barriers are currently stopping stakeholders from acting. The barriers can be internal to the individual, such as a lack of information about the benefits of solar power, or external, as in policy barriers that exist to prevent rapid adoption of solar power systems in the state. The barriers are also unique to the behavior or technology, i.e. the barriers that prevent people from installing solar panels on their homes or businesses are different from those that prevent them from engaging in recycling. Finally, the barriers are different for each stakeholder group (homeowners, business owners, etc.) and have been addressed individually for each identified target audience in this report.

Behavior Change Tools

Social science research has identified a variety of tools that can be helpful in changing attitudes and behaviors to effect widespread adoption of sustainable behaviors. Because these tools and the key points to making each effective were used extensively in developing the proposed projects for the Turkey Lake Service Plaza Solar Project, they are outlined here as a point of reference:

A. Commitment: From Intention to Action
    - Emphasize written over verbal commitments.
    - Ask for public commitments.
    - Seek group commitments.
    - Actively involve the person.
    - Consider cost-effective ways to obtain commitments.
    - Use existing points of contact to obtain commitments.
    - Help people to view themselves as environmentally concerned.
    - Don’t use coercion (commitments must be freely volunteered).
    - Combine commitment with other behavior change techniques.

B. Prompts: Remembering to Act
    - Make the prompt noticeable.
    - The prompt should be self-explanatory. Through graphics and/or text the prompt should explain simply what the person is to do (e.g., turn off the lights).
    - The prompt should be presented as close in time and space as possible to the targeted behavior (e.g., place a prompt to turn off lights directly on a light switch; place a prompt to purchase a product with recycled content directly below the product).
    - Use prompts to encourage people to engage in positive behaviors rather than to avoid environmentally harmful actions (e.g., use prompts to encourage people to buy environmentally friendly products rather than to dissuade them from purchasing environmentally unfriendly products).

C. Norms: Building Community Support
    - The norm should be noticeable.
    - As with prompts, the norm should be made explicit at the time the targeted behavior is to occur (e.g., upon entering a supermarket, customers could be greeted by a prominent display that indicates the percentage of shoppers who purposely select products that favor the environment).
    - As with prompts, when possible use norms to encourage people to engage in positive behaviors rather than to avoid environmentally harmful actions.

D. Communication: Effective Messages
    - Make sure that your message is vivid, personal and concrete.
    - Explore the attitudes and behavior of your intended audience prior to developing your message.
    - Have your message delivered by an individual or organization who is credible with the audience you are trying to reach.
    - Frame your message to indicate what the individual is losing by not acting, rather than what he/she is saving by acting.
    - If you use a threatening message, make sure that you couple it with specific suggestions regarding what actions an individual can take.
    - Use a one-sided or two-sided message depending upon the knowledge of your audience regarding the particular issue.

- Make your communication, especially instructions for a desired behavior, clear and specific.
- Make it easy for people to remember what to do, and how and when to do it.
- Integrate personal or community goals into the delivery of your program.
- Model the activities you would like people to engage in.
- Make sure that your program enhances social diffusion by increasing the likelihood that people will discuss their new activity with others.
- Where possible, use personal contact to deliver your message.
- Provide feedback at both the individual and community levels about the impact of sustainable behaviors.

E. Incentives: Enhancing Motivation

- Closely pair the incentive and the behavior.
- Use incentives to reward positive behavior.
- Make the incentive visible.
- Be cautious about removing incentives.
- Prepare for people's attempts to avoid the incentive.
- Consider the size of the incentive.
- Consider non-monetary forms of incentives.

F. Convenience: Making it Easy to Act

Piloting

Another principle of Dr. McKenzie-Mohr's approach is to pilot any community-based social marketing strategy in a small portion of the community before it is rolled out to the general population. This has been accomplished in the Marketing and Educational Plan by phasing in each project at Turkey Lake Service Plaza so that it starts small and grows over time, based on the results of piloting and constant evaluation. This is discussed further in the Tools section of this chapter.

Evaluation

The final step in any community-based social marketing campaign involves the direct measurement of behavior change in the targeted stakeholder group and the measurement of less direct results such as changes in overall attitudes towards the sustainable behavior. Concrete plans for this phase of education and marketing have not been included here since they fall outside the scope of a conceptual report. Nevertheless, the team highly recommends that an evaluation phase be included in any marketing and educational projects undertaken at Turkey Lake Service Plaza since the resulting data would be extremely valuable for the sponsoring organizations, other government agencies, solar manufacturers and installers, and non-profits engaged in supporting solar in Florida and the US.

OBJECTIVES

Four main objectives for the Marketing and Educational Plan emerged from interviews with agency representatives and a review of stated goals and objectives in agency publications. They are listed below, with implications for the project and plan.

Showcase FDOT/FTE as Progressive and Innovative Organizations in a Post-Carbon World

Both agencies are understandably tied in the minds of most citizens to a carbon economy based on fossil fuel vehicles and unsustainable transportation networks. Internally, however, both organizations see themselves as progressive and have already taken huge steps towards thinking about the future of more sustainable transportation networks and alternative energy and fuel sources. The Turkey Lake Service Plaza Solar Project presents an excellent opportunity to educate the public about current FDOT/FTE initiatives and reframe the agencies as progressive and innovative leaders in the post-carbon future in Florida.

Highlighting Current Changes at Turkey Lake Service Plaza

The Marketing and Educational Plan is designed to tie into the existing plans by the new concessionaire, Areas USA, to redesign the Turkey Lake Service Plaza buildings and achieve a LEED Silver rating for them. The decision to aim for LEED Silver for all of the renovated service plaza buildings on the system is in itself progressive and innovative, and provides an excellent springboard for the marketing and educational efforts proposed here. The last section of this chapter addresses possible ways the Marketing and Educational Plan could be extended across the system to take advantage of the environmental themes proposed for all of the service plazas.

Evaluating the Power Generation Scenarios for Education and Marketing

The project team is proposing three alternative power generation scenarios for Turkey Lake Service Plaza, all of which have important (but different) possibilities for showcasing the organizations as progressive and innovative. First is the maximum power scenario, which would maximize the amount of energy produced at Turkey Lake Service Plaza and provide a highly visible demonstration project for what is possible on a large scale in Florida. The second scenario would create the nation's first net zero energy service plaza, with the site producing as much energy over the course of a year as is used by the service plaza. The fact that this would be the first project of its kind in the US creates significant marketing impact. The final scenario would minimize power output on the site but focus on experimental and artistic installations of solar to excite and intrigue the public.

For the purposes of this report, the marketing and educational potential of all three scenarios is considered equal since each has benefits and drawbacks. It is the opinion of the project team that an effective Marketing and Educational Plan that showcases the progressive and innovative nature of the FDOT and FTE can be implemented for any of the three scenarios, with the focus shifting slightly depending on the amount of energy produced.

Support Exponential and Immediate Growth of Solar in Florida

Why Is This Critical?

According to an April 2009 briefing from the non-partisan group Florida TaxWatch ("The Positive Economic Impact of Solar Energy on the Sunshine State," available at http://www.floridataxwatch.org/resources/pdf/04162009SolarEnergy.pdf), Florida stands at "an opportune crossroads and... is uniquely positioned to take advantage of public and governmental encouragement to reach beyond the historical dependency of the US on fossil fuel." The briefing goes on to state that while Florida's appetite for energy appears insatiable, the state is also poised to become the second-largest producer of electricity from the sun in the nation (after California) within the next few years. After the 111 MW currently under construction are completed, however, there are no large projects on the drawing boards. This means that the entire solar industry in Florida could lose its critical momentum and the state could lose future jobs from manufacturing, installation, and research to competitor states.

An article in the April/May 2008 issue of Home Power ("The Best States for Solar," available at http://www.homepower.com/article/?file=HP124_pg84_Davidson), a magazine focused on the home installation market for renewable energy systems, listed the the best states for solar installation, green jobs and manufacturing as being:

1. California
2. Colorado
3. Connecticut
4. Maryland
5. Massachusetts
6. Minnesota
7. New Jersey
8. New Mexico
9. Oregon
10. Pennsylvania

Florida is noticeably absent from the list, despite having more days of sunshine than almost anywhere else on the planet and having far more MW installed or under development than any state but California. As the TaxWatch briefing puts it, Florida is currently facing a "once-in-a-generation opportunity to attract a new, clean-tech industry to the state, bringing with it new jobs, taxpayer advantages, and critical forward thinking energy policy." The National Renewable Energy Laboratory's economic data estimates that if Florida installed 1,500 MW of solar power production up to 45,000 direct jobs and 50,000 indirect jobs would be created (quoted in the TaxWatch briefing). "These jobs could be a necessity to an energy-driven state struggling in the current economic crisis," the briefing goes on to say. Another benefit of these green jobs is the wide variety of skill sets and educational background they require, from roofers to engineers, health and safety officers to materials scientists. Thanks to the historical support of the Florida Public Service Commission, the state is uniquely positioned to attract the kind of investment necessary for this exponential and immediate growth of the solar industry. The conclusion of the briefing's authors is that "Immediate action and assertive policy measures need to be taken in the state's interest so that Florida can encourage and expedite solar technology projects."

The Turkey Lake Service Plaza Solar Project, with its ambitious goals and high visibility, could become the catalyst for important changes in the state's policies and programs for the future. It could be a critical piece in supporting the immediate and exponential growth of solar manufacturing, installation, research and development for the state, the nation, and the world. The Marketing and Educational Plan is aimed at realizing this potential of the project and making it a reality.

Potential Partnerships

The Turkey Lake Service Plaza Solar Project also has a unique opportunity to bring a number of related state organizations together for a single project, providing a display area for their current individual efforts and creating a place for consumers to interact with their services. Potential academic partners include the University of Central Florida's Solar Energy Center, which houses the “Employ Florida Banner Center for Alternative Energy,” and the University of Florida's Florida Institute for Sustainable Energy. Industry partners could include several large-scale manufacturers with a strong presence in Florida, such as Sharp Solar, or industry organizations like the Florida Solar Energy Industries Association. Finally, the team identified and made contact with some potential corporate partners with an interest in solar development in the state, including The Home Depot, The Walt Disney Company, and the Babcock Ranch development.

Develop Turkey Lake Service Plaza as a Solar Destination

The third objective identified in the preliminary stage of research is to make Turkey Lake Service Plaza a solar destination that attracts diverse audiences. This objective is closely related to the first two objectives, to showcase the FDOT and FTE as innovative and to foster immediate growth of solar in the state, but it takes them a step further. The idea here is to develop a nuanced understanding of who is visiting the plaza, who might be encouraged to visit it, and how to make the service plaza unique in the state and the nation as a place of active learning and engagement with solar technologies. The Marketing and Educational Plan handles this objective by addressing each audience segment individually, always with the goal in mind of making Turkey Lake Service Plaza a world-class destination for solar.

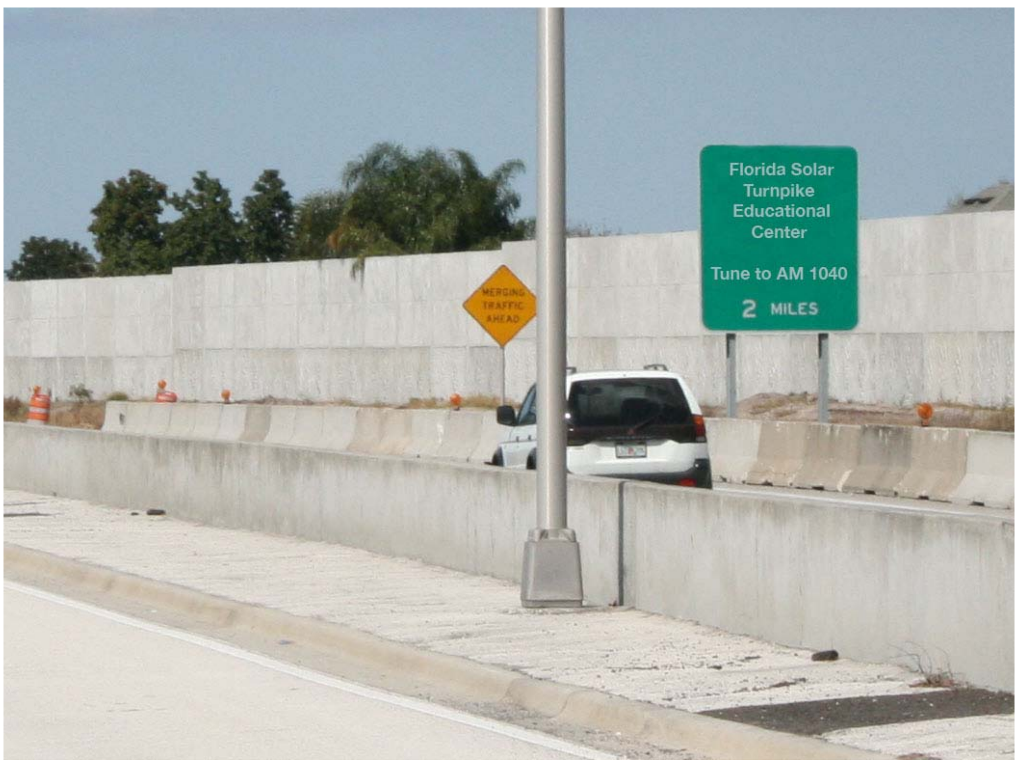


Figure 6.3 An example of signage on the Florida Turnpike that can alert the public to the solar installation located at the Turkey Lake Service Plaza.

Find Options That Are Interactive, Engaging and Creative for Each Phase of the Project
Throughout the research phase, the team kept this fourth and final objective front and center in its thinking. The need to engage the project's various audiences prompted the use of the Community-Based Social Marketing framework discussed above. The messages and tools proposed in this plan were designed to maximize opportunities inherent in the previous three objectives: to showcase the FDOT and FTE as innovative organizations, to promote the rapid development of the solar industry in Florida and to develop Turkey Lake Service Plaza as a solar destination. All three are best accomplished by keeping this final objective in mind— by engaging the public in each phase of the project in the most interactive and creative ways imaginable.

AUDIENCES
The next step in the process was to define the various target audiences the Turkey Lake Service Plaza Solar Project can effectively reach and to understand who these audiences are and how they could benefit from marketing and educational messages and the projects proposed for Turkey Lake Service Plaza (See Table 6.1).

Figure 6.4 A solar project at the Turkey Lake Service Plaza will be able to reach a wide audience, including future solar outcomes.

Demographics of Current Turnpike and Turkey Lake Service Plaza Visitors
According to the "FY 2009 Service Plaza Customer Survey" (FTE, April 2009), approximately 60,000 vehicles carrying 120,000 passengers (based on the 1.98 average vehicle occupancy figure given in the report) pass by or stop at the Turkey Lake Service Plaza daily. The total number of visitors to the plaza exceeds 2 million per year, presenting an enormous opportunity for marketing and educational outreach.

The diversity of reasons plaza visitors have for traveling is also helpful in reaching the maximum number of audiences identified as stakeholders in the research phase of the project. About 40% of visitors are traveling for social, family or recreation purposes, and 25% are tourists or on vacation. Together these represent 65% of Turkey Lake Service Plaza's visitors and can be expected to spend more time at the plaza exploring any potential marketing or educational installations. Just over 30% of the plaza's visitors are traveling on work or business, making them short on time but amenable to making connections with companies that might be good partners in Florida or finding other information about the business climate in the state.

In addition to the diversity of trip purpose, Turkey Lake Service Plaza also enjoys visits from people from a broad geographic area. Almost three-quarters (71%) of the plaza's visitors are from Florida, making the plaza an excellent place for solar manufacturers and installers to advertise. Just over a quarter (27%) of visitors are from other US states, making the site highly visible to a variety of audiences from the region and nation. The remaining 2% of plaza visitors are from another country.

The diversity of the audiences' trip purpose and residency characteristics, combined with the high overall visitor counts, make Turkey Lake Service Plaza an unusually visible and potentially highly influential location in Florida for a marketing and educational campaign about solar and the state's future. In order to fully explore this opportunity, the team also broke the potential audiences down further by geographic region and potential role in moving Florida further into solar.

Table 6.1 Overview of Audiences, Tools to Reach Them, Project Goals and Effective Messages			
Audience	**Framework**	**Goals**	**Messages**
Homeowners	Communication: Effective Messages	Convince 2% of homeowners to install solar water heating systems.	Solar is easy to install and has immediate financial benefits.
		Get 250,000 signatures a year in favor of solar.	
Educators and Students	Prompts: Remembering to Act AND Communication: Effective Messages	Attract 50,000 students a year.	Solar is interesting and fun (students) and today's students are the leaders of Florida's solar future (educators).
		Teach these students enough about solar to pass a quiz.	
		Develop engaging materials that all schools can use.	
Trucking Industry	Incentives: Enhancing Motivation	Have 100% of truckers visiting Turkey Lake Service Plaza use power pedestals.	Solar provides an immediate solution to restrictions on idling.
Workforce	Communication: Effective Messages AND Convenience: Making it Easy to Act	Create a clearinghouse of solar job information.	Florida is growing its solar workforce and has opportunities for everyone.
Construction Industry	Communication: Effective Messages AND Convenience: Making it Easy to Act (more research required)	Develop a green collar training program on site.	Solar is an easy way to incorporate desirable green features into residential and commercial construction.
		Reach 1,000 Florida building professionals a year with activities that demonstrate the potential of solar.	
Entrepreneurs	Communication: Effective Messages AND Convenience: Making it Easy to Act	Reach 1,000 Florida current and potential entrepreneurs a year with activities that demonstrate the potential of solar.	Florida has an excellent business climate for solar entrepreneurs.
Solar Manufacturers	Communication: Effective Messages AND Convenience: Making it Easy to Act	Bring representatives of every major solar manufacturing company to the site to meet with Florida decision makers within 2 years of opening the project.	Florida will do everything possible to attract major solar manufacturers.

