Central Florida Expressway Authority

SUSTAINABILITY STUDY

June 24, 2019

Stanley Consultants INC.

Executive Summary

Central Florida Expressway Authority (CFX) is entering the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties in Orlando, Florida. Stanley Consultants, Inc. (ENGINEER) has been tasked to conduct the study to evaluate the viability of several initiatives for the CFX infrastructure and system. The sustainability study will provide an assessment of the energy potential, system size, costs, risks, and benefits associated with each option, the required equipment, and the recommended locations of each project.

Ground-Mounted Photovoltaic

This photovoltaic (PV) system refers to what has now become a very typical solar panel system that is mounted on the ground of your property rather than on the roof. ENGINEER reviewed the CFX Land Inventory, along with its meter data to determine a pool of possible sites. Consideration was limited to properties designated as EXCESS or SURPLUS land within 0.5 miles of existing meters. There are 65 total sites to be considered, and no significant environmental or regulatory impediments were found during the high level in-house evaluation.

The system, as applicable to CFX facilities, is both environmentally and technically feasible. ENGINEER recommends a ground-mounted, fixed tilt, monocrystalline PV system with string inverters. Due to the number of sites under consideration, base systems of 100/200 kW were sized for analysis such that the available energy capacity of each system is less than the yearly site load. Based on a review of existing site loadings, net metering is recommended in all cases.

Top Site Choices

Nine locations were found as viable options for ground-mount PV systems. The top three recommended choices are shown below:

Location	Coral Hills Mainline Plaza	University Mainline Plaza	John Young Mainline Plaza
Maximum Behind the Meter Capacity (kW)	726	436	1132
Recommended Capacity for Net Metering (kW)	190	170	170
Meter Annual Energy Usage (kWh)	291049	261130	249662
Estimated Capital Cost	$347,000	$313,000	$313,000
Estimated Annual O&M Cost	$2,850	$2,550	$2,550
Estimated Lifetime Savings (30yr)	$2,331,000	$2,080,000	$2,080,000
Estimated Payback Period	10.6	10.8	10.8
Utility	Duke	Duke	Duke
Meter Number	2822587	2371197	2818014

* Top recommended choices are based on lower payback periods. See Appendix-I for summary table of all ground mounted PV choices.

Floating PV

The floating PV solar farm is an array of solar panels on a structure that floats on a man-made or naturally occurring body of water and was evaluated for CFX wet ponds. ENGINEER reviewed the CFX Land Inventory along with its meter data to determine a pool of possible sites. As with the dry pond PV, consideration was limited to wet ponds within 0.5 miles of meters. There are 228 total sites to be considered, and no significant environmental or regulatory impediments were found.

The system, as applicable to CFX facilities, is viable. ENGINEER recommends a floating system with fixed tilt, monocrystalline PV with string inverters. Due to the number of sites under consideration, base systems of 100/200kW were sized for analysis such that the available capacity is less than the site load. This includes Based on a review of existing site loadings, net metering is recommended in all cases.

Top Site Choices

Twenty-four locations were found as viable options for ground-mount PV systems. The top three recommended choices are shown below:

Location	Boggy Creek Mainline Plaza	Pine Hills Main Plaza	3454 J Lawson Blvd SR-417 & Boggy Creek
Maximum Behind the Meter Capacity (kW)	2362	478	4500
Recommended Capacity for Net Metering (kW)	180	270	150
Meter Annual Energy Usage (kWh)	3632756	406632	225910
Estimated Capital Cost	$370,000	$532,000	$316,000
Estimated Annual O&M Cost	$4,050	$6,075	$3,375
Estimated Lifetime Savings (30yr)	$2,296,000	$2,420,000	$1,887,000
Estimated Payback Period	12.3	15.2	12.9
Utility	Duke	OUC	Duke
Meter Number	2821260	1ZR11291	7226207

* Top recommended choices are based on lower payback periods. See Appendix-I for summary table of all floating PV choices. Headquarters was not considered because available pond is not available for use as an option.

Elevated Ground-Mount PV

This system is a variation on the traditional ground-mounted solar system. It is installed in the dry bed of a retention pond, but must be elevated above the rain water fill level. ENGINEER reviewed the CFX Land Inventory, along with its meter data to determine a pool of possible sites. As with the traditional PV, consideration was limited to dry ponds within 0.5 miles of meters. There are 157 total sites to be considered, and no significant environmental or regulatory impediments were found.