Homeowners

Approximately 1.2 million of the plaza's annual visitors are homeowners, based on the percentage of visitors from Florida and current homeownership rates in Florida (US Census, April 2009). Almost every one of these visitors is a potential customer for solar hot water heating or solar photovoltaic systems, making the plaza an excellent opportunity for marketing and education on the benefits and practical aspects of these technologies. Net Zero Energy homes, which annually generate as much energy as they consume, are emerging as an approach to decentralized energy systems that homeowners will be able to consider as an option for their future homes (See Figure 6.5).


Figure 6.5 The Net Zero Energy concept can be applied to homes in Florida.

This audience is particularly important to the future of solar in Florida since they also represent the all-important voters who will be needed to move any solar energy policy forward in the future. They are actively looking for ways to cut utility costs and household expenditures in these tough economic times and generally simply lack the basic information about how much a solar hot water heating system could save them, or how to find a reputable solar installer. Therefore the tool most likely to reach this audience effectively is good communications, with vivid, personal and concrete messages. Homeowners will respond best to messages delivered by organizations that are credible and that focus on money lost by not acting quickly. The projects proposed for this audience focus on providing step-by-step instructions for how homeowners can act, making it easy for them to remember what to do, and how and when to do it. It will also be helpful to integrate Florida's overall goals into the messages, helping homeowners feel they are part of a larger trend and increasing the likelihood that they will discuss the technologies with others.

Educators and Students

The next major state audience group to be targeted at Turkey Lake Service Plaza is educators and students. Turning Turkey Lake Service Plaza into a destination that informs and educates the next generation of Floridians on the potential and promise of solar as part of a sustainable future is critical. Central Florida is predicted to see explosive growth in the next few decades, making it an excellent choice for an educational hub on solar. In fact, continuous urban development in the central part of the state means that the area's population could more than double by 2060 ("Florida 2060" from 1,000 Friends of Florida and University of Florida's GeoPlan Center, available at http://www.1000fof.org/planning/2060.asp).

This audience is harder to reach since they do not have an existing need for more information about solar and would have to be induced to travel to the site. That said, this audience is also the most easily targeted via the Web, with an informative and educational site that tracks power produced at Turkey Lake Service Plaza and provides solar-related lesson plans for teachers. All of the tools discussed in the Framework section of this chapter apply to this audience, with particular attention paid to prompts and communication.

Figure 6.6 Solar-powered amenity stations could permit trucks to run off PV-generated electricity.

Trucking Industry

Although commercial truck capture rates are significantly lower than those of cars, there are still a significant number of truckers passing by and stopping at Turkey Lake Service Plaza. New laws and regulations limiting the idling time for truck drivers have left the industry seeking new solutions to cab cooling and heating that do not require the engine to run. Most of the solutions being proposed involve hybrid solar powered heating and air conditioning units that harness the sun's energy during the day so that it can be used to run the truck's environmental systems at night. Turkey Lake Service Plaza could become a demonstration site for these technologies as well as hosting plug-in solar charging stations that offer truckers the same benefits with their existing systems, fed by energy from the solar installation at the plaza.

The most effective tool to reach this audience is incentives, which could provide motivation for truckers and their companies to consider adopting hybrid solar systems more rapidly. Evaluating the viability of power systems installed and powered by the plaza will require further technical studies beyond the scope of this report. It is safe to say, however, that if such systems are installed the most effective marketing and educational campaigns associated with the project would closely pair the incentive and the desired behavior, and use incentives to reward positive changes. This could include providing power for free or at a reduced rate, showing the trucking industry that hybrid solar systems are an economically viable solution.

Workforce
A 2008 report on the solar workforce in California ("California's Solar Industry & Workforce Study Key Findings, 2008" available at http://coeccc.net/documents/Solar_KeyFindings_CA.pdf) uncovered some workforce statistics that are equally relevant for Florida. The report's authors found that the majority of solar-related firms are small, with fewer than 25 employees, and that the majority of those are non-manufacturing, meaning they are installers, contractors and distributors. The majority of these firms are looking to hire new employees in the next 12 months, and overall they will be increasing employment by up to 29% in the same time period. However, two out of three employers indicated difficulty finding entry-level employees, and three out of four employers indicated difficulty finding experienced employees.

As other states continue to compete for solar manufacturing facilities, the demand for workers will also grow. Building Turkey Lake Service Plaza's marketing and educational campaign to address the needs of potential solar workers would benefit both the industry and individual employers in Florida, and could result in recruitment of a qualified workforce at all levels of education and experience. This is a critical mission that has yet to be filled in the state and represents one of the major opportunities for the Marketing and Educational Plan in the opinion of the project team.

The most effective tools to reach this untapped market will be communicating with effective messages and making it easy and convenient for them to act. This can be accomplished in a variety of ways, all of which involve making Turkey Lake Service Plaza a clearinghouse for information on training, jobs and other opportunities in the solar industry in Florida.

Figure 6.7 Construction industry will need to change its approach to buildings and infrastructure to meet the emerging requirement for low energy, renewable energy powered facilities.

Construction Industry
Although the Florida construction industry is currently in an economic crisis, there is reason to believe it will recover along with the rest of the country in the next few years. When that recovery comes, it will have to involve green building technologies and renewable energy production and consumption. Turkey Lake Service Plaza can play a role in educating workers and owners throughout the construction industry about the potential and affordability of solar. It is even possible that the construction industry could be faced with increasing pressure from decision makers and the public to make more sustainable systems available in new construction, following in the footsteps of California and even Hawaii, which made solar water heaters mandatory in all new homes starting in 2010 ("Solar Water Heaters Now Mandatory In Hawaii," available at http://www.enn.com/pollution/article/37518).

Several of the tools from the Framework section are relevant here, and considerably more research is required to determine what the most effective messages and incentives would be to help remove barriers to solar in Florida's construction industry. It is clear the construction industry needs information and assistance in this transformation to sustainable practices and Turkey Lake Service Plaza could play an important role in making the case for solar technologies. There are several viable industry partners active in the state, perhaps most notably the U.S. Green Building Council.

Entrepreneurs
Luring existing or new small businesses to Florida to build the solar industry in the state is as important as luring new workers here to staff it. Florida is not currently seen as a top destination for solar businesses, but that could be changed with a targeted campaign at Turkey Lake Service Plaza. Creating buzz around the state's solar plans benefits all of the audiences listed, but could perhaps have the greatest long-term impact on the state's economy with entrepreneurs, who turn their profits and payrolls directly over into the state tax revenues.

Information is a key barrier for entrepreneurs, and any campaign at Turkey Lake Service Plaza has to focus its message and content on making it easy for businesses to see themselves in Florida. This is a particularly good area for governmental, non-profit, academic and corporate partnerships, since all four sectors gain from bringing new business to the state and already have informational programs established to ease the transition for entrepreneurs. The best tools to use to reach this audience are communication and convenience.

Solar Manufacturers
Although international visitors only comprise 2% of the current visitors to Turkey Lake Service Plaza, the plaza's proximity to Orlando and its world-class attractions means it has the potential to attract targeted audiences to see the installation and learn more about Florida's solar initiatives. For this reason, the project team considers the target audience of solar manufacturers an important one. Providing a one-stop showcase for the solar movement in the state could be an important catalyst for convincing international manufacturers to relocate or open new facilities here.

The key tools for this audience are communication and convenience, putting positive and effective messages out at the plaza and then making it as easy as possible for decision makers at the companies to visit.

GOALS

The next step in the process, after deciding on a framework for developing the plan and determining the key audiences' needs and barriers to action, was to develop specific and measurable goals for each audience. The following were determined to be reasonable “stretches” for the marketing and educational campaigns, and steps for accomplishing each are detailed in the Tools section of this chapter.

All of these goals and the proposed projects were developed with the plan's overarching objectives in mind:

- Showcase FDOT/FTE as Progressive and Innovative Organizations in a Post-Carbon World
- Support Exponential and Immediate Growth of Solar in Florida
- Develop Turkey Lake Service Plaza as a Solar Destination
- Find Options That Are Interactive, Engaging and Creative for Each Phase of the Project

Homeowners

Goal 1: Convince 2% (24,000) of the homeowners who visit Turkey Lake Service Plaza each year to install a solar water heating system in their home.

- Tell every visitor to Turkey Lake Service Plaza the story of successful home solar installations using clear, vivid and personal storytelling techniques.
- Allow every visitor to Turkey Lake Service Plaza to calculate their potential energy cost savings and simple payback period for a solar water heating system and solar photovoltaic installation.
- Provide every interested homeowner with literature and a customized list with reviews of solar water heating system and/or photovoltaic installers in their area.

Goal 2: Get 250,000 signatures a year for a public commitment to solar initiatives.

- Show every homeowner who visits Turkey Lake Service Plaza the newest technologies available for home solar photovoltaic and other solar energy production.
- Ask every Florida homeowner who visits Turkey Lake Service Plaza to make a commitment to vote to support solar energy initiatives in Florida.

Educators and Students

Goal 1: Attract 5,000 Florida students a year to visit the solar walk and other exhibits at Turkey Lake Service Plaza.

- Develop a standardized visit for student groups with a route, quiz and completion certificates.
- Create a group of volunteer Solar Ambassadors to act as hosts for the student groups.

- Have students who visit take a quiz on what they learned on site and achieve 75% passing rates.

Goal 2: Develop a week's worth of engaging materials that all Florida schools can use in their science curricula.

- Create a website where students can learn about solar and monitor the energy production at Turkey Lake Service Plaza.
- Develop components in every proposed project that serve K-12 students and further their knowledge of and commitment to solar energy production.

Trucking Industry

Goal 1: Convince 100% of truckers visiting Turkey Lake Service Plaza to use plug-in "power pedestals" instead of idling.

- Install enough power pedestals to accommodate 100% of truckers visiting Turkey Lake Service Plaza.
- Develop an educational campaign for truck parking area on how the system works and the financial benefits of using power pedestals.
- Devote some rotating exhibition space inside the plaza to showcase marketing materials from manufacturers of hybrid solar systems for trucks.

Workforce

Goal 1: Create a clearinghouse of job information for solar in Florida that addresses all levels of worker skill and education and contains at least 100 employers and 1,000 current and open jobs.

- Create a website where employers and employees can meet virtually and find out about new opportunities in solar in Florida.
- Display information about the variety of jobs available in the industry and growth projections for solar in Florida.
- Enable interested visitors to search for current openings and e-mail themselves the results.

Goal 2: Develop a green collar training program that capitalizes on Turkey Lake Service Plaza's central location and nearby amenities and serves at least 1,000 participants annually after the first year.

- Hold several half- and full-day training programs at Turkey Lake Service Plaza, growing the program incrementally.
- Renovate an existing outbuilding or consider building a new structure to house the training program.

Construction Industry

Goal 1:Reach 1,000 Florida building professionals a year with activities at Turkey Lake Service Plaza that demonstrate the construction potential of solar.

- Hold an annual green building exposition featuring solar photovoltaics, solar water heating, and other relevant technologies.

- Devote some rotating exhibition space inside the plaza to showcasing innovative products and technologies.
- Renovate an existing outbuilding or consider building a new structure to house a permanent green building exposition.

Entrepreneurs

Goal 1: Reach 1,000 current and potential entrepreneurs a year with activities at Turkey Lake Service Plaza that demonstrate the business potential of solar in Florida.

- Hold an annual small business exposition featuring solar technologies, business networking events, and a job fair.
- Devote some rotating exhibition space inside the plaza to showcase Florida's business climate and current opportunities in solar.

Solar Manufacturers

Goal 1: Bring representatives of every major international solar manufacturing company to the Turkey Lake Service Plaza site on formal visits with state decision makers within 2 years of opening the project.

- Develop a standardized visit for major manufacturers with a meeting schedule with key decision makers and a tour around Central Florida highlighting available land, workforce, policies, and more.

MESSAGES

The fourth step in the process of developing this Marketing and Educational Plan was to find messages that would resonate with each of the target audiences and guide the development of specific projects. The first task was to develop an overarching slogan that would tie together the disparate needs and barriers to action experienced by the audiences and inspire immediate action, one of the key overall objectives of the plan.

Campaign: Shine ON Florida!

Over 40 different slogans were developed and tested in small informal focus groups at the plaza, with “Shine ON Florida!” the clear winner. The results should be considered preliminary, however, and deserve further study before a final marketing campaign is launched. The main factors considered for success of any slogan were:

- Be positive and inspiring
- Be immediately identifiable with the sun, and thus with solar power
- Build on Florida's existing “Sunshine State” campaign
- Be solar specific but also applicable to other service plaza themes if program is expanded
- Be future- and action-oriented

What follows is a breakdown of individual messages that must be included within the larger campaign in order to reach all of the target audiences. Table 6.2 is a summary of the audiences who would be addressed by the projects described in this chapter.

Homeowners
Solar is easy to install and has immediate financial benefits.

Educators and Students
Solar is interesting and fun (students), and today's students are the leaders of Florida's solar future (educators).

Trucking Industry
Solar provides an immediate solution to restrictions on idling.

Workforce
Florida is growing its solar workforce and has opportunities for everyone.

Construction Industry
Solar is an easy way to incorporate desirable green features into residential and commercial construction.

Entrepreneurs
Florida has an excellent business climate for solar entrepreneurs.

Solar Manufacturers
Florida will do everything possible to attract major solar manufacturers.

Table 6.2 Summary of Audiences Addressed by Proposed Projects							
	Home-owners	**Educators and Students**	**Trucking Industry**	**Work-force**	**Construction Industry**	**Entrepre-neurs**	**Solar Manu-facturers**
PHASE 1: Virtual Display on the Web							
1. Social Marketing Campaign	x	x	x	x	x	x	x
2. Project Website with Components	x	x	x	x	x	x	x
PHASE 2: Solar Walk Area							
3. Personal RECharging Stations	x		x				
4. Art Installation		x					x
5. Solar Science Walk	x	x	x	x	x	x	x
PHASE 3: Exhibition Space							
6. Virtual Power Usage Displays	x	x					
7. Educational Kiosks	x	x	x	x	x	x	x
8. Rotating Exhibition Space	x	x	x	x	x	x	x
PHASE 4: Truck Parking							
9. Truck Parking Informational Campaign			x				
10. Solar Trucking Exhibition			x				x
11. Trucking Demonstration Project			x				x
PHASE 5: Renovation/Construction of Dedicated Outbuilding							
12. Green Job Training Center		x	x	x	x	x	
13. Green Building Expo					x	x	x
14. Research & Development Connection		x		x		x	x
15. Florida Solar Museum and Gift Shop	x	x				x	x
TOTAL PROJECTS SERVING THIS AUDIENCE	**8**	**10**	**10**	**7**	**7**	**9**	**11**

TOOLS
The final phase of the plan's development was to choose specific projects that would address each of the target audiences, would fit the established objectives of the sponsoring agency, and would provide an excellent platform for delivery of the messages identified above.

To simplify this task, one virtual zone and four physical zones are being proposed as locations for marketing and educational projects. The virtual zone consists of an informational and interactive website that can serve all of the targeted audiences as a first step in building the marketing and educational campaign. The physical zones consist of: a) an outdoor solar walk area, b) a rotating exhibition space inside the main plaza building, c) a truck parking installation, and d) renovation/construction of a dedicated outbuilding. The virtual and physical zones also correspond to phases in which the FTE could develop the campaign, starting with a website and later moving on to an exhibition space, truck parking, and dedicated outbuilding. Finally, each of the five zones is further broken down into three sub-phases, presenting the FTE with 15 discrete projects to undertake as resources permit.

In short, each proposed marketing and educational project starts in the virtual zone (website) and is later developed incrementally in each physical zone as it is shown to be effective through piloting and evaluation. This has the following benefits:

- Efficacy of the proposed messages can be measured before undertaking major marketing campaigns.
- Potential audiences' interest levels can inform future developments across the system.
- The FTE can begin to generate online content immediately for very little investment, fostering a buzz about the project that precedes construction and identifying potential partners for future collaboration.
- The space required for each marketing and educational project can be minimized during the planning and construction phases of the solar installation, while still providing clear updates for the public about what is happening at the plaza.
- Sponsorship potential can be effectively gauged before major construction is undertaken.
- Limited financial resources can be used most judiciously based on hard data about the impacts of the marketing and educational campaign on the various stakeholder groups.
- Staffing the project can be accomplished on a limited consulting basis in the initial phases and increased slowly over time, with the eventual goal of housing the campaign at the FTE.

The 15 proposed projects are:

(1) Social Marketing Campaign
(2) Project Website with Audience Components
(3) Personal REcharging Stations
(4) Art Installation
(5) Solar Science Walk
(6) Virtual Power Usage Displays
(7) Educational Kiosks

(8) Rotating Exhibition Space
(9) Truck Parking Informational Campaign
(10) Solar Trucking Exhibition
(11) Trucking Demonstration Project
(12) Green Job Training Center
(13) Green Building Expo
(14) Research & Development Connection
(15) Florida Solar Museum and Gift Shop

What follows in this section is an overview of each project. Details about elements, costs, time to completion, and sponsorship and revenue potential are pulled out in Table 6.3 below:

Table 6.3 Overview of Costs and Revenue Potential of Proposed Projects							
	Elements	**Cost**	**Time to Complete**	**Partner Potential**	**Sponsor Potential**	**Ad Potential**	**Space Required**
PHASE 1: Virtual Display on the Web							
1. Social Marketing Campaign	various social networking sites (Facebook, LinkedIn, Twitter, etc.)	$	3 months	high	low	low	none
2. Project Website with Components, including all project branding	website	$$	6 months	high	low	high	none
PHASE 2: Solar Walk Area							
3. Personal REcharging Stations	solar umbrellas, mobile recharging stations, signage	$ - $$	3 months	low	high	medium	500 sq ft
4. Art Installation	sculptural elements	$ - $$	12+ months	low	high	low	variable
5. Solar Science Walk	outdoor displays	$	3 months	high	high	high	minimal for signage
PHASE 3: Exhibition Space							
6. Virtual Power Usage Displays	display screens	$	1 month	low	high	high	none (wall)
7. Educational Kiosks	indoor terminal displays, signage	$	1 month	medium	medium	high	100 sq ft
8. Rotating Exhibition Space	indoor exhibit displays, signage	$$	3 months	high	high	high	400+ sq ft
PHASE 4: Truck Parking							
9. Truck Parking Informational Campaign	outdoor displays	$	3 months	high	high	high	minimal for signage
10. Electrified Trucking Exhibition	solar charging stations	$$$	3 months	high	high	high	parking area
11. Solar Trucking Demonstration Project	equipment demonstration	$	3 months	high	high	high	parking area

PHASE 5: Renovation/Construction of Dedicated Outbuilding							
12. Green Job Training Center	classroom equipment	$$$$	2+ years	high	low	high	1000+ sq ft
13. Green Building Expo	indoor exhibit displays, signage	$$$$	2+ years	high	high	high	1000+ sq ft
14. Research & Development Connection	office equipment	$$$$	2+ years	high	medium	low	1000+ sq ft
15. Florida Solar Museum and Gift Shop	indoor exhibit displays, signage	$$$$	2+ years	high	low	low	1000+ sq ft
	LEGEND:	**$ = under $25,000**	**$$ = $25,000 to $50,000**	**$$$ = $50,000 to $100,000**	**$$$$ = over $100,000**		

Phase 1: Virtual Display on the Web

Project 1: Social Marketing Campaign
The first project is a social marketing campaign using established tools like Facebook, Twitter, LinkedIn and blogging to rapidly establish a public presence for the project. This will enable the FTE to reach out to all of the targeted audiences and provide a place for regularly updating the public on progress at the plaza. The cost of such a campaign is relatively low and requires only the time of a staff communications person or part-time consultant to complete. It is also an easy way for early collaboration efforts with potential project partners, since a number of useful websites on solar already exist in the state but are not connected in any single place. For example, the FTE could partner with the University of Central Florida's Florida Solar Energy Center, which already provides extensive tools on their website for homeowners interested in converting to solar water heaters. There is not currently a comprehensive solar social network online for Florida, so this is an easy project that can get the word out early about the Turnpike's efforts and help the state at the same time. Depending on the scope of contacts made and tools used, the total cost in staff or consultant time should be under $25,000 and would include maintenance for 3 months. Beyond that timeframe, costs for further development and maintenance are included in Project 2.

Project 2: Project Website with Audience Components and Project Branding
The social marketing campaign can easily be expanded within six months of launch into a project website with components for all of the target audiences. The benefit of launching a website before moving on to physical installation of marketing and educational displays on the plaza is that data collected about traffic to the site and demographics of users could be used to inform phasing decisions for future projects. Such a website could also be developed and used by the target audiences during the planning phase of the solar project and renovation of the existing plaza buildings. Costs for project branding are being included in this project since they would have to be completed in order to create a consistent look between the website and the final installations. The potential for partnerships to develop content is very high and would provide an

excellent basis for ongoing relationships in later phases of the marketing and educational campaign.

The website could include:

- An informational section for homeowners where they can learn about the benefits of solar technologies and connect with installers in their area.
- An educational section for educators and students where they can learn about the science behind solar and keep up with progress on the plaza installation from their classrooms.
- A section for the trucking industry explaining the changes at the plaza and the future of solar plug-in opportunities there.
- A basic database of solar employers and available jobs for the workforce audience.
- An introductory section about solar potential in residential and commercial construction in the state.
- A comprehensive section on solar and other business initiatives in the state that would interest existing businesspeople or future entrepreneurs.
- Contact information for international solar manufacturers interested in arranging a visit to the state and plaza.

The main costs associated with construction of and marketing such a website are as follows:

- Project branding - $25,000
- Website conceptualization and design - $15,000
- Staff and/or consultant development time: $10,000 - $50,000
- Staff and/or consultant ongoing maintenance time: $25,000 per year

Phase 2: Solar Walk Area

Project 3: Personal RECharging Stations

The third project the project team is recommending is conversion of one or more of the existing open areas at the plaza into outdoor rest areas for visitors with solar recharging stations for personal electronics. A number of technologies exist, including solar umbrellas that combine shade, seating and standard plugs for cell phones and laptop computers. Installation of a small number of these devices would be an easy way to involve plaza visitors, particularly the homeowner and trucking audiences, in the changes taking place and serve two unmet needs at the plaza: outdoor seating and a chance to recharge personal electronics on the road. There are several areas in the current plaza configuration, including small areas around the outdoor deck by the toll administration building and sidewalks near the plaza building itself. Signs will also be needed on the southbound side of the plaza directing these visitors to the new outdoor recharging areas.

The cost of the technologies varies but purchasing enough for the proposed area would cost approximately $25,000. There is a local Orlando company, SKYShades, that might make a good sponsor for this particular project, making the cost to the FTE negligible. This installation could be completed before or during renovation of the plaza and would provide a tangible indication of the kind of innovations that are coming to the plaza.

Project 4: Art Installation
Beyond the immediate area surrounding the plaza building, there are numerous open areas that are highly visible from the road and parking areas that would make excellent locations for solar art installations. Such installations would involve all of the potential audiences in the FTE's project equally, as well as addressing the need to let passersby know that something innovative is happening.

A first step in this direction would be to erect billboards with solar-powered moving elements at the north and south end of the plaza. These could be enhanced over time by additional displays including, but not limited to, solar lighting, solar sculptures, solar fountains, and more.

The cost of such displays is hard to predict since it depends on the complexity of the chosen design, but it would be easy and prudent to seek corporate sponsors for each of the installations and base the design on their capacity and interests. A number of large manufacturers are already sponsoring such art installations in other countries and the visibility of the Turkey Lake Service Plaza site makes it an attractive option for companies looking to enter the Florida market.

Project 5: Solar Science Walk
The idea of an outdoor walking tour of the plaza's installations was one of the earliest concepts proposed by the project team. It is an excellent way to tell the story of solar to visitors who want to stretch their legs during their stop at the plaza. Without knowing which specific installation recommendations (phased, scenario, etc.) will be adopted by the FTE, it is impossible at this conceptual stage to specify exactly where such a walk would go or what specific technologies will be showcased. In general it is possible to say that the walk should stay close to the renovated plaza and car parking areas and should provide a vantage point of every kind of solar technology installed at the plaza.

To keep the cost of signage and displays down, each stop could be indicated with a small plaque with a number on it. Existing services offer the ability to record narration about each stop and upload it to the Web. Visitors then use their cell phones to access the recorded content on site, making it easy to add, delete, or update stop narration quickly and easily without changing signs. The narrations could be written to include messages from sponsors to help defray the cost of developing and maintaining the system. In addition, the technology exists to allow a visitor's phone call to trigger a device to move, for example a solar panel to rotate on its axis to demonstrate the concept of tracking and energy production.

Spatial Adventures is one company that offers monthly hosting starting at $50 and usage plans starting at $25 for cell phone tours. There are no setup fees and narration can be written and recorded anywhere and then uploaded via the Web. They publish a useful guide to launching a cell phone tour (available at http://www.spatialadventures.com/Guide_to_Launching_a_Cell_Phone_Tour.pdf) that outlines the simple steps required.

Assuming no additional solar technologies are installed beyond what is required for the chosen energy production scenario, the costs for setting up the solar science walk are as follows:

- Signage for individual stops – approximately $1,000 for 10 stops
- Development of the content - $3,000 - $5,000 of staff or consultant time
- Ongoing content maintenance - approximately $1,000 per year
- Monthly hosting and usage fees, depending on the number of users - $75 - $500

Although every potential audience for the project can be addressed on the solar science walk, the focus should still be on homeowners and educators and students, since they are most likely to benefit from the information there. This means the focus should be on demonstrating specific residential technologies and technologies that could be adopted in the near future. Extremely experimental displays should be reserved for the art installation project or exhibition space inside the plaza (Phase 3, described next).

Figure 6.8 Businesses that manufacture, supply, and install renewable energy systems are candidates to exhibit their capabilities at the Turkey Lake Service Plaza.

Phase 3: Exhibition Space

Project 6: Virtual Power Usage Displays and Webcams
The third phase of marketing and educational installations moves the campaign inside a renovated Turkey Lake Service Plaza building. This permits the campaign to start while construction is underway, and then provides a location for the logical next step of the virtual and outdoor installations. The first and easiest project is the installation of virtual power usage displays and webcams trained on the installed technologies on site. These displays will be relevant to all of the audiences that visit Turkey Lake Service Plaza and provide a live stream of interactive data for the website sections as well.

Such displays have become a common feature of green buildings and could serve to display the power production of the solar installation, the improved energy usage of the plaza itself, and additional data about sponsors and other opportunities to learn at the site. The project team has already identified a potential sponsor of this equipment; DC Power Systems has written a letter (attached to this report) indicating they would be willing to supply all of the display and other required equipment for this project, making the cost to the FTE effectively zero. A prominent location for the display panels and allowances for the required wiring should be included in the design phase of the plaza renovation.

Project 7: Educational Kiosks
Directly next to the display panels would be the best location for the next project, a set of educational kiosks that make the existing website components available to visitors at the plaza. Developing the website early in the project allows the FTE to begin collecting data immediately about the effectiveness of the content and the number of visitors using each section. This data will be supplemented by usage statistics gathered at these on-site kiosks to use in developing the next project, a rotating exhibition space.

Kiosks generally cost approximately $2,000 to $4,000 per unit and be configured with built-in printers, for example for installer information or job listings, making the total cost for this project $10,000 to $20,000 for five kiosks.

Project 8: Rotating Exhibition Space - - 400 sq ft or about 20x20, more if possible
The final project inside the renovated plaza building is a rotating exhibition space near or surrounding the educational kiosks. This space should be a minimum of 400 square feet (or approximately 20 by 20 feet) to maximize the circulation of visitors and compatibility with existing trade show booth layouts.

The space can address the interests of one or more audience groups at the same time and should be programmed based on the data collected by the website and educational kiosks regarding visitor demographics and tool effectiveness. A few examples of potential exhibits for this space, which is really limited only by imagination and effectiveness for reaching the target audiences, include:

- Innovative technologies for the home, office, school, etc.
- Solar-powered gadgets display area and store
- Solar-powered personal electronics and store
- Solar sales center for homeowners
- Manufacturers exhibition space
- Solar car exhibit

The costs here are highly variable due to the following factors:

- Number of exhibitions planned per year?
- Use of FTE staff or an outside consultant to program the space and arrange for rotating exhibitions?
- Creation of unique displays just for Turkey Lake Service Plaza or repurposing existing booth displays created by companies for other trade shows?
- Ability to attract partner organizations and corporate sponsors for the scheduled exhibitions

Overall, the rotating exhibition space could be constructed, programmed and managed for less than $50,000 annually. This project, like many of the projects preceding it, was developed specifically with the idea of maximizing advertising revenue for the FTE. It is the project team's opinion that this project could go beyond breaking even and actually provide a steady revenue stream for Turkey Lake Service Plaza.

Phase 4: Truck Parking

The projects in Phase 4 can be done at any time during pre-construction, construction, or after completion of the Turkey Lake plaza renovation. They involve the truck parking area only and do not have any elements that need to be included in the area immediately surrounding the plaza or area inside it.

Project 9: Truck Parking Informational Campaign

The first project in this phase is a basic informational campaign on outdoor displays in the truck parking area. It can be incorporated into the existing sidewalk design and will serve to inform truckers about the changes to the plaza and plug-in solar stations project. Although demonstration projects like this exist in other parts of the country, the common problem is that truckers do not plug into the units because they do not understand how they work ("Next freeway exit: a greener truck stop," available at http://djcoregon.com/news/2009/08/25/energy-next-freeway-exit-a-greener-truck-stop/). An informational campaign could start the education process so that installation of the demonstration spaces would be more effective.

The only audience for this project is the truckers themselves but the cost of the project is low, around $5,000 for the design and writing and about $5,000 for the signage. There is strong potential to support this project with corporate sponsorship and there are also several potential partner organizations, including the Florida Trucking Association, who could be involved.

Project 10: Electrified Trucking Demonstration

Beyond the informational campaign, the next project would be to install the infrastructure for electrified parking spaces at Turkey Lake Service Plaza. The engineering requirements of an installation of this kind are outside the scope of this conceptual report, but figures cited in the article mentioned above indicate that such spaces cost approximately $6,000 apiece. The companies involved, Cascade Sierra Solutions and Shorepower received a $22.2 million award from the US Department of Energy to install 30 spaces in each of 50 truck stops across the country, so it is clear that there are grants and corporate sponsorship solutions available. Given Turkey Lake Service Plaza's ability to power these spaces from an alternative energy source, the project team feels this project could easily be self-funding with a governmental grant.

Project 11: Solar Trucking Demo Project

The final project in this phase is a demonstration/exhibition of a solar-powered rig. This equipment is quite new on the market, but has the potential to revolutionize trucking because panels on the cab collect solar energy throughout the day and then power the cab's mechanicals all night, eliminating or at least reducing the need for electrified parking spaces. This project does not need to cost the FTE anything assuming it can find a manufacturer interested in displaying its product on the site.

Phase 5: Renovation/Construction of Dedicated Outbuilding

This final phase is a brief look at more large-scale, long-term projects the FTE might undertake to further its objective of supporting rapid and immediate growth of solar in Florida. All four of the following projects have their roots in the phases that precede this one, but they each take marketing and education a huge step further by making Turkey Lake Service Plaza a regional or even national destination. Each would require extensive renovation or construction of a new building at Turkey Lake Service Plaza, but they could all share the space and cost. Exact costs for each are not included here since they depend heavily on final design, construction costs, and much more. They are listed here as an exercise in “thinking big” and imagining a larger role for the plaza in coming years.

Project 12: Green Job Training Center
There is currently no centralized location in the state or region for training tomorrow's workforce in green technologies. Given Turkey Lake Service Plaza's geographic advantages and proximity to Orlando's airport and amenities, it would make an excellent location for a green job training center. A center could build partnerships with academic institutions, non-profit groups and manufacturers and installers to move training at all levels forward immediately.

Project 13: Green Building Expo
The U.S. Green Building Council holds a national convention every year, Greenbuild, and attendance has been rapidly rising in recent years, with over 25,000 attendees in Boston in 2008. There are small regional centers demonstrating green building products and practices, but none of them combines comprehensiveness and permanence in one facility. Turkey Lake Service Plaza could provide such an expo space, which could heavily influence Florida builders in particular to join the green building revolution.

Project 14: Research & Development Connection
Florida already hosts one of the most important solar research centers in the country, the Florida Solar Energy Center. The University of Florida is home to several relevant institutes and centers and is a national leader in solar technology. Other state institutions already play or could play an increasingly important role in solar research and development. Turkey Lake Service Plaza's central location makes it an ideal hub for researchers and manufacturers to meet and explore each other's work and needs. A Research and Development Connection could serve to facilitate such meetings and provide physical meeting space for the groups.

Project 15: Florida Solar Museum and Gift Shop
A final project that could house projects and exhibitions of interest to all of the target audiences is a solar museum and gift shop. It would expand dramatically upon the rotating exhibition space inside the plaza building and provide permanent and temporary space for showcasing technologies, manufacturers, and research programs in Florida and beyond.

Revenue Potential
There are several ways for the FTE to generate revenue from the projects listed above.

The most direct method would be to obtain corporate sponsorship for each of the projects that would pay for the project itself and include additional funds for advertising exclusivity at the plaza or within the individual project. Good examples of projects that lend themselves to this model are the Solar Science Walk and the Solar Trucking Demo Project. In addition to solar manufacturers, the team also had framing conversations with other companies that might be interested in sponsoring part or all of the project (The Walt Disney Company, Home Depot, etc.) and found them generally receptive to the idea. The team encourages the FTE to include further discussions with these companies in their immediate next steps.

In addition to sponsorship, most of the projects can be designed to allow for a variety of advertising opportunities within them. Good examples of this are the Project Website with Audience Components, the Personal RECharging Stations and the Rotating Exhibition Space.

Finally, the FTE could generate revenues from some of the projects by charging for their use to defray the cost of installation. Examples of projects suited to this type of revenue generation are the Trucking Demonstration Project and the Research & Development Connection. Charging truckers to plug into the solar power system at night or offering space for rent for meetings and conferences could each generate substantial and ongoing revenue streams for the FTE.

The sponsorship potential for each project was evaluated based on initial conversations with companies and is included in the tables above. The advertising potential for each project depends heavily on the final design of each project and therefore could not be determined for this report. The project team strongly recommends that the FTE hire a consulting firm that specializes in green advertising and public relations to be involved in the design and construction phases of the project to assist with maximizing revenue generation from the site.

Immediate Next Steps

In order to get these projects started, there are a number of simple first steps the FTE should take immediately:

- Incorporate spatial requirements for educational kiosks and rotating exhibition space in plaza renovation designs.
- Pick someone to be responsible for continuing forward with the marketing and educational campaign. This could be an internal staff member or a consultant but the person should have experience with building social media campaigns using standard tools like Facebook, LinkedIn, Twitter, and others.
- Start branding review process to evaluate “Shine ON Florida!” campaign and investigate alternatives. The FTE could utilize the same communications staff members and consulting company that developed the SunPass brand.
- Pick liaison between FTE and potential corporate sponsors to continue framing conversations. This person should be fairly high up in the organization to indicate the seriousness of the FTE in pursuing this project.
- Determine piloting and evaluation programs for all projects chosen. Evaluation in particular was left out of this conceptual report, but it is a critical step since each phase of the marketing and educational campaign depends on evaluation of data collected in the previous phase.
- Consider doing a feasibility study immediately for the personal charging stations and truck parking information campaigns, since both projects could be installed during the planning phase for the solar installation and provide an immediate indication of the FTE's intentions at Turkey Lake Service Plaza.