The system, as applicable to CFX facilities, is viable. ENGINEER recommends a ground-mounted, fixed tilt, monocrystalline PV system with string inverters. Due to the number of sites under consideration, base systems of 100/200 kW were sized for analysis such that the available capacity is less than the site load. Based on a review of existing site loadings, net metering is recommended in all cases.

Top Site Choices

Twelve locations were found as viable options for elevated ground-mount PV systems. The top four recommended choices are shown below:

Location	1220 East West Connector SR-408 EB ramp	Hiawassee Mainline Plaza	Conway West Main Plaza
Maximum Behind the Meter Capacity (kW)	120	1130	478
Recommended Capacity for Net Metering (kW)	120	250	280
Meter Annual Energy Usage (kWh)	335284	379253	423427
Estimated Capital Cost	$229,000	$457,000	$509,000
Estimated Annual O&M Cost	$1,800	$3,750	$4,200
Estimated Lifetime Savings (30yr)	$1,113,000	$3,075,000	$2,669,000
Estimated Payback Period	14.1	10.4	12.6
Utility	OUC	Duke	OUC
Meter Number	5CM10371	2791026	1ZR11403

* Top recommended choices are based on lower payback periods. See Appendix-I for summary table of all elevated ground mounted PV choices.

Rooftop-Mounted PV

This system is one in which solar panels are roof-mounted to buildings. It has been evaluated for CFX toll plazas and office buildings. ENGINEER reviewed the CFX-provided list of facilities, along with its meter data to determine a pool of possible sites. There are 69 total sites to be considered, and no significant environmental or regulatory impediments were found beyond typical building and fire inspections. After reviewing the loading and roof data, it was determined that only Headquarters and Mainline Plazas were appropriate sites.

The system, as applicable to CFX facilities, is viable, but care must be taken due to CFX facilities use bitumen roof membranes common in flat roof systems. ENGINEER recommends specific site selection should be limited to those rooftops near replacement. The suggested system sizes were selected at 40/55/130 kW based on existing consumption such that the available system capacity is less than the site load. Note that rooftop PV system sizes are smaller than traditional ground mounted systems due to limited roof area. Based on a review of existing site loadings, net metering is recommended in all cases.

Top Site Choices

Twelve locations were found as viable options for rooftop-mounted PV systems. The top four recommended choices are shown below:

Location	Forest Lake Mainline Plaza	Hiawassee Mainline Plaza	Goldenrod Mainline Plaza	University Mainline Plaza
Maximum Behind the Meter Capacity (kW)	55.6	55.8	55.6	55.8
% of Annual Usage Offset (kWh)	36%	18%	30%	33%
Roof Projected Replacement Year	2020	2021	2021	2021
Estimated Capital Cost	$121,000	$121,000	$121,000	$121,000
Estimated Annual O&M Cost	$600	$600	$600	$600
Estimated Lifetime Savings (30yr)	$365,000	$365,000	$281,000	$365,000
Estimated Payback Period	10.8	10.8	13.5	10.8
Utility	Duke	Duke	OUC	Duke
Meter Number	2816670, 2803386	2821772, 2791026	1JR01475	2370607

*Other more cost-efficient alternatives are available for Forest Lake and Hiawassee apart from the rooftop option. These are the locations with closer expected replacement time and rooftop should be considered as backup options for these meters.

Sound Wall-Mounted PV

This examines the use of roadway noise barriers as a place to mount solar panels for use in net metering. It is a new approach to existing technology and is not in use anywhere in the U.S. Currently, Ko-Solar has a proposed site in Massachusetts (650 kWh/2500 sq.ft.). Hiawassee and Dean Mainline Plazas were selected for pilot projects to test this type of installation. No significant environmental or regulatory impediments were found.

Sound barrier PV systems, as applicable to the two listed locations, would be suitable only for piloting at this time. The cost associated with the design and installation can be shown to be offset by the performance of the system, however there some engineering challenges that will need to be addressed. ENGINEER recommends a pilot system-mounted flush on the wall, using a monocrystalline PV system with string inverters. Other options such as using the top of the walls or green areas in front of walls should also be considered. A model of both systems was created utilizing maximum amount of wall space available. Based on a review of existing site loadings, net metering is recommended in both cases.