Taking it System Wide

The marketing and educational campaign at Turkey Lake Service Plaza was mainly designed to build interest in solar in Florida, but it could also serve as a model for campaigns at other service plazas in the Turnpike system. As Areas further develops its plaza themes (currently Turkey Lake Service Plaza's theme is “Sun” and two other plazas will be “Water” and “Land”), each plaza could have a unique but interconnected marketing and educational campaign to highlight and encourage Florida's sustainable future in every area. Different projects would need to be developed and partners and corporate sponsors would change, but the lessons learned at Turkey Lake Service Plaza in reaching target audiences and fostering changes in sustainable behavior in Florida could serve to shorten the development curve for other plazas.

SUMMARY

The project team believes that Turkey Lake Service Plaza offers a unique opportunity to showcase solar energy in Florida. By including marketing and educational projects in each phase of the project, the FDOT/FTE can ensure that target audiences receive customized information and prompts that will advance solar energy in the state quickly and effectively.

This plan proposes targeting 8 major audiences with 15 unique marketing and educational projects. The objectives, audiences, goals, messages and tools were carefully chosen to meet the criteria of community-based social marketing in order to have the maximum impact, going beyond mere informational campaigns to get audiences involved in specific behavioral changes. Understanding that resources may be limited in the next few years, the marketing and educational plan also focuses on providing options and next steps that require minimal resource inputs for maximum results.

The conclusion of the project team is that Turkey Lake Service Plaza can fulfill its mission as a solar destination in the state and accomplish all of the objectives identified for it by the FDOT/FTE.

CHAPTER 7
SUMMARY AND CONCLUSIONS

A University of Florida research team, in collaboration with FDOT and FTE performed a feasibility analysis for the installation of a renewable energy system at the Turkey Lake Service Plaza on the Florida Turnpike. A wide variety of solar PV and SHW options were analyzed to determine which technologies were best suited for the various conditions present at the Turkey Lake Service Plaza. This assessment of solar technologies can be found in Chapter 2 of this research report. The PV technologies analyzed included thick film, thin film, and concentrating PV systems. In general conventional thick film technologies provide the best combination of cost and efficiency for most applications. For building roofs, newer thin film and concentrating PV systems have some advantages because they can be installed without violating roof warranties. In contrast thick film systems are heavier and need more conventional mounting systems.

In order to better analyze the Turkey Lake Service Plaza for solar energy output, the Plaza area was divided into eight Phases (Table 7.1).

Phase	PV Systems	Other
1. Open Areas	Thin film, thick film, organic PV (such as Konarka)	Tracking options, multi-panel options (2 or more)
2. Building Roofs	Thin film, thick film, organic PV (such as Konarka)	Tracking options
3. Employee Parking	Thin film, thick film, organic PV (such as Konarka), EV charging stations	None
4. Visitor Parking	Thin film, thick film, organic PV (such as Konarka), EV charging stations	None
5. Truck Parking	Thin film, thick film	Mounting options, “idle mode” use
6. Noise Walls	Thin film, thick film	Tracking options, mounting options, combination mounting (top and sides of walls), multi-panel option (2 or more)
7. Retention Ponds	Thin film, thick film, organic PV (such as Konarka)	Tracking options, multi-panel options (2 or more), floating system
8. Education and Marketing	All	Locate corporate display areas, solar walk zone

Table 7.1 The Phases used for organizing the assessment of Turkey Lake Service Plaza for its solar potential.

Three Scenarios were used as the basis for selecting technologies, designing the solar systems, and laying out the solar systems on or near the Turkey Lake Service Plaza. The three Scenarios used the seven Phases described above in various combinations to assess the Plaza for its energy generation potential. These three Scenarios are as follows:

1. Maximum Energy Scenario. The goal is to maximize solar generated electricity production and to use virtually all the available surfaces for mounting PV panels. The UF research team estimates that about 9.15 megawatts (MW) of electricity could be generated from an extensive system using all available areas for installation of solar PV panels. In the Maximum Energy Scenario, the solar PV system actually generates more electricity that the Turkey Lake Service Plaza consumes in a nominal year.

2. Net Zero Energy Scenario. For this scenario the analysis is based on eliminating high cost/low benefit options and focuses on relatively high energy outputs. The basic concept for this Scenario is Net Zero Energy (NZE) and the goal was to determine the conditions under which the Turkey Lake Service Plaza could become energy self-sufficient. For the Turkey Lake Service Plaza to become the first NZE service plaza, the power output of the PV system would have to be about 3.8 MW. This insures that the Plaza generates more energy than it consumes in any given month of the year, resulting in not only the NZE scenario, but also zero payment for energy on an monthly basis.

3. Showcase Energy Scenario. The final scenario focused less on energy generation and more on maximizing education and marketing with the emphasis of using Turkey Lake Service Plaza as a place where Floridians would be able to see and interact with solar technology and easily obtain information about solar energy systems directly from installers, suppliers, and manufacturers.

The Net Zero Energy scenario could be produced using a number of combinations of Phases. Based on current consumption, a peak power of 3.8 MW was calculated as providing for Net Zero Energy in all months of a typical year. The scenarios used in this Scenario are the mean value of the base case for each of the three phases: Open Areas, Building Roofs, and Visitor Parking. While visitor parking represents the same cost as employee parking, it is more visible and accessible to the public and so considered more of a priority. (See Table 7.2)

Phase	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production (kWh)
1	Open Area System	A. Rail Mounted Crystalline	100%	1.97	$ 9,835,000.00	3,221,000
2	Building Roofs	A. Solyndra	100%	0.21	$ 856,000.00	350,468
3	Employee Parking	A. Crystalline Engineered Structure	76%	1.02	$ 6,124,080.00	1,671,568
4	Visitor Parking	A. Crystalline Engineered Structure	80%	0.60	$ 3,590,400.00	980,000
5	Truck Parking		0%	0.00	$ 0.00	0
6	Noise Walls		0%	0.00	$ 0.00	0
7	Retention Ponds		0%	0.00	$ 0.00	0
8	Education/Marketing					
Total				**3.80**	**$ 20,405,480**	**6,223,036**
Average $/Watt					**$ 5.37**	

Table 7.2 Net Zero Energy Scenario using four of the eight Phases, peak power production of 3.8 MW

The following case is representative of the maximum energy production. This is achieved by selecting the best performing technologies and utilizing 100 percent of the areas allotted. The maximum energy production equates to 9.15 MW, which may vary slightly depending on the weather conditions and efficiency of the panels. The scenarios used below are the maximum values derived from the base case for all phases. (See Table 7.3)

Phase	Description	Scenario	Percentage of Scenario	System Size (MW)	System Cost	Production (kWh)
1	Open Area System	D. Dual-Axis Tracking Crystalline	100%	2.55	$ 15,282,000.00	5,364,191
2	Building Roofs	C. SunPower	100%	0.47	$ 1,864,000.00	763,168
3	Employee Parking	A. Crystalline Engineered Structure	100%	1.34	$ 8,058,000.00	2,199,431
4	Visitor Parking	A. Crystalline Engineered Structure	100%	0.75	$ 4,488,000.00	1,225,000
5	Truck Parking	A. Crystalline Engineered Structure	100%	0.66	$ 3,984,000.00	1,087,433
6	Noise Walls	A. Dual-Vertical Row Crystalline PV	100%	1.86	$ 10,208,000.00	2,868,413
7	Retention Ponds	A. Floating Crystalline	100%	1.53	$ 9,912,500.00	2,497,493
8	Education/Marketing					
Total				**9.15**	**$ 53,796,500**	**16,005,129**
Average $/Watt					**$ 5.88**	

Table 7.3 Maximum Power Scenario using all Phases to produce 9.15 MW of peak power

A summary of all the various scenarios and sub-scenarios, along with the system costs and power generation is shown in Table 7.4

SUMMARY OF SCENARIOS

Scenario	MW	kWh/yr	$/kWh	System Cost
PHASE 1 - Open Areas				
A: Rail Mounted Crystalline	1.97 MW	3,221,000 kWh	$ 0.18	$ 9,835,000.00
B: Passive Tracking Crystalline	1.97 MW	3,804,000 kWh	$ 0.15	$ 9,835,000.00
C: Single-Axis Tracking Crystalline	1.97 MW	3,804,421 kWh	$ 0.16	$ 10,818,500.00
D: Dual-Axis Tracking Crystalline	1.97 MW	4,142,664 kWh	$ 0.16	$ 11,802,000.00
E: Enclosed/Mounted Thin Film	1.07 MW	1,744,151 kWh	$ 0.14	$ 4,260,000.00
F: Concentrating PV	1.81 MW	2,960,962 kWh	$ 0.25	$ 12,656,000.00
PHASE 2 - Roof Mounted				
A: Solyndra	0.21 MW	350,468 kWh	$ 0.14	$ 856,000.00
B: Flat Thin Film	0.20 MW	291,855 kWh	$ 0.12	$ 585,000.00
C: SunPower	0.45 MW	732,052 kWh	$ 0.14	$ 1,788,000.00
PHASE 3 - Employee Parking				
A: Crystalline Engineered Structure	1.34 MW	2,199,431 kWh	$ 0.21	$ 8,058,000.00
B: Thin Film Engineered Structure	0.73 MW	1,192,246 kWh	$ 0.18	$ 3,640,000.00
C: Envision Solar Grove	1.65 MW	2,700,567 kWh	$ 0.21	$ 9,894,000.00
PHASE 4 - Visitor Parking				
A: Crystalline Engineered Structure	0.75 MW	1,225,000 kWh	$ 0.21	$ 4,488,000.00
B: Thin Film Engineered Structure	0.41 MW	663,269 kWh	$ 0.18	$ 2,025,000.00
C: Envision Solar Grove	0.92 MW	1,503,409 kWh	$ 0.21	$ 5,508,000.00
PHASE 5 - Truck Parking				
A: Crystalline Engineered Structure	0.51 MW	838,502 kWh	$ 0.21	$ 3,072,000.00
B: Thin Film Engineered Structure	0.28 MW	455,281 kWh	$ 0.18	$ 1,390,000.00
C: Envision Solar Grove	0.63 MW	1,030,113 kWh	$ 0.21	$ 3,774,000.00
PHASE 6 - Noise Walls				
A: Dual-Vertical Row Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
B: Dual-Horizontal Row Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
C: Two Rows of Vertical Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
D: Two Rows of Horizontal Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
E: Two Rows of Vertical Crystalline PV - South	0.82 MW	1,341,276 kWh	$ 0.19	$ 4,504,500.00
F: Top Mounted Crystalline PV	0.68 MW	1,054,018 kWh	$ 0.21	$ 3,751,000.00
G: Flush Thin Film	0.95 MW	1,468,207 kWh	$ 0.17	$ 4,275,000.00
PHASE 7 - Retention Ponds				
A: Floating Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00
B: Mounted Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00

Notes:
Summary uses the mean performance numbers for each scenario.
$/kWh includes gross first cost based on the cost/Watt installed with a production life of 20 years.

Table 7.4 Summary of Scenarios and Phases

The issues of wind loads and infrastructure were covered in Chapter 4 of this research report. The UF research team analyzed the effects of hurricane force winds on PV systems and concluded that in all cases the systems and their mounting systems would be able to handle the wind loads specified in the Florida Building Code. Additionally the tipping forces on the noise walls caused by an overturning moment from top-mounted solar PV panels would not cause the walls to topple. With respect to infrastructure, the existing electrical infrastructure is adequate for adding in a solar PV system of 9.15 MW, corresponding to the Maximum Power Scenario. Mounting a system on the noise walls provides significant power potential, 1.86 MW, but will require additional work in providing a scheme for collecting the solar generated electricity from along the 2 mile long wall.

In Chapter 5, innovative financing options for the Maximum Power and Net Zero Energy Scenarios were analyzed two cases for each Scenario: the Ownership Option in which the FTE would fund, operate, and maintain the system; and the Developer Option in which a utility or other entity would fund, operate, and maintain the system and provide the solar generated electricity to the Turkey Lake Service Plaza facilities in a Purchased Power Agreement or PPA. The present economic situation presents significant opportunities for installing a large solar system due to reduced equipment costs, low construction costs, low interest rates, significant tax incentives, and funding available from the ARRA 2009 stimulus package. If a developer were to be involved, the likelihood is that they would prefer the Maximum Power option to both provide the Turkey Lake Service Plaza with energy via a PPA and sell surplus energy to other customers. If the FTE were to opt to be the developer, the most likely option would be Net Zero Energy sized to offset the worst case month to ensure all electrical needs were met over the course of a year.

Finally, in Chapter 6, the UF research team also looked at how best to market the project to the general public and to decision makers in the State. It was quickly realized that Turkey Lake Service Plaza is an ideal location for marketing and educating the public and decision makers in the State. It is centrally located in the State and on the Turnpike and has very large traffic from both Floridians and visitors. As such it provides a unique opportunity to showcase solar energy and to provide the Service Plaza users with information about solar energy. As such Turkey Lake Service Plaza could be made into a “solar destination” with significant opportunities for publicity via interesting, state-of-the-art projects. Indeed the FTE has made the decision to designate the Turkey Lake Service Plaza as the “solar” themed plaza on the Turnpike.

Four major objectives guided the design of the marketing and education plan:

1. Showcase FDOT/FTE as Progressive and Innovative Organizations in a Post-Carbon World
In the minds of most citizens FDOT and FTE are connected to a carbon based economy based on fossil fuel vehicles and unsustainable transportation networks. In fact, both organizations see themselves as progressive and have already taken huge steps towards thinking about the future of more sustainable transportation networks and alternative energy and fuel sources. The Turkey Lake Solar Project presents an excellent opportunity to educate the public about current FDOT/FTE initiatives and reframe the agencies as progressive and innovative leaders in the post-carbon future in Florida.

2. Support Exponential and Immediate Growth of Solar in Florida
According to an April 2009 briefing from the non-partisan group Florida TaxWatch, Florida stands at “an opportune crossroads and... is uniquely positioned to take advantage of public and governmental encouragement to reach beyond the historical dependency of the US on fossil fuel.” The briefing goes on to state that while Florida's appetite for energy appears insatiable, the state is also poised to become the second-largest producer of electricity from the sun in the nation (after California) within the next few years. After the 111 MW currently under construction are completed, however, there are no large projects on the drawing boards. This means that the entire solar industry in Florida could lose its critical momentum and the state could lose future jobs from manufacturing, installation, and research to competitor states. Consequently projects like the potential solar energy installation at Turkey Lake Plaza are key to maintaining this critical momentum and attracting jobs and industry based on renewable energy to Florida.

3. Develop Turkey Lake as a Solar Destination
Making the Turkey Lake Plaza a solar destination that attracts diverse audiences was identified as a key objective in the initial stages of this research project. This objective is closely related to the first two objectives, to showcase the FDOT and FTE as innovative and to foster immediate growth of solar in the state, but it takes them a step further. The idea here is to develop a nuanced understanding of who is visiting the plaza, who might be encouraged to visit it, and how to make the service plaza unique in the state and the nation as a place of active learning and engagement with solar technologies. The Marketing and Educational Plan handles this objective by addressing each audience segment individually, always with the goal in mind of making Turkey Lake a world-class destination for solar.

4. Find Options That Are Interactive, Engaging and Creative for Each Phase of the Project
Throughout the research, the interaction of the public with the solar installation was a key element in selecting and designing the installations. The need to engage the project's various audiences prompted the use of the Community-Based Social Marketing framework discussed above. The messages and tools proposed in this plan were designed to maximize opportunities inherent in the previous three objectives: to showcase the FDOT and FTE as innovative organizations, to promote the rapid development of the solar industry in Florida and to develop Turkey Lake as a solar destination. All three are best accomplished by keeping this final objective in mind— by engaging the public in each phase of the project in the most interactive and creative ways imaginable.

Among the opportunities envisioned by the UF research team are electrical vehicle charging stations, truck amenity stations to allow trucks to turn off their engines during their stays at the Plaza, solar art, technology displays, booths by suppliers and manufacturers, LCD panels with information about solar energy and incentive programs for homeowners, to name but a few. The following are the 15 projects described in Chapter 6 as part of an education and marketing program:

(1) Social Marketing Campaign
(2) Project Website with Audience Components
(3) Personal RECharging Stations
(4) Art Installation

(5) Solar Science Walk
(6) Virtual Power Usage Displays
(7) Educational Kiosks
(8) Rotating Exhibition Space
(9) Truck Parking Informational Campaign
(10) Solar Trucking Exhibition
(11) Trucking Demonstration Project
(12) Green Job Training Center
(13) Green Building Expo
(14) Research & Development Connection
(15) Florida Solar Museum and Gift Shop

RECOMMENDATIONS FOR OTHER TURNPIKE PLAZAS AND FDOT FACILITIES

Turkey Lake Service Plaza is an especially challenging location for the installation of renewable energy systems. It is densely populated with buildings, roads, and parking, and there is not substantial open area available for solar PV arrays. On top of the physical issues, there is also the problem of obtaining funding for support of this type of major project. In spite of these limitations, this research indicated that there is enormous potential, at this point in time, for solar energy projects. The following are the major recommendations to FDOT and FTE for other facilities that may be considered for renewable energy systems:

The main obstacle to the feasibility of renewable energy projects is their financial feasibility. A preliminary evaluation of a proposed project can be accomplished using the data generated in the Turkey Lake Service Plaza research. The following are the suggested steps in this evaluation.

(1) Break the project into phases based on the types of areas available for solar PV installation, with the first phase being the most feasible, to the last phase being the least feasible. In order of priority, for the Turkey Lake Service Plaza, it was found that this priority order is: open areas, building roofs, employee parking, visitor parking, truck parking, and retention ponds.

(2) Use the Turkey Lake Service Plaza research data to determine the power output, energy generation, and cost for each phase. The cost data should be adjusted based on the model developed for this research should conditions change.

(3) Complete the preliminary evaluation by using the approach laid out in this research report in which the life cycle costing analyses were run for each Phase and combined into a final outcome. Both Net Zero Energy and Maximum Power scenarios should be examined because a developer may be willing to support a project if significant energy can be derived from it. The Net Zero Energy case may not generate adequate interest and support.