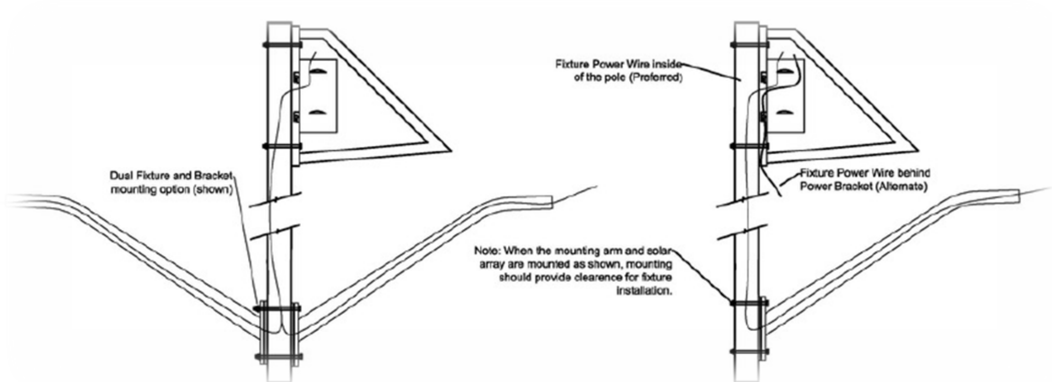
Pilot Projects Information

Location	Dean Road Mainline Plaza	Hiawassee Mainline Plaza (Datacenter)
Recommended Capacity for Net Metering (kW)	156	320
Meter Annual Energy Usage (kWh)	219412	485395
Estimated Capital Cost	$302,000	$591,000
Estimated Annual O&M Cost	$2,340	$4,800
Estimated Lifetime Savings	$1,020,805	$2,207,067
Estimated Payback Period	19.0	17.6
Utility	Duke	Duke
Meter Number	2370607	2821772

*Other more cost-efficient alternatives are available for these two meters apart from the sound wall PV. These are the locations recommended specifically for use with the application.

Street Light-Mounted PV

Streetlight solar examines the use of pole-mounted PV systems for use with streetlights. The new system requires new pole or the replacement of existing fixtures, arms, and new LED bulb. Addition of battery cabinet and PV panel is required.



Maximum size available of light fixtures for PV lights is 120W. CFX standard LED lights are rated for 207-240W. Estimated system cost is $8,500 (excl. installation) and payback is around 19 years.

ENGINEER does not recommend lowering lumen levels unless lumens to ground and photometric design requirements from FDOT are met. A detailed photometric design should be conducted if CFX is willing to consider this option. Technical challenges and long payback makes this option impractical. ENGINEER recommends using PV street lights only in applications where LED lights with 120W of power or less is required. Some example applications include local streets, pathways, parking lots, and bill boards. Based on ENGINEER research, system costs typically range from $5,000-$9,000.

Wattway Pavement PV

Wattway by Colas has developed a unique system by which PV modules are integrated into the road surfacing for use in parking lots, existing roads, bike paths, etc., to generate energy. This is a unique technology and is currently under pilot in several locations around the world. The only U.S. installation of this technology is currently in West Point, Georgia. Public performance data shows the system is only producing 33% of expected performance in pilot projects.

Based on the initially provided technical specs, a 26 panel, 3 kW pilot project to test the Wattway technology is possible. The system is compatible for use with existing DMS components and would cost approximately $46,440 (based on past system cost). No official estimate provided by Colas yet. Road performance should be tested against USA standards before installation in public roadways. More information from Wattway is needed to determine full viability. ENGINEER recommends pavement PV only as a test pilot at headquarters parking lot at this time.

Main Office Building Energy and Water Study

Energy Intensity Benchmarking

Annually, Johnson Controls conducts an Energy Efficiency Indicator Survey and it was found that 77% of U.S. organizations in 2018 began to examine their energy efficiency and 57% made plans to increase energy efficiency. The US Department Of Transportation (DOT) 2016 Sustainability Plan identified building energy conservation as one of its goals. A reduction of energy intensity by 30% is a recommended goal in the US DOT plan for building energy conservation. Energy Intensity (EI) or Energy Use Intensity (EUI) is defined by the US Department of Energy (DOE) Energy Star program as energy per square foot per year. Based on data below from the Energy Information Administration (EIA) commercial buildings energy consumption survey (CBECS), CFX energy intensity ratio falls well beyond the 75th percentile, which corresponds to an Energy Star Score of under 25 out of 100.