(4) Begin discussions with the development community and the local utility to assess issues with connection, net metering, and wheeling charges to further assess the project’s feasibility.

(5) Time is of the essence, conditions now are the best they have ever been for renewable energy projects and they are unlikely to improve. The year 2010 is likely the end of the stimulus

package and major tax advantages such as accelerated depreciation and bonus depreciation. A good strategy would be a strategic partnership between FDOT/FTE and a major developer who would be willing to support projects throughout the system. Packaging these projects could result in a major shift in energy generation for their facilities and provide enough power generation to make the overall project extremely attractive to a developer.

EMPLOYMENT AND BUSINESS IMPLICATIONS

One of the benefits of shifting from fossil fuel derived energy to renewable energy is the number of jobs that can result from manufacturing, installing, and maintaining the solar equipment. The nature of a distributed energy system versus a high energy centralized system is that more jobs are inherent in the former compared to the latter. In fact Charles Kibert of the University of Florida, one of the authors of this report, estimates that for the same size power output, 7 times as many jobs are created for a renewable energy system compared to a conventional coal-fired plant, with far less environmental damage. Additionally in a research report to determine the job implications of investments in energy conservation, it was estimated that between 12 and 17 jobs could be generated for each $1 million dollars of investment. For the approximately $54 million dollar Maximum Power case described in Chapter 3 of this report, based on this research it is estimated that at least 648 jobs can result from an installation of this scale. This includes only the jobs that would be created by the installation of a project of this scale. Additional jobs, as many as 100 would be likely created in the plants where the solar equipment is manufactured. Should enough of these large scale solar projects occur in Florida, it is probable that significant manufacturing capacity would transfer to Florida and the citizens of Florida would benefit directly from this industry.

CONCLUSIONS

The Turkey Lake Service Plaza has enormous potential for installing a viable, cost-effective, and high impact solar PV installation. Due to the wide variety of conditions at the Plaza, there are several installation options that could be replicated throughout the FDOT and FTE system. Turkey Lake Service Plaza is an ideal location for marketing to the public and educating them about solar technologies and opportunities. The current economic conditions make renewable energy projects especially attractive and there are ample incentives and opportunities to support a relatively low cost installation. In short, the UF research team has concluded that the installation of a solar PV system at the Turkey Lake Service Plaza, along with a number of SHW systems to serve domestic hot water needs, is feasible and would have significant impact on the rate of penetration of renewable energy in Florida.

REFERENCES

Kibert, Charles J. and Richard Fobair. 2007."Translating Energy Conservation Investments to Jobs," Center for Wisconsin Strategy.

GLOSSARY

ASCE - American Society of Civil Engineers

Alternating current (AC) - An electric current that reverses its direction at regularly recurring intervals —abbreviation AC

Carbon credits - The value of carbon associated with climate change mitigation as traded on an exchange established for this purpose. Carbon credits are a key component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). One Carbon Credit is equal to one ton of Carbon. Carbon trading is an application of an emissions trading approach.

Cell efficiency - The ratio of the electrical energy produced by a photovoltaic cell (under full sun conditions or 1 kW/m^2) to the energy from sunlight falling upon the cell

Charge controller - A component that controls the flow of current to and from the battery subsystem to protect the batteries from overcharge and over discharge. The charge controller may also monitor system performance and provide system protection

Diffuse radiation - Sunlight received indirectly as a result of scattering due to clouds, fog, haze, dust or other substances in the atmosphere

Direct current (DC) - The unidirectional flow of electric charge. Direct current is produced by such sources as batteries, thermocouples, or solar modules

Direct radiation - Light that has traveled in a straight path from the sun (also referred to as beam radiation).

Discount Rate - A certain interest rate that is used to bring a series of future cash flows to their present value in order to state them in current, or today's, dollars. Use of a discount rate removes the time value of money from future cash flows.

Flat-plate array - A photovoltaic array in which the incident solar radiation strikes a flat surface and no concentration of sunlight is involved

Fresnel Lens - A concentrating lens, positioned above and concave to a PV cell to concentrate light on the cell.

Generator - A machine by which mechanical energy is changed into electrical energy

Green Power - Power generated by renewable energy systems that can be purchased from the grid to support a green building project. Green power describes sources of power that are considered to be environmentally friendly and non-polluting, such as geothermal, wind, solar, and hydro.

Grid-connected - An energy producing system connected to the utility transmission grid (also called utility-interactive grid)

Hybrid system - A power system consisting of two or more power generating subsystems (e.g., the combination of a wind turbine and a photovoltaic system)

Insolation - The amount of sunlight reaching an area, usually expressed in Watts per square meter per day

Inverter - An electrical converter that converts direct current into alternating current

Load - Electrical power being consumed at any given moment. The load that an electric generating system supplies varies greatly with time of day and day of the year

Life Cycle Cost - The cost of a product over its lifetime. The costs include initial cost, maintenance cost, replacement cost, and salvage value (subtracted from the costs). LCC is used for comparison purposes of various building material/system options.

Mean Time Between Failure (MBTF) - Is the arithmetic mean (average) time between failures of a system

Moment - A tendency to produce motion, esp. about an axis

NEMA 3R - A rating prescribed by the National Electrical Manufacturer's Association (NEMA) that specifies that the electrical equipment is rain tight, and suitable for mounting outdoors.

Net metering - Service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period

Net Zero Energy (NZE) - Refers to a scenario for a building or group of buildings that are energy self-sufficient, generating all the energy needed on an annual basis on-site using renewable energy systems such as solar photovoltaic modules.

Parallel connected - A method of connection in which positive terminals are connected together and negative terminals are connected together. Current output adds and voltage remains the same

Photovoltaic cell - The semiconductor device that converts light into electricity (building block of photovoltaic modules)

Photovoltaic module or panel - A collection of photovoltaic cells wired in series and parallel for the purpose of generating electricity from the sun in useful quantities.

Power Purchase Agreement (PPA) - A long-term contract to buy power from a specific energy provider. Solar PPAs are agreements between a provider and a customer to purchase on-going solar power, usually equal to or less than market rates.

Series connected - A method of connection in which the positive terminal of one device is connected to the negative terminal of another. The voltages add and the current is limited to the least of any device in the string

Solar constant - The rate at which energy is received from the Sun just outside the Earth's atmosphere on a surface perpendicular to the Sun's rays (1.36 kW/m^2)

Spall - To break or split off in chips or bits

Switchgear - A term used to describe the equipment used in an electric power distribution

Thick-film cells - Conventional cells, such as crystalline silicon cells, which are typically from 4 to 17 mm thick (in contrast, thin-film cells are several microns thick)

Thin-film cells - Photovoltaic cells made from a number of layers of photo-sensitive materials which are typically applied using a chemical vapor deposition process in the presence of an electric field

Tracker, active - Use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction

Tracker, passive - Use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance. As this is a non-precision orientation it is unsuitable for certain types of concentrating photovoltaic collectors but works fine for common PV panel types

Tracking systems - A device for orienting a daylighting reflector, solar photovoltaic panel or concentrating solar reflector or lens toward the sun

Voltage regulator - A device that controls the operating voltage of a photovoltaic array

Watt (W) - The power produced by a current of one ampere across a potential difference of one volt. One Watt = 1/746 Horsepower. kilowatt (kW) = 1,000 W; megawatt (MW) = 1,000,000 Watts.

Watt-Hour (Wh) - Power of one Watt for over a one hour time period; kilowatt-hour (kWh) = 1,000 Wh; megawatt-hour (MWh) = 1,000,000 Wh.

APPENDIX A
SOLAR TECHNOLOGY REFERENCE MATERIALS

Photovoltaic Companies

SANYO Energy (U.S.A) Corp., http://us.sanyo.com/solar/
BP Solar USA, http://www.bp.com/modularhome.do?categoryId=8050&contentId=7035481
Suntech America, http://www.suntech-power.com/
SunPower Corporation, http://us.sunpowercorp.com/business/
Kaneka Corporation, http://www.kaneka.co.jp/kaneka-e/business/electro02.html
CANROM Photovoltaics Inc., http://www.canrom.com/
DM Solar, http://www.dmsolar.com/
Bright Watts Inc., http://www.brightwatts.com/
Sharp Solar, http://www.sharpusa.com/SolarElectricity.aspx
GE Energy, http://www.gepower.com/prod_serv/products/solar/en/index.htm
EPV Solar Inc., http://www.epv.net/
UNI-SOLAR, http://www.uni-solar.com/
Solyndra Inc., http://www.solyndra.com/
XsunX Inc., http://www.xsunx.com/
Signet Solar Inc., http://www.signetsolar.com/
First Solar Inc., http://www.firstsolar.com/
Xunlight Corporation, http://www.xunlight.com/index.shtml
Solar Systems Pty Ltd., http://www.solarsystems.com.au/
Energy Innovations Inc., http://www.energyinnovations.com/
Soliant Energy Inc., http://www.soliantenergy.com/
Amonix Inc., http://www.amonix.com/
Pyron Solar Inc., http://www.pyronsolar.com/
Sol3g, http://www.sol3g.com/
Zytech Solar Inc., http://www.zytech.es/index.asp
Arima EcoEnergy Technologies Corp., http://www.arimaeco.com/
Evergreen Solar Inc., http://www.evergreensolar.com/
Konarka Technologies Inc., http://www.konarka.com/

PV Tracking Systems

RayTracker Inc., http://www.raytracker.com/
Array Technologies Inc., http://www.wattsun.com/
Zomeworks Corporation, http://zomeworks.com/

Inverters

SMA Solar Technology AG, http://www.sma.de/en.html
Xantrex Technology Inc., http://www.xantrex.com/

Battery Systems

U.S Battery Manufacturing Co., http://www.usbattery.com/
Crown Battery Manufacturing, http://www.crownbattery.com/
Trojan Battery Company, http://www.trojan-battery.com/
Exide Technologies, http://www.exide.com/portal/server.pt/community/home_community/210
Surrette Battery, http://www.surrette.com/
Sun Xtender Solar Batteries (Div. of Concorde Battery Corp.), http://www.sunxtender.com/

APPENDIX B
SYSTEM SELECTION AND DESIGN ASSUMPTIONS

The data used throughout the System Selection and Design Alternatives segment of this report is based on various assumptions and calculations as presented in this appendix. The following is a list of assumptions relevant to this segment of the report.

1. Solar radiation data is based on the latest National Solar Radiation Database data for the Orlando International Airport (MCO) in Orlando, Florida.
2. Calculations were made using Maui Software PV Design Pro – G.
3. The areas used for all calculations are summarized below and are further detailed within this appendix. These areas were calculated for each phase and are representative of the maximum square footage of solar panel, not the installable surface area.

Description	Panel Area
PHASE 1: Open Areas	142,000 SF
PHASE 2: Building Roofs	26,000 SF
PHASE 3: Employee Parking	97,000 SF
PHASE 4: Visitor Parking	54,000 SF
PHASE 5: Truck Parking	37,000 SF
PHASE 6: Noise Walls	49,000 SF - 127,000 SF
PHASE 7: Retention Ponds	85,000 SF
PHASE 8: Education/Marketing	N/A

4. The optimum angle was determined to be 27 degrees from horizontal based on the above mentioned radiation data and software.
5. The optimum angle yielded a yearly kWh per kW of 1640 based on a crystalline SunPower 315 panel with 19.3% efficiency.
6. Single Axis tracking represents a 18.1% increase in efficiency over a 27 degree fixed panel.
7. Dual Axis tracking represents a 28.6% increase in efficiency over a 27 degree fixed panel.
8. Flat oriented panels represent a 8.6% decrease in efficiency below a 27 degree fixed panel.
9. Southwest oriented panels represent a 5.7% decrease in efficiency below a 27 degree fixed panel.
10. The noise walls were considered facing 45 degrees west of due south.
11. Production % or Percentage of 2008 Production refers to the production of a proposed photovoltaic system as a percentage of the 2008 consumption at Turkey Lake.
12. The 2008 usage referred to in this report is based on five buildings at the Turkey Lake Plaza for a total of 5,891,880 kWh consumed for the year.
13. Production summary minimums are based on the lowest performing technologies, while maximums are based on the highest performing technologies, and means are based on the average of all researched available technologies for any given phase.
14. Net Zero Energy refers to producing as much energy on a single site in a year as is consumed on the same site in that year.

SUMMARY OF SCENARIOS

Scenario	MW	kWh/yr	$/kWh	System Cost
PHASE 1 - Open Areas				
A: Rail Mounted Crystalline	1.97 MW	3,221,000 kWh	$ 0.18	$ 9,835,000.00
B: Passive Tracking Crystalline	1.97 MW	3,804,000 kWh	$ 0.15	$ 9,835,000.00
C: Single-Axis Tracking Crystalline	1.97 MW	3,804,421 kWh	$ 0.16	$ 10,818,500.00
D: Dual-Axis Tracking Crystalline	1.97 MW	4,142,664 kWh	$ 0.16	$ 11,802,000.00
E: Enclosed/Mounted Thin Film	1.07 MW	1,744,151 kWh	$ 0.14	$ 4,260,000.00
F: Concentrating PV	1.81 MW	2,960,962 kWh	$ 0.25	$ 12,656,000.00
PHASE 2 - Roof Mounted				
A: Solyndra	0.21 MW	350,468 kWh	$ 0.14	$ 856,000.00
B: Flat Thin Film	0.20 MW	291,855 kWh	$ 0.12	$ 585,000.00
C: SunPower	0.45 MW	732,052 kWh	$ 0.14	$ 1,788,000.00
PHASE 3 - Employee Parking				
A: Crystalline Engineered Structure	1.34 MW	2,199,431 kWh	$ 0.21	$ 8,058,000.00
B: Thin Film Engineered Structure	0.73 MW	1,192,246 kWh	$ 0.18	$ 3,640,000.00
C: Envision Solar Grove	1.65 MW	2,700,567 kWh	$ 0.21	$ 9,894,000.00
PHASE 4 - Visitor Parking				
A: Crystalline Engineered Structure	0.75 MW	1,225,000 kWh	$ 0.21	$ 4,488,000.00
B: Thin Film Engineered Structure	0.41 MW	663,269 kWh	$ 0.18	$ 2,025,000.00
C: Envision Solar Grove	0.92 MW	1,503,409 kWh	$ 0.21	$ 5,508,000.00
PHASE 5 - Truck Parking				
A: Crystalline Engineered Structure	0.51 MW	838,502 kWh	$ 0.21	$ 3,072,000.00
B: Thin Film Engineered Structure	0.28 MW	455,281 kWh	$ 0.18	$ 1,390,000.00
C: Envision Solar Grove	0.63 MW	1,030,113 kWh	$ 0.21	$ 3,774,000.00
PHASE 6 - Noise Walls				
A: Dual-Vertical Row Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
B: Dual-Horizontal Row Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
C: Two Rows of Vertical Crystalline PV	1.43 MW	2,214,674 kWh	$ 0.21	$ 7,881,500.00
D: Two Rows of Horizontal Crystalline PV	0.82 MW	1,265,749 kWh	$ 0.21	$ 4,504,500.00
E: Two Rows of Vertical Crystalline PV - South	0.82 MW	1,341,276 kWh	$ 0.19	$ 4,504,500.00
F: Top Mounted Crystalline PV	0.68 MW	1,054,018 kWh	$ 0.21	$ 3,751,000.00
G: Flush Thin Film	0.95 MW	1,468,207 kWh	$ 0.17	$ 4,275,000.00
PHASE 7 - Retention Ponds				
A: Floating Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00
B: Mounted Crystalline	1.18 MW	1,927,573 kWh	$ 0.23	$ 7,650,500.00

Notes:

Summary uses the mean performance numbers for each scenario.

$/kWh includes gross first cost based on the cost/Watt installed with a production life of 20 years.

Phase 1: Open Areas

142,000 SQ FT

P1-A	Rail Mounted Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	1,254,000	2,054,000	35%
Mean	1,967,000	3,221,000	55%
Maximum	2,547,000	4,171,000	71%

P1-D	Dual-Axis Tracking Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	1,254,000	2,641,027	45%
Mean	1,967,000	4,142,664	70%
Maximum	2,547,000	5,364,191	91%

P1-B	Passive Tracking Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	1,254,000	2,425,000	41%
Mean	1,967,000	3,804,000	65%
Maximum	2,547,000	4,926,000	84%

P1-E	Enclosed/Mounted Thin Film		
	W	kWh / yr	% of 2008 usage
Minimum	701,000	1,148,028	19%
Mean	1,065,000	1,744,151	30%
Maximum	1,704,000	2,790,641	47%

P1-C	Single-Axis Tracking Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	1,254,000	2,425,391	41%
Mean	1,967,000	3,804,421	65%
Maximum	2,547,000	4,926,213	84%

P1-F	Concentrating PV		
	W	kWh / yr	% of 2008 usage
Minimum	1,389,000	2,274,765	39%
Mean	1,808,000	2,960,962	50%
Maximum	2,770,000	4,536,429	77%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

Concentrating PV	W / m2	W / sf
Minimum	105	9.78
Mean	137	12.73
Maximum	210	19.51

Phase 2: Building Roofs

26,000 SQ FT

P2-A	Solyndra		
	W	kWh / yr	% of 2008 usage
Minimum	184,000	301,337	5%
Mean	214,000	350,468	6%
Maximum	246,000	402,874	7%

P2-B	Flat Thin Film		
	W	kWh / yr	% of 2008 usage
Minimum	128,000	191,577	3%
Mean	195,000	291,855	5%
Maximum	312,000	466,969	8%

P2-C	SunPower		
	W	kWh / yr	% of 2008 usage
Minimum	417,000	682,921	12%
Mean	447,000	732,052	12%
Maximum	466,000	763,168	13%

Solyndra	W / m2	W / sf
Minimum	76	7.09
Mean	88	8.22
Maximum	102	9.45

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

SunPower	W / m2	W / sf
Minimum	173	16.05
Mean	185	17.18
Maximum	193	17.94

Phase 3: Employee Parking

97,000 SQ FT

P3-A	Crystalline Engineered Structure		
	W	kWh / yr	% of 2008 usage
Minimum	857,000	1,403,509	24%
Mean	1,343,000	2,199,431	37%
Maximum	1,740,000	2,849,598	48%

P3-B	Thin Film Engineered Structure		
	W	kWh / yr	% of 2008 usage
Minimum	479,000	784,458	13%
Mean	728,000	1,192,246	20%
Maximum	1,164,000	1,906,283	32%

P3-C	Envision Solar Grove		
	W	kWh / yr	% of 2008 usage
Minimum	1,649,000	2,700,567	46%
Mean	1,649,000	2,700,567	46%
Maximum	1,649,000	2,700,567	46%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

Envision	W / m2	W / sf
Minimum	183	17.00
Mean	183	17.00
Maximum	183	17.00

Phase 4: Visitor Parking

54,000 SQ FT

P4-A	Crystalline Engineered Structure		
	W	kWh / yr	% of 2008 usage
Minimum	477,000	781,183	13%
Mean	748,000	1,225,000	21%
Maximum	969,000	1,586,931	27%
P4-B	**Thin Film Engineered Structure**		
	W	kWh / yr	% of 2008 usage
Minimum	267,000	437,266	7%
Mean	405,000	663,269	11%
Maximum	648,000	1,061,230	18%
P4-C	**Envision Solar Grove**		
	W	kWh / yr	% of 2008 usage
Minimum	918,000	1,503,409	26%
Mean	918,000	1,503,409	26%
Maximum	918,000	1,503,409	26%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

Envision	W / m2	W / sf
Minimum	183	17.00
Mean	183	17.00
Maximum	183	17.00

Phase 5: Truck Parking

37,000 SQ FT

P5-A	Crystalline Engineered Structure		
	W	kWh / yr	% of 2008 usage
Minimum	327,000	535,528	9%
Mean	512,000	838,502	14%
Maximum	664,000	1,087,433	18%

P5-B	Thin Film Engineered Structure		
	W	kWh / yr	% of 2008 usage
Minimum	183,000	299,699	5%
Mean	278,000	455,281	8%
Maximum	444,000	727,139	12%

P5-C	Envision Solar Grove		
	W	kWh / yr	% of 2008 usage
Minimum	629,000	1,030,113	17%
Mean	629,000	1,030,113	17%
Maximum	629,000	1,030,113	17%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

Envision	W / m2	W / sf
Minimum	183	17.00
Mean	183	17.00
Maximum	183	17.00

Phase 6: Noise Walls

127,000 SQ FT

P6-A	Dual-Vertical Row Crystalline PV		
103437	W	kWh / yr	% of 2008 usage
Minimum	913,000	1,411,024	24%
Mean	1,433,000	2,214,674	38%
Maximum	1,856,000	2,868,413	49%

P6-B	Dual-Horizontal Row Crystalline PV		
59107	W	kWh / yr	% of 2008 usage
Minimum	522,000	806,741	14%
Mean	819,000	1,265,749	21%
Maximum	1,060,000	1,638,210	28%

P6-C	Two Rows of Vertical Crystalline PV		
103437	W	kWh / yr	% of 2008 usage
Minimum	913,000	1,411,024	24%
Mean	1,433,000	2,214,674	38%
Maximum	1,856,000	2,868,413	49%

P6-D	Two Rows of Horizontal Crystalline PV		
59107	W	kWh / yr	% of 2008 usage
Minimum	522,000	806,741	14%
Mean	819,000	1,265,749	21%
Maximum	1,060,000	1,638,210	28%

P6-E	Two Rows of Vertical Crystalline PV Facing South		
59107	W	kWh / yr	% of 2008 usage
Minimum	522,000	854,879	15%
Mean	819,000	1,341,276	23%
Maximum	1,060,000	1,735,962	29%

P6-F	Top Mounted Crystalline PV		
49256	W	kWh / yr	% of 2008 usage
Minimum	435,000	672,284	11%
Mean	682,000	1,054,018	18%
Maximum	884,000	1,366,205	23%

P6-G	Flush Thin Film		
126720	W	kWh / yr	% of 2008 usage
Minimum	626,000	967,471	16%
Mean	950,000	1,468,207	25%
Maximum	1,521,000	2,350,677	40%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

Thin Film	W / m2	W / sf
Minimum	53	4.94
Mean	81	7.50
Maximum	129	12.00

sf / m2	10.76	
kWh / yr * kW	1545.5	Southwest Facing (5.7% Efficiency Decrease)
kWh / yr * kW	1637.7	Fixed (27 Degree Tilt)

Turkey Lake kWh / yr	5,891,880
$	$ 589,188
MW	3.81

Phase 7: Retention Ponds

85,000 SQ FT

P7-A	Floating Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	751,000	1,229,913	21%
Mean	1,177,000	1,927,573	33%
Maximum	1,525,000	2,497,493	42%

P7-B	Mounted Crystalline		
	W	kWh / yr	% of 2008 usage
Minimum	751,000	1,229,913	21%
Mean	1,177,000	1,927,573	33%
Maximum	1,525,000	2,497,493	42%

Crystalline	W / m2	W / sf
Minimum	95	8.83
Mean	149	13.85
Maximum	193	17.94

PHOTOVOLTAIC CALCULATIONS

	Turkey Lake Consumption		PV Output (100 kW System)		PV Output (3.8 MW System)		Utility Costs
January	415,500	kWh	11,321	kWh	430,203	kWh	$ (588.11)
February	450,180	kWh	11,682	kWh	443,916	kWh	$ 626.41
March	476,760	kWh	15,321	kWh	582,180	kWh	$ (4,216.81)
April	486,840	kWh	16,881	kWh	641,481	kWh	$ (6,185.62)
May	488,160	kWh	16,529	kWh	628,112	kWh	$ (5,598.08)
June	545,940	kWh	13,881	kWh	527,481	kWh	$ 1,845.87
July	504,960	kWh	14,061	kWh	534,316	kWh	$ (1,174.25)
August	542,160	kWh	13,291	kWh	505,060	kWh	$ 3,710.01
September	524,940	kWh	12,983	kWh	493,354	kWh	$ 3,158.63
October	443,820	kWh	13,145	kWh	499,525	kWh	$ (2,228.22)
November	530,340	kWh	12,635	kWh	480,146	kWh	$ 5,019.44
December	482,280	kWh	11,951	kWh	454,139	kWh	$ 2,814.12
	5,891,880	**kWh**	**163,769**	**kWh**	**6,219,912**	**kWh**	**$ (2,816.61)**

Tilt (Degrees)	PV Output (100 kW System)	% of Optimum Angle	kWh/yr/kW	Notes
90	94574.24	57.75%	945.74	Vertical
45	157228.69	96.01%	1572.29	
30	163576.30	99.88%	1635.76	
29	163682.41	99.95%	1636.82	
28	163746.83	99.99%	1637.47	
27	163769.65	100.00%	1637.70	Optimum Angle
26	163751.47	99.99%	1637.51	
25	163692.78	99.95%	1636.93	
20	162790.58	99.40%	1627.91	
15	160899.21	98.25%	1608.99	
10	158075.48	96.52%	1580.75	
5	154346.08	94.25%	1543.46	
0	149704.43	91.41%	1497.04	Flat
2-Axis	210424.98	128.49%	2104.25	Dual Axis Tracking
1-Axis	193282.21	118.02%	1932.82	Single Axis Tracking

27	154547.065	94.37%	1545.47	Southwest Facing
27	31601.515	19.30%	316.02	Thin Film

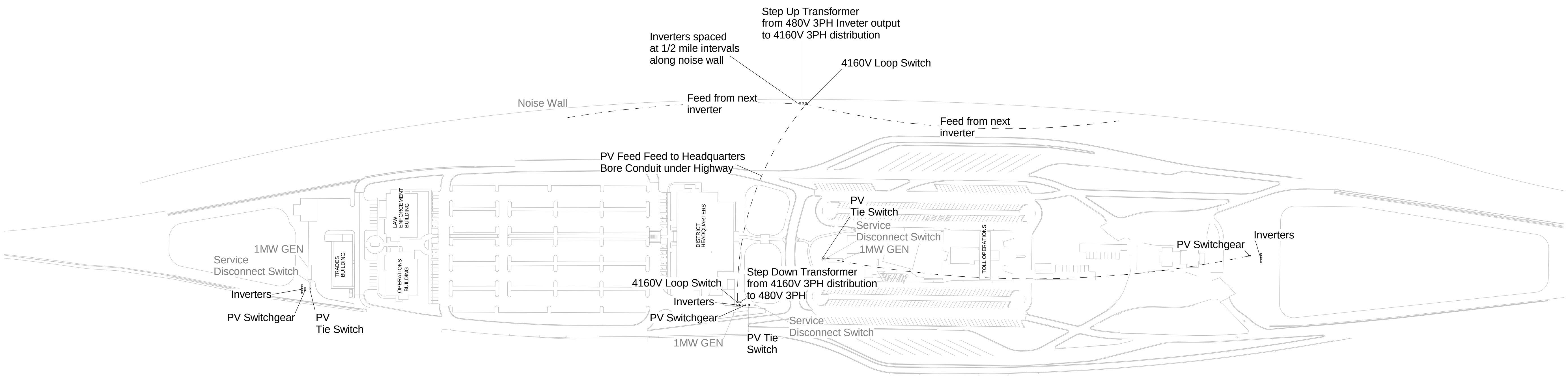
Assumptions

Location:	Orlando (MCO)
Type:	Fixed Tilt
Azimuth:	180 Degrees (Due South)
Tilt:	27 Degrees (From Horizontal)
Cost of Electricity	$ 0.10
PV Panel:	SunPower 315
Thin Film Panel:	First Solar FS-55 2004 (E) CdTe

COST ASSUMPTIONS

Cases	$/Watt
Base Solar Panel	$ 3.00
Thin Film (-1)	$ 2.00
CPV (+1)	$ 4.00
Support System (Ground)	$ 1.00
Single Axis Tracking	$ 0.50
Dual Axis Tracking	$ 1.00
Support System (Ground Walls)	$ 1.50
Electrical Integration	$ 1.00
Employee and Visitor Parking	$ 2.00
Truck Parking	$ 2.00
Retention Ponds	$ 2.50

APPENDIX C
INFRASTRUCTURE ISSUES



1 Level 1
1" = 300'-0"

M.E. RINKER, SR. SCHOOL of
BUILDING CONSTRUCTION

www.bcn.ufl.edu

Florida Turnpike Enter.

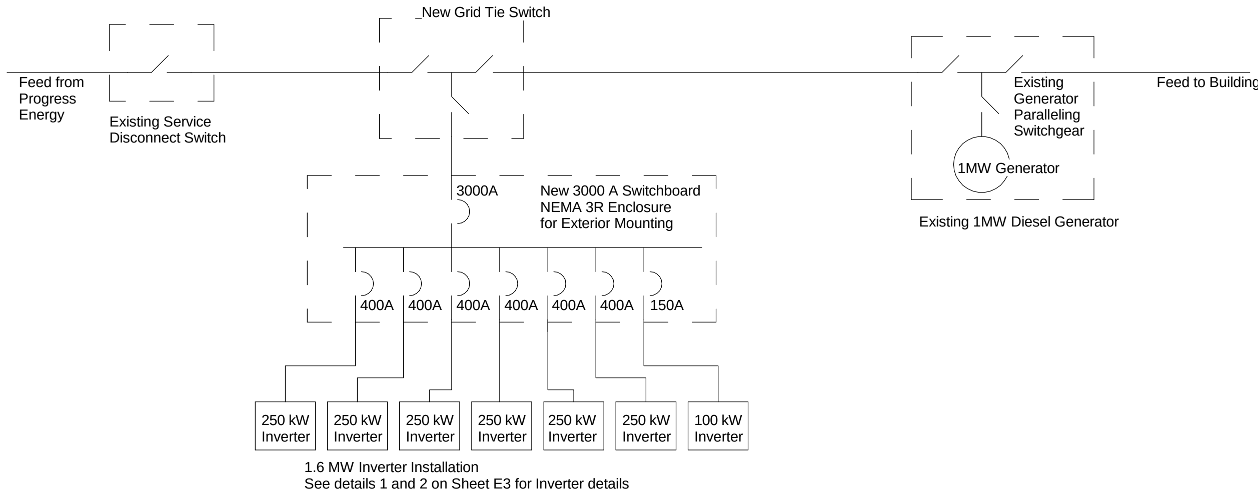
Turkey Lake Solar Study

No.	Description	Date

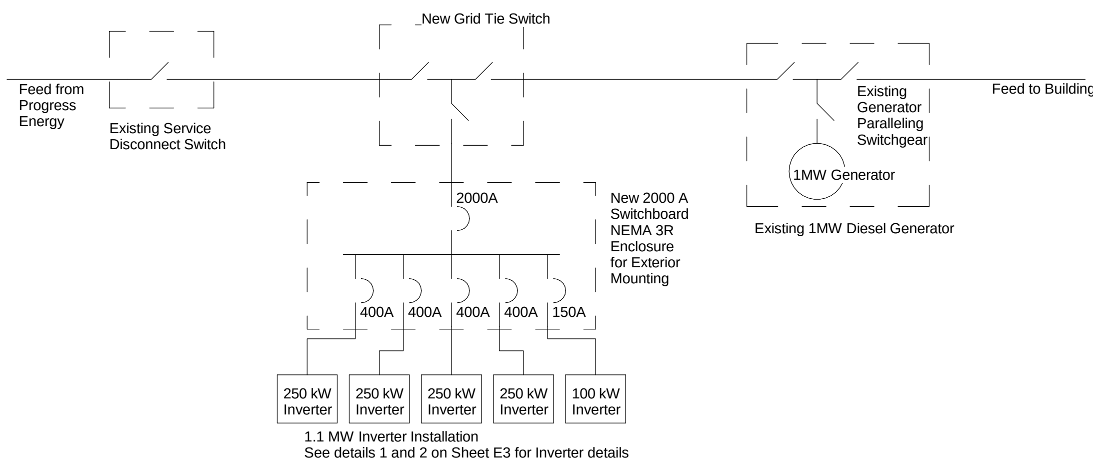
PV Site Plan

Project number	1	E1
Date	9/11/2009	
Drawn by	RW	
Checked by	RW	Scale 1" = 300'-0"

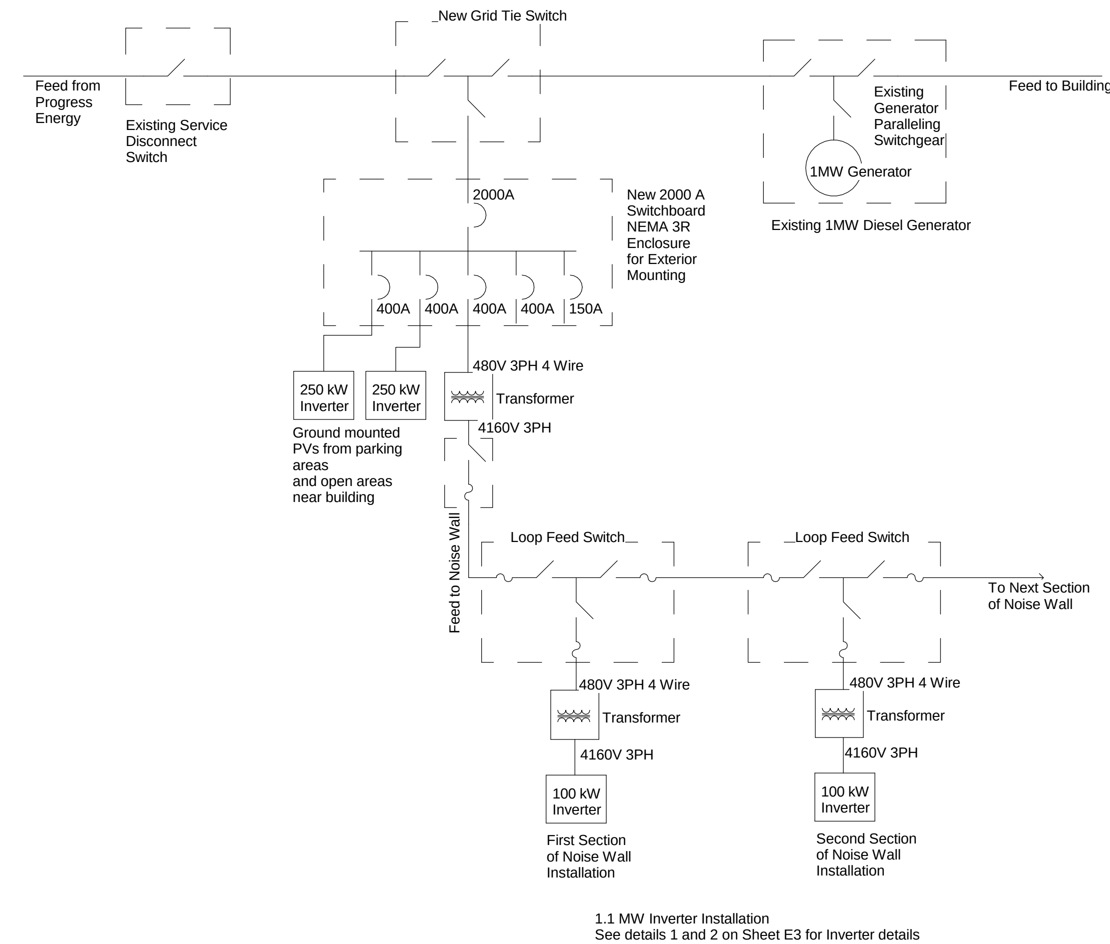
12/7/2009 11:14:50 AM



1 FHP/SunWatch PV Connections
1/8" = 1'-0"



2 Service Plaza PV Connections
1/8" = 1'-0"



3 Headquarters PV Connections
1/8" = 1'-0"

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Turkey Lake Solar Study

No.	Description	Date

Grid Connection Details

Project number	1
Date	9/11/2009
Drawn by	RW
Checked by	RW

E2

Scale 1/8" = 1'-0"