***Buildings – All US Regions**

*** Buildings – South Atlantic Region**

Building	Consumption (kWh)	Total Area (sqft)	CFX ratio	US DOE EIA CBECS avg	US DOE EIA CBECS 75th pctl	US DOE EIA CBECS 50th pctl	US DOE EIA CBECS 25th pctl
Headquarters	4018000	85946	46.75	14.1	16.6	10.7	6
Headquarters	4018000	85946	46.75	16.3	21.4	10.7	5

Water Intensity Benchmarking

CFX is well beyond the 75th percentile for water intensity also. Water intensity is a measure of the efficiency of water usage. It is defined as the water used per square foot per year. Based on the DOE's Better Buildings Challenge, a metric of 20% improvement over 10 years is recommended.

Building	Consumption (gallons)	Total Area (sqft)	CFX ratio	US Average Large Building Consumption per square feet	Distribution Intensities 75th pctl	Distribution Intensities 50th pctl	Distribution Intensities 25th pctl
Headquarters	2182400	85946	25.39	20.3	21.6	12.8	7.9

Because CFX is below national averages in terms of both energy and water consumption, ENGINEER recommends conducting and energy audit and retro-commissioning of the Headquarters. Based on industry standards, an audit should cost no more than $67,597. Based on benchmark data, low cost measures such as retro-commissioning would save around $50,900 per year on energy bills alone. Payback of retro-commissioning updates only are expected to be less than one year. Additional measurements that require larger capital investments could be implemented as part of CFX's sustainability plan.

Electric Vehicle Charging Stations

Electric Vehicle (EV) charging is a very common addition to sustainability planning around the country. Every plug-in electric vehicle (PEV) owner has the option to utilize Level 1 charging at home, providing about 5 miles of range per hour, or Level 2 in the workplace which provides approximately 10 to 25 miles of range per 1 hour of charging.

ENGINEER evaluated the viability of installing electric vehicle charging stations and recommends a Dual, Ground-Mounted, Pedestal Charging Station to be installed at the Headquarters in the parking lot near the main entrance.

Assuming maximum utilization for five days throughout the work week, the monthly consumption costs for one dual charging station would be around $92. It is not recommended to offset usage costs with the installation of solar panels over the unit. The PV installation costs will far outweigh the realized costs savings from the generated PV output. Actual costs vary due to site characteristics and available incentives from OUC, but in general the cost ranges from about $5,500 to $18,000.

Based on average calculations, ENGINEER found that converting a single traditional combustion vehicle to a Plug in Hybrid (PHEV) or Battery Electric (BEV) vehicle would prevent release of 5-10 thousand lbs. of CO_2 annually. These average numbers could be used by CFX to justify the installation of EV charging stations and the conversion of the fleet to electric vehicles.

Fleet Vehicle Replacement

The fleet vehicle replacement analysis studies the existing CFX vehicle inventory and recommend replacement vehicles as part of a strategy for increased sustainability. The 2016 DOT sustainability performance plan identified fleet management as a key goal going forward. The objective of this analysis was to evaluate the implementation and cost-effectiveness of EVs used in fleet operations.

With the replacement of conventional fleet vehicles with comparable EVs, the study results in a reduction in petroleum usage and greenhouse gas emissions (GHGe), as well as cost-effectiveness over the life of an EV.

ENGINEER recommends replacing all internal combustion engine (ICE) vehicles with comparable EVs based on the lowest total cost of ownership (TCO) throughout a vehicles optimum life cycle. Historically, this occurs between 9 and 12 years and is determined based on mileage, age, and maintenance costs. Subsequently, ENGINEER recommends the following vehicles be replaced with an EV as soon as possible:

Model Year	Make	Model	Usage	Replacement Window	Recommended Replacement Vehicle	Replacement Vehicle Type
2008	Honda	Ridgeline - Blue	Construction	0	N/A*	
2009	Honda	Civic - Blue	Toll Op.	0	2019 Nissan Leaf	All Electric
2009	Toyota	Camry	Pool	0	2019 Nissan Leaf	All Electric
2010	Hyundai	Santa Fe	Maintenance	0	2019 Kia Niro	Plug-In Hybrid
2010	Nissan	Frontier	Traffic Op.	0	N/A*	

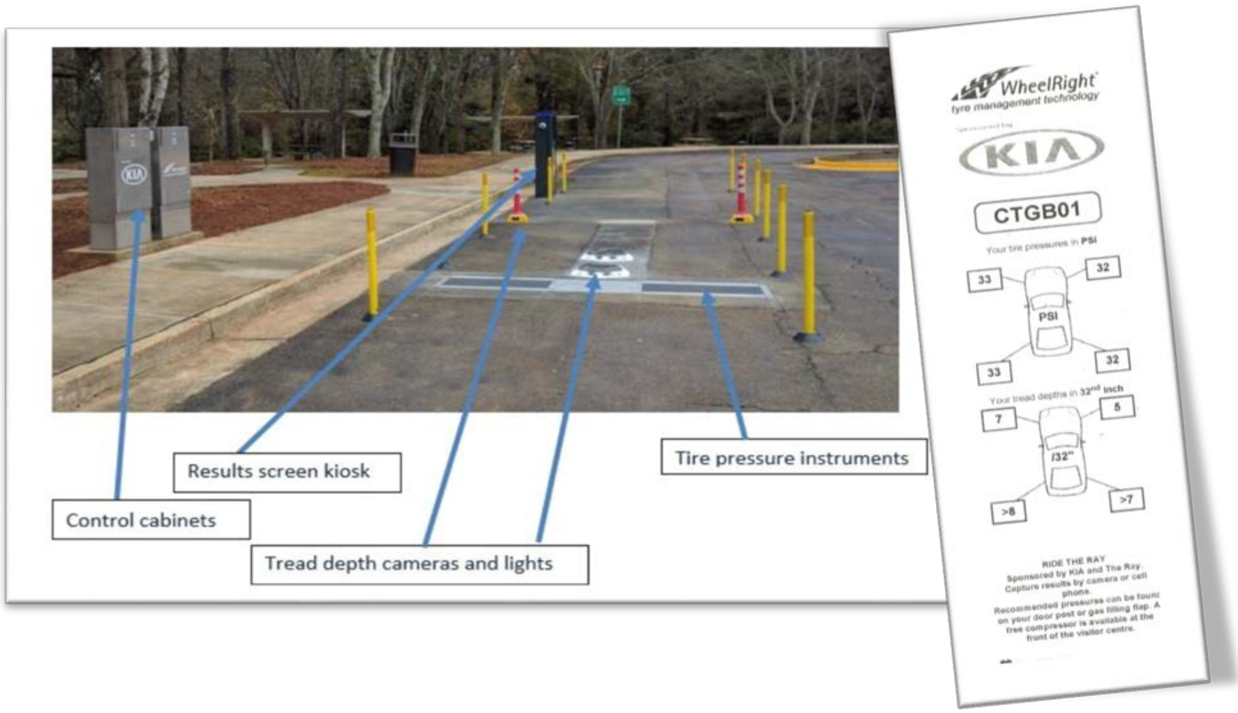
CFX has many varying fleet operation requirements, driving habits, driving cycles, and vehicle types; therefore, the following considerations should also be taken prior to replacement:

- Consider performing an annual physical condition assessment of vehicles at least 10 years or older, or exceed 150,000 miles.
- Consider the feasibility of purchasing used vehicles 1 to 3 years old to reduce the new vehicle prestige depreciation costs.
- Consider incorporating historical vehicle reliability into the vehicle procurement process.
- Reassign older vehicles to less intensive uses where possible, which can help extend replacement cycle.

In addition, each EV acquired will require an EVSE unit or charging station. A Level 2 charging station will be adequate based on anticipated charging needs. Please refer to the section on charging stations for more detailed information.

Tire Sensors

This option refers to a drive-over tire inspection center that utilize sensors to conduct tire condition diagnostics. CFX has shown interest in WheelRight's Tyre Management Technology.



All vehicles that weight under 10,000 lbs. manufactured after September 2007 have at least one type of Tire Pressure Monitoring System, which informs drivers when low pressure is present. Tire thread monitoring would be the only advantage of using this technology.