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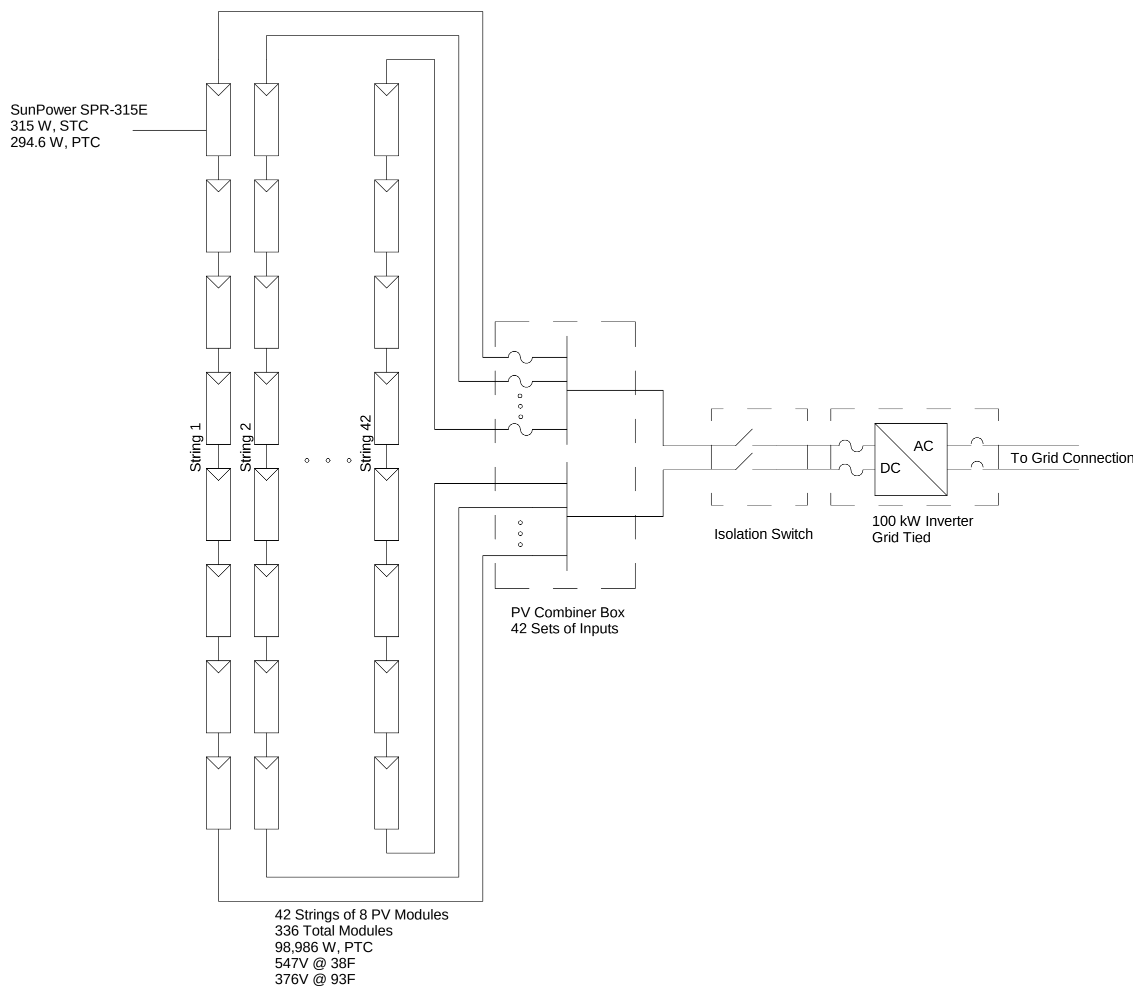
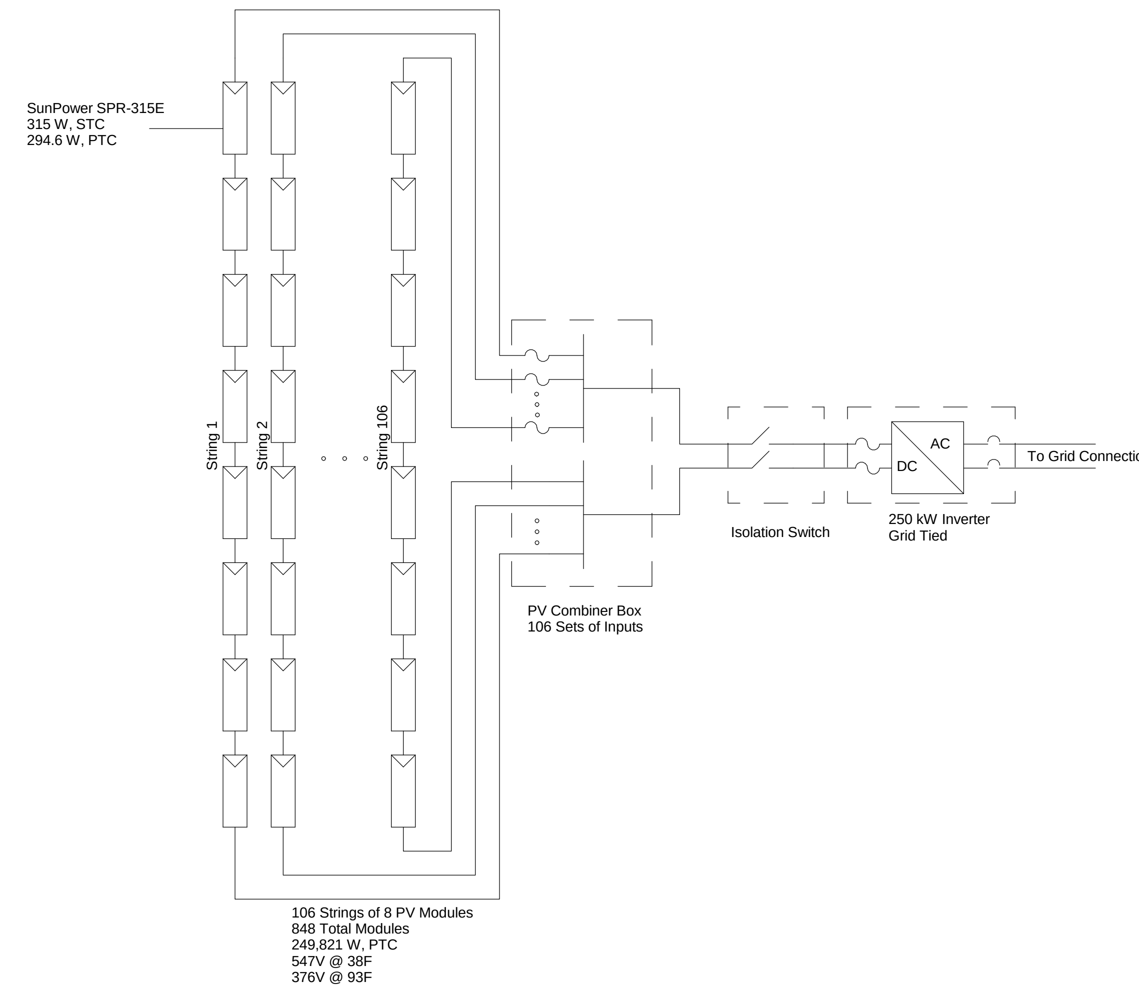


1 100 kW PV Array
1/8" = 1'-0"



2 250 kW PV Array
1/8" = 1'-0"

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BUILDING CONSTRUCTION

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01/07/2010

Florida Turnpike Enter.

Turkey Lake Solar Study

No.	Description	Date

PV Array Connection Details

Project number	1	E3
Date	9/11/2009	
Drawn by	RW	
Checked by	RW	Scale 1/8" = 1'-0"

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APPENDIX D
INNOVATIVE FINANCING OPTIONS

SUMMARY
Appendix D is broken down into three Sections.

- Grant Application Procedures
- Terms and Conditions
- Grant Application

Each section explains in detail what is required by the owner as far as deadlines that need to be met and steps that need to be taken to in order to receive the payments.

Payments for Specified Energy Property in Lieu of Tax Credits under the American Recovery and Reinvestment Act of 2009

Program Guidance

Applicants interested in receiving payments under Section 1603 may submit an application on-line by going to www.treasury.gov/recovery. Applications may only be submitted after the property to which the application relates is placed in service, or is under construction. All applications must be received before the statutory deadline of October 1, 2011. A completed application will include:

- Signed and complete application form
- Supporting documentation
- Signed Terms and Conditions
- Complete payment information

For property not placed in service in 2009 or 2010 but for which construction began in 2009 or 2010, applications must be submitted after construction commences but before October 1, 2011. If the property has been placed in service at the time of the application, Treasury will make payments to qualified applicants within 60 days from the date the completed application is received. For property not yet placed in service at the time of the application, Treasury will review such applications and notify the applicant if all eligibility requirements that can be determined prior to the property being placed in service have been met. If so notified, applicants must then submit, within 90 days after the date the property is placed in service, supplemental information sufficient for Treasury to make a final determination. Treasury will conduct a final review of the application at that time and make payment to qualified applicants within 60 days after the supplemental information is received by Treasury. Instructions provided on the application will indicate which portions of the application must be completed at the time the application is initially submitted and which portions must be completed at the time the application is supplemented.

If an applicant is applying for Section 1603 payments for multiple units of property that are treated as a single, larger unit of property (see Section IV. D. below), all such units may be included in a single application. The application form requests, among other identifying data elements, the applicant's Data Universal Numbering System (DUNS) number from Dun and Bradstreet. If the applicant does not already have a DUNS number, it may request one at no cost by calling the dedicated toll-free DUNS Number request line at 1-866-705-5711. Applicants must also register with the Central Contractor Registration (CCR). To register, go to www.ccr.gov/startregistration.aspx. The registration must be completed before a payment can be made.

When Treasury determines that an application is approved, it will send a notice to the applicant. The notice informs the applicant that the payment will be made and incorporates the information contained in the applicant's completed application form and the Terms and Conditions. Treasury makes payment to the applicant no later than five days from the date of the notice. Payment will be made by Electronic Funds Transfer based upon the banking information in the CCR.

In cases where an applicant has not submitted sufficient information upon which a determination can based, the applicant will be so notified and given 21 days from the date of the notice to submit additional information. If additional information is not received within the 21 day period, the application will be denied.

When Treasury determines that the application does not qualify for payment, the applicant will be so notified. Such notification will include the reasons for the determination and will be considered the final agency action on the application.

APPLICANT ELIGIBILTY

Certain persons are not eligible to receive Section 1603 payments. These include:

- any Federal, state or local government, including any political subdivision, agency or instrumentality thereof
- any organization that is described in section 501(c) of the IRC and is exempt from tax under section 501(a) of the IRC
- any entity referred to in paragraph (4) of section 54(j) of the IRC or
- any partnership or other pass-thru entity, any direct or indirect partner (or other holder of an equity or profits interest) of which is an organization or entity described above unless this person only owns an indirect interest in the applicant through a taxable C corporation.

As long as each direct and indirect partner in the partnership or shareholder or similar interest holder in any other pass-thru entity is eligible to receive Section 1603 payments, the partnership or pass-thru entity is eligible to receive Section 1603 payments. Having as a direct or indirect partner, shareholder, or similar interest holder a taxable C corporation any of whose shareholders are not eligible to receive Section 1603 payments does not affect the eligibility of the partnership or pass-thru entity. Neither a Real Estate

Investment Trust, nor a cooperative organization described in section 1381(a) of the IRC is a pass-thru entity for this purpose.

For an applicant to be eligible to receive a Section 1603 payment it must be the owner or lessee of the property and must have originally placed the property in service. Lessees are eligible to apply for Section 1603 payments only if the conditions described in LEASED PROPERTY of this Guidance are met.

A foreign person or entity may be eligible for a Section 1603 payment if the person or entity qualifies for the exception in section 168(h)(2)(B) of the IRC.

Applicant eligibility will be determined as of the time the application is received.

PROPERTY AND PAYMENT ELIGIBILITY

Placed in Service
Qualified property must be originally placed in service between January 1, 2009, and December 31, 2010, (regardless of when construction begins) or placed in service after 2010 and before the credit termination date (see below) if construction of the property begins between January 1, 2009, and December 31, 2010. Qualified property includes expansions of an existing property that is qualified property under section 45 or 48 of the IRC.

Specified Energy Property	**Credit Termination Date**	**Applicable Percentage of Eligible Cost Basis**
Solar	January 1, 2017	30%

Beginning of Construction
Construction begins when physical work of a significant nature begins. Physical work of a significant nature begins when the requirements of any one of the following options have been met:

Self Construction
If an applicant manufactures, constructs, or produces property for use by the applicant in its trade or business (or for its production of income), construction begins when physical work of a significant nature begins (including as described in safe harbor below). Physical work does not include preliminary activities such as planning or designing, securing financing, exploring, or researching. Construction begins when physical work of a significant nature commences at the site; that is, when work begins on the excavation for the foundation, the setting of anchor bolts into the ground, or the pouring of the concrete pads of the foundation.
Preliminary work, such as clearing a site, test drilling to determine soil condition, or excavation to change the contour of the land (as distinguished from excavation for footings and foundations) does not constitute the beginning of construction.

Construction by Contract

For property that is manufactured, constructed, or produced for the applicant by another person under a written binding contract (as described below) that is entered into prior to the manufacture, construction, or production of the property for use by the applicant in its trade or business (or for its production of income) construction begins when physical work of a significant nature begins under the contract. A contract is binding only if it is enforceable under State law against the applicant or a predecessor, and does not limit damages to a specified amount (for example, by use of a liquidated damages provision). For this purpose, a contractual provision that limits damages to an amount equal to at least 5 percent of the total contract price will not be treated as limiting damages to a specified amount. If a contract provides for a full refund of the purchase price in lieu of any damages allowable by law in the event of breach or cancellation, the contract is not considered binding. A contract is binding even if the contract is subject to a condition, as long as the condition is not within the control of either party or a predecessor. A contract will continue to be binding if the parties make insubstantial changes in its terms and conditions or any term is yet to be determined by a standard beyond the control of either party. A contract that imposes significant obligations on the applicant or a predecessor will be treated as binding notwithstanding the fact that certain terms remain to be negotiated by the parties to the contract. An option to either acquire or sell property is not a binding contract. A binding contract does not include a supply, or similar, agreement if the amount and design specifications of the property to be purchased have not been specified.

Safe Harbor
An applicant may treat physical work of a significant nature as beginning when the applicant incurs (in the case of an accrual basis applicant) or pays (in the case of a cash basis applicant) more than 5 percent of the total cost of the property (excluding the cost of any land and preliminary activities such as planning or designing, securing financing, exploring, or researching). When property is manufactured, constructed, or produced for the applicant by another person, this test must be met by the applicant, not the other person. For the purpose of determining whether an applicant has incurred more than 5 percent of the total cost of the property, the economic performance standards of IRC section 461(h) apply.

Units of Property
For purposes of determining the beginning of construction of property or the date property is placed in service, all the components of a larger property are a single unit of property if the components are functionally interdependent. Components of property that are produced by, or for, the applicant are functionally interdependent if the placing in service of one component is dependent on the placing in service of the other component. For example, an array of solar panels, its structure, and its inverter are a single unit or property. Each array can be separately operated and metered and can begin producing electricity individually.

The owner of multiple units of property that are located at the same site and that will be operated as a larger unit may elect to treat the units (and any property, such as a computer control system, that serves some or all such units) as a single unit of property for purposes of determining the beginning of construction and the date the property is placed in service. In such a case, the entire cost of such larger unit of property is taken into account in applying the safe harbor. The owner may not include within this larger unit any property that was placed in service before January 1, 2009. In cases where the applicant treats multiple units of property as a single unit, failure to complete the entire planned unit will not preclude receipt of a Section 1603 payment. For example, if only 3MW, of a proposed 4MW, system are installed by the credit termination date, an otherwise eligible applicant would be eligible for a payment based on the 3 MW.

Specified Energy Property Installed on Other Property
Only the portion of a facility that is described in section 48 of the IRC is taken into account in computing the Section 1603 payment. For example, in the case of a building with solar property on its roof, only the cost of the solar property (including the cost of mounting the solar property on the roof) qualifies for a Section 1603 payment; the cost of the building does not qualify.

Original Use
The original use of the property must begin with the applicant. If the cost of the used parts contained within a facility is not more than 20 percent of the total cost of the facility (whether acquired or self-constructed), an applicant will not fail to be considered the original user of property because the facility contains used parts.

If new property is originally placed in service by a person and is sold to an applicant and leased back to the person by the applicant within three months after the date the property was originally placed in service by the person, unless the lessor and lessee elect otherwise, the applicant-lessor is considered the original user of the property and the property is considered to be placed in service not earlier than when it is used under the lease back.

Required Documentation
Applicants must submit supporting documentation demonstrating that the property is eligible property and that it has been placed in service, and if placed in service after December 31, 2010, that construction began in 2009 or 2010 (See section V below for documentation required to support costs). The following documents are required as indicated below:

Eligible Property
The following documentation must be provided, as applicable, to demonstrate that the property is eligible (for further details on property eligibility, see sections 45 or 48 of the IRC):
Design plans (required of all applicants). Final engineering design documents, stamped by a licensed professional engineer.

Documentation demonstrating that the property is designed to have a nameplate capacity that meets required minimums or maximums (see Section 4A of the Application for properties with minimum or maximum nameplate capacity requirements): Solar Electricity Property – uses solar energy to generate electricity.

Placed in Service
The following documentation must be provided, as applicable, to demonstrate that the property is placed in service:

- *Commissioning Report* (required for all properties placed in service). A report provided by the project engineer, or the equipment vendor, or an independent third party that certifies that the equipment has been installed, tested, and is ready and capable of being used for its intended purpose.

- *Interconnection Agreement* (required only for properties placed in service that are interconnected with a utility). A formal document between the applicant and the local utility that establishes the terms and conditions under which the utility agrees to interconnect with the applicant's system. Applicants must also submit any subsequent documentation to demonstrate that the interconnection agreement has been placed in effect.

Under Construction but Not Yet Placed in Service
The following documentation must be provided, as applicable, to demonstrate that construction has begun on the property:

- *Paid Invoices and/or other financial documents* demonstrating that physical work of a significant nature has begun on the property as described in Section IV.C. If beginning of construction is based on the safe harbor, these documents must demonstrate that more than 5 percent of the total cost of the property (excluding the cost of any land and preliminary activities such as planning, designing, securing financing, exploring, or researching) has been incurred or paid by the applicant.

- *Binding Contract* (required for property not yet placed in service that is being manufactured, constructed or produced for the applicant by another person). The binding contract for the manufacture, construction or production of the property as described in section IV.C above.

Leased Property
The following documentation must be provided where the applicant is the lessee of the property to demonstrate that the lessor and lessee have entered into the agreement required by section VI of this guidance.

Types of Property

Property eligible to receive Section 1603 payments is “specified energy property.” Specified energy property includes only tangible property (not including a building) that is an integral part of the facility. The tangible property is tangible personal property and other tangible property as defined in sections 1.48-1(c) and (d) of the Income Tax Regulations. Specified energy property is property for which depreciation (or amortization in lieu of depreciation) is allowable.

Qualified property includes only tangible property that is both used as an integral part of the activity performed by qualified facility and located at the site of the qualified facility. Qualified property does not include a building but may include structural components of a building. Property is an integral part of a qualified facility if the property is used directly in the qualified facility, is essential to the completeness of the activity performed in that facility, and is located at the site of the qualified facility. Roadways and paved parking areas located at the qualified facility and used for transport of material to be processed at the facility or equipment to be used in maintaining and operating the facility are integral to the activity preformed there, but roadways or paved parking lots that provide solely for employee and visitor vehicle traffic are not an integral part a qualified facility. Property is considered used as an integral part of a qualified facility if so used either by the owner of the property or by the lessee of the property.

Specified energy property, within the meaning of Section 1603, consists of two broad categories of property - certain property described in IRC section 45 and certain property described in IRC section 48. The following types of property are specified energy property within the meaning of Section 16031:
Generally, a qualified facility must be capable of operating as an independent unit even though the property is installed at the site of an existing facility. Certain modifications to property installed on an existing facility qualify as specified energy property even if the facility was placed in service before 2009.

Energy property described under IRC section 48:
Specified energy property for purposes of Section 1603 includes, in addition to qualified property that is part of a qualified facility, any other energy property described under IRC section 48. Such energy property must meet performance and quality standards that are prescribed either in IRC section 48 or in associated Treasury Regulations and that are in effect at the time of the acquisition of the property.

Solar property: Equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat, excepting property used to generate energy for the purposes of heating a swimming pool; equipment that uses solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight.

ELIGIBLE BASIS

The basis of property is determined in accordance with the general rules for determining the basis of property for federal income tax purposes. Thus, the basis of property generally is its cost (IRC section 1012), unreduced by any other adjustment to basis, such as that for depreciation, and includes all items properly included by the taxpayer in the depreciable basis of the property, such as installation costs and the cost for freight incurred in construction of the specified energy property. If property is acquired in exchange for cash and other property in a transaction described in IRC section 1031, in which no gain or loss is recognized, the basis of the newly acquired property is equal to the adjusted basis of the other property plus the cash paid.

Costs that will be deducted for federal income tax purposes in the year in which they are paid or incurred are not includible in the basis on which the payment is determined. For example, if the applicant will take the IRC section 179 deduction for all or part of the cost of the property, then no payment is allowed for the portion of the cost of the property for which the IRC section 179 deduction will be taken.

Only the cost basis of property placed in service after 2008 is eligible for a Section 1603 payment. Thus, if property is placed in service in 2009 at a qualified facility that was placed in service in an earlier year, only the basis of the property placed in service in 2009 is eligible for a Section 1603 payment.

Applicants must submit with their application for a Section 1603 payment documentation to support the cost basis claimed for the property. Supporting documentation includes:

- Detailed breakdown of all costs included in the basis
- Contracts, copies of invoices, and proof of payment must be retained by the applicant and made available to Treasury upon request
- For properties that have a cost basis in excess of $500,000 applicants must submit an independent accountant's certification attesting to the accuracy of all costs claimed as part of the basis of the property

LEASED PROPERTY

A lessor who is eligible to receive a Section 1603 payment with respect to a property may elect to pass-through the Section 1603 payment to a lessee. The election may only be made with respect to property that would be eligible for the Section 1603 payment if owned by the lessee. Such an election will treat the lessee as having acquired the property for an amount equal to the independently assessed fair market value of the property on the date the property is transferred to the lessee and will generally follow the rules in the IRC and Treasury regulations governing elections to allow lessees to receive energy tax credits.

The lessor and lessee must agree that the lessor waives all right to a Section 1603 payment or an investment tax credit with respect to the eligible property, before the lessee may apply for a Section 1603 payment with respect to such property. The lessee must agree to include ratably in gross income over the five year recapture period an amount equal to 50 % of the amount of the Section 1603 payment.

In order to make this election, both the lessor and the lessee must be persons eligible to receive a payment under Section 1603. Additionally, this election may not be made by a lessor that is a mutual savings bank or similar financial organization, a regulated investment company or a real estate investment trust. The election of a lessor to allow the lessee to receive a Section 1603 payment may be made with respect to each property leased by the lessor to the lessee. The lessee's written consent is required. The lessor's election is made by a written agreement with the lessee that contains the following information:

- A waiver of the lessor's right to receive any payment under Section 1603 with respect to the property, as well as a waiver of the lessor's right to claim an investment tax credit under section 48 of the IRC with respect to the same property for the taxable year of the payment or subsequent years
- All information necessary to determine the amount of lessee's Section 1603 payment
- The name, address, and employer identification number of the lessor and the lessee
- A description of each property with respect to which the election in being made
- The date on which possession of the property is transferred to the lessee
- The lessee's consent to the election
-

A copy of this agreement must be included in the lessee's application for the Section 1603 payment. This election is irrevocable.

Special Rule for Sale-leaseback Transaction
In a sale-leaseback transaction, the lessee, who is not the owner of the property, may claim the Section 1603 payment, if three conditions are satisfied:

1. The lessee must be the person who originally placed the property in service.
2. The property must be sold and leased back by the lessee, or must be leased to the lessee, within three months after the date the property was originally placed in service.
3. The lessee and lessor must not make an election to preclude application of the sale-leaseback rules.

RECAPTURE

If the applicant disposes of the property to a disqualified person or the property ceases to qualify as a specified energy property within five years from the date the property is placed in service (hereinafter "disqualifying event"), the Section 1603 payment must be repaid to the Treasury as follows: 100% of the payment must be repaid if the disqualifying event takes place within one year from the date placed in service; 80% of the payment must be repaid if the disqualifying event takes place after one year but before two years from the date placed in service; 60% of the payment must be repaid if the disqualifying event takes place after two years but before three years from the date placed in service; 40% of the payment must be repaid if the disqualifying event takes place after three years but before four years from the date placed in service; and 20% of the payment must be repaid if the disqualifying event takes place after four years but before five years from the date placed in service.

Property is considered to have been disposed of to a disqualified person if any interest in the property or in the applicant or in any partnership or pass-thru entity that is a direct or indirect owner of an interest in the applicant is sold to: any Federal, state or local government, including any political subdivision, agency or instrumentality thereof; any organization that is described in section 501(c) of the IRC and is exempt from tax under section 501(a) of the IRC; any entity referred to in paragraph (4) of section 54(j) of the IRC; or any partnership or other pass-thru entity any partner (or other holder of an equity or profits interest) of which is a Federal, state or local government, including any political subdivision, agency or instrumentality thereof; an organization that is described in section 501(c) of the IRC and is exempt from tax under section 501(a) of the IRC; or an entity referred to in paragraph (4) of section 54(j) of the IRC. A taxable corporation some or all of whose shareholders are disqualified persons is not a disqualified person and such a corporation's ownership of an interest in a partnership or other pass-thru entity will not cause the partnership or other entity to be treated as a disqualified person.

Property ceases to qualify as a specified energy property if the use of the property changes so that it no longer qualifies as specified energy property. For example, use of property predominantly outside the United States in a year will result in recapture. Temporary cessation of energy production will not result in recapture provided the owner of the property intends to resume production at the time production ceases. Permanent cessation of production will result in recapture. Permanent cessation of production due to natural disaster will not result in recapture unless the property is replaced with property for which a Section 1603 payment is allowed. Replacement would be treated as occurring if the applicant uses IRC section 1033 to avoid gain recognition.

Selling or otherwise disposing of the property to an entity other than a disqualified person does not result in recapture provided the property continues to qualify as a specified energy property and provided the purchaser of the property agrees to be jointly liable with the applicant for any recapture. Recapture would occur in the event the property is resold to a disqualified person or ceases to qualify as a specified energy property. The applicant remains jointly liable to the Treasury for the recapture amount even if the applicant no longer has control over the property.

Where a lessor elects to pass through the Section 1603 payment to a lessee, if the lessor sells the property to a disqualified person, the lessee is liable to the Treasury for the recapture amount even if the lessee maintains control over the property. If the lease is terminated and possession of the property is transferred by the lessee to the lessor or any other person, the lessee is liable to the Treasury for the recapture amount if the use of the property changes during the recapture period so that it no longer qualifies as specified energy property.

Applicants are not required to post a bond as a condition of receiving payment under the section 1603 program and receipt of payment does not create a lien on the property in favor of the United States. However, funds that must be repaid to the Treasury under these rules are considered debts owed to the United States and if not paid when due, will be collected by all available means against any assets of the applicant, including enforcement by the United States Department of Justice. Debts arising under these rules are not considered tax liabilities.

MISCELLANEOUS PROVISIONS

Assignment of Payment

Applicants may submit, along with their request for payment, a Notice of Assignment, assigning the payment to a third party provided the requirements of the Federal Assignment of Claims Act (31 U.S.C. 3727) are met. The Notice of Assignment will include the DUNS number for the third party. The third party will be required to register in CCR.

National Environmental Protection Act (NEPA)

A Section 1603 payment with respect to specified energy property does not make the property subject to the requirements of NEPA and similar laws.

Davis- Bacon

A 1603 payment with respect to specified energy property does not make the property subject to the requirements of the Davis-Bacon Act.

Treatment of Payments as Taxable Income

Except as described in Section IV of this Guidance with respect to leased property, a Section 1603 payment with respect to specified energy property is not includible in the gross income of the applicant. The basis of the property is reduced by an amount equal to 50% of the payment.

Real Estate Investment Trusts

A Real Estate Investment Trust (REIT) will be eligible to receive Section 1603 payments only to the extent allowed by section 50 of the IRC. IRC section 50(d)(1) specifies that rules similar to the rules of former IRC section 46(e) will apply. IRC section 46(e)(1)(B) provides that, in general, in the case of a REIT, qualified investment is limited to the REIT's ratable share of such qualified investment. The ratable share is a ratio, the numerator of which is its taxable income and the denominator of which is its taxable income computed without regard to the deduction for dividends paid (provided by IRC section 857(b)(2)(B)). For this purpose, the REIT's taxable income is determined without regard to any deduction for capital gains dividends and by excluding any net capital gain.

Applicability of Normalization Rules

Payments received under the Section 1603 program must be normalized. See former IRC Section 46(f).

Reporting

Applicants will be required to provide reports, as required by Treasury, including an annual performance report as set forth in the Terms and Conditions.

Payments for Specified Energy Property In Lieu of Tax Credits under the AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009

TERMS AND CONDITIONS

1. Authority
Section 1603 of the American Recovery and Reinvestment Tax Act of 2009 (Section 1603) authorizes the United States Department of the Treasury (Treasury) to make payments to persons who place in service specified energy property provided certain conditions are met.

2. Eligibility
a. The applicant is the owner or lessee of specified energy property that qualifies for funds under Section 1603 and is the original user of the property.

b. Where the applicant is the lessee of the specified energy property, the owner of the specified energy property has agreed, in writing, to the lessee being the recipient of the Section 1603 payment and has waived, in writing, its right to receive any payment under Section 1603 as well as its right to claim a tax credit under section 45 and 48 of the Internal Revenue Code (IRC) with respect to the property.

c. The applicant is not a federal, state or local government, or any political subdivision, agency or instrumentality thereof; an organization that is described in section 501(c) of the IRC and is exempt from tax under section 501(a) of the IRC; or an entity referred to in section 54(j)(4) of the IRC.

d. The applicant is not a partnership or pass-thru entity that has a person described in section 2.c above as a direct or indirect partner (or other holder of an equity or profits interest) unless this person only owns an indirect interest in the applicant through a taxable C corporation.

e. The applicant is not a foreign person or entity unless it is a foreign person or entity that qualifies for the exception in section 168(h)(2)(B) of the IRC.

3. Ongoing Representations and Obligations
a. The applicant understands that Treasury is relying on the accuracy of the information contained in the application in making determinations with respect to the applicant's eligibility for a Section 1603 payment. If the applicant determines that any information included on or with the application was materially inaccurate or incorrect, the applicant must immediately inform Treasury. If Treasury determines, as a result of this information, that the applicant does not qualify for funds or that the applicant received funds in excess of the amount to which the applicant was entitled, the applicant must immediately return the funds to Treasury.

b. The applicant understands that none of the applicant's obligations herein terminate upon the sale or other disposition of the property to an eligible entity.

4. Production and Investment Tax Credit

a. The applicant will not claim a tax credit under section 45 or section 48 of the IRC with respect to the property described in the application.

5. Reporting

a. The applicant shall provide periodic reports as required by Treasury. A project performance report is required on an annual basis for a period of five years after the property was placed in service. Annual performance reports are due no later than 21 days following the end of the reporting period. The first reporting period begins on the date the property is placed in service.

b. On an annual basis, the applicant must provide a project performance report including the following elements:

- Name of applicant
- Current owner of property
- Treasury application number
- Name of project
- Location of project: city/county, State, zip code
- Number of jobs retained
- Annual production (in kilowatt hours, MMBTUs, or horsepower as applicable)
- Installed nameplate capacity (in kilowatts, MMBTUs, or horsepower as applicable)

c. The applicant shall submit any other reports that Treasury deems necessary to comply with American Recovery and Reinvestment Act guidance.

6. Recapture

a. The applicant shall certify to Treasury on an annual basis for a period of five years from the date the property was placed in service that the property has not been disposed of to a disqualified person and that the property continues to qualify as specified energy property (as that term is used in Section 1603). Annual certifications shall be submitted at the same time as the performance report described in Section 5 above.

b. If the property is disposed of to a disqualified person and/or ceases to qualify as a specified energy property (hereinafter "disqualifying event") within five years from the date the property is placed in service the applicant must repay funds to the Treasury as follows: 100% of the funds must be repaid if the disqualifying event takes place within one year from the date the property is placed in service; 80% of the funds must be repaid if the disqualifying event takes place after one year but before two years from the date the property is placed in service; 60% of the funds must be repaid if the disqualifying event takes place after two years but before three years from the date the property is placed in service; 40% of the funds must be repaid if the disqualifying event takes place after three years but before four years from the date the property is placed in service; and 20% of the funds must be repaid if the disqualifying event takes place after four years but before five years from the date the property is placed in service.

c. Any amount subject to recapture becomes a debt owed to the United States payable to the General Fund of the Treasury and enforceable by all available means including enforcement by the United States Department of Justice against any assets of the applicant entity. Debts arising under these rules are not considered tax liabilities.

7. Maintenance Of and Access To Records
The applicant must maintain project, financial, and accounting records sufficient to demonstrate that Section 1603 funds were properly obtained in accordance with the Section 1603 program and these Terms and Conditions. The Treasury, as the awarding office, the cognizant Treasury inspector general, and the Comptroller General of the United States, or any of their authorized representatives, shall have the right of physical access to the applicant's facilities and to any pertinent books, documents, papers, or other records (electronic and otherwise) of the applicant and each partnership and pass-thru entity that directly or indirectly owns an interest in the applicant which are pertinent to the Section 1603 payment, in order to conduct audits, examinations, and evaluations.

8. Disallowance
a. If the applicant materially fails to comply with any term of the award, whether stated in a Federal statute or regulation, program guidance, these Terms and Conditions, or a notice of award, Treasury may take any remedial action that is legally available including disallowing all or a part of the Section 1603 payment. Any payment that is disallowed must be returned to the Treasury.

b. In taking an enforcement action, Treasury will provide the applicant with the opportunity for a hearing, appeal, or other administrative proceeding to which the applicant is entitled under any statute or regulation applicable to the action involved.

c. The applicant must immediately report any indication of fraud, waste, abuse, or potentially criminal activity pertaining to Section 1603 funds to Treasury and the cognizant Treasury inspector general.

9. Information Sharing
a. The applicant agrees that any information provided to the Treasury in the application, attachments, supporting documents, reports or otherwise in connection with its application under Section 1603 may be shared with other federal agencies, including the Internal Revenue Service, as needed by those agencies to conduct official agency business. Notwithstanding the foregoing, bank account information and proprietary information will not be shared unless required by law.

b. The applicant acknowledges that Treasury may publicly release the name of the applicant; the type, location, and description of the property that is the subject of the application; and the amount of funding provided.

Signature
Under penalties of perjury, I declare that I have examined these Terms and Conditions, agree to them, and will ensure that they will be followed. I declare that I am an authorized official of the applicant entity and am authorized to bind the applicant to these Terms and Conditions.

Name		Title	
Phone		Email	
Signature		Date Signed	