A pilot project is viable, but benefits are limited. WheelRight's system can be used to monitor tire pressure and tread in visitor centers. Another option is adding WheelRight's system in highways. This option proved to engage a larger number of drivers, but it was hard to measure customer response and actions afterwards. Pressure monitoring system will become obsolete as older cars are retired from the road. Additionally, current thread monitoring technology might be commercialized in a few years. ENGINEER does not recommend the tire sensor option at this time, but perhaps the technology can be revisited as it changes or improves over time.

Landscape Sustainability

This option reviews effective sustainable landscaping in CFX roadways through creative plant selection, arrangement, and maintenance practices. Recommended practices include selection of durable, large native drought tolerant plants and grasses along the highway; integrated Pest Management systems instead of pesticides; and sustainable landscaping practices. Additionally, native tree buffers provide shade areas while reducing maintenance, erosion, and heat islands.

Hydrilia population in wet retention ponds can be controlled using Grass Carp fish. Other control methods should be explored.

As new processes and methods are discovered and implemented, this successful program will only improve.

Roadway Sustainability

This option examines FDOT guidelines and construction requirements for the use of recycled materials in highway projects.

Recycled materials are used under the following conditions:

- The recycled material performs as well or better than the material it replaces.
- The use of a recycled material minimizes the impact on limited resources.
- The use of the recycled material does not exceed the cost of the material it replaces.

Reclaimed materials have already been used for CFX projects. Some examples include coal combustion fly ash in concrete; recycled asphalt in pavement; recycled plastic in guardrail offset blocks; and flexible delineator posts. As FDOT approves new recycled materials, CFX plans to implement them.

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Section 1

Background

Central Florida Expressway Authority (CFX) is entering the first phase of a multi-year program to identify and explore beneficial projects that can increase sustainability throughout its roadways, facilities, and properties. Stanley Consultants, Inc. (ENGINEER) has been tasked to conduct the study to evaluate the viability of several sustainability solutions for the CFX infrastructure and system. The sustainability study will provide an assessment of the systems, costs, risks, and benefits associated with each option, the required equipment, and the recommended locations.

CFX has identified an array of options for evaluation:

- **Traditional PV Solar**. This is the traditional ground-mounted PV solar farm approach that will be evaluated for applicability to the CFX land inventory.
- **Floating PV Solar (wet pond)**. This application is characterized by its floating array of solar panels and will be evaluated for applicability to the CFX retention ponds.
- **Elevated Pond PV Solar (dry pond)**. This is a variation of the traditional ground-mounted PV solar farms and is examined for its applicability to CFX dry retention ponds.
- **Rooftop PV Solar**. This application involves the evaluation of CFX office building, on and off ramps, and plaza structures for the viability of rooftop solar PV systems.
- **Sound Wall PV**. This option explores the conceptual design, locations, cost, and economic analysis of using sound barriers to mount PV panels that will be used to offset CFX consumption.
- **PV Street Lights.** This option evaluates a pole-mounted solar application that generates small scale energy that can be utilized by CFX to power street lighting circuits.
- **Pavement PV**. This is a system of pavement or roadway-mounted PV modules developed by Wattway. The study will explore the conceptual design, locations, cost, and economic analysis of using pavement PV panels.

- **Building Energy Efficiency Study**. This application involves the evaluation of a CFX office building for potential energy enhancements measuring the benchmark factors, cost, etc. for the building energy study.
- **EV Charging Station.** This option examines electric vehicle charging solutions that can be utilized by CFX employees or the public.
- **Fleet Vehicle Analysis**. This option examines the maintenance costs, gas consumption, GHG, mileage, etc., of the existing CFX fleet vehicles and juxtapose with possible EV fleet improvements.
- **Tire Pressure System.** This option explores the conceptual design, possible partnerships, cost, and economic analysis of using a tire pressure monitor system at its facilities.
- **Landscape Sustainability**. This option reviews effective sustainable landscaping in CFX roadways through creative plant selection, arrangement, and maintenance practices.
- **Roadway Sustainability.** This option examines FDOT guidelines and construction requirements for the use of recycled materials in highway projects.

The analysis was conducted based on data provided by project participants, regulatory requirements, and following industry standard costs and modeling procedures. Additionally, the study includes recommendations and next steps required for possible project development.

PHOTOVOLTAIC SYSTEMS

Photovoltaics (PV) is a widely popular option in sustainability efforts around the country, so it is reasonable that several of the options under study involve PV. Photovoltaic cells (solar cells) are electronic devices that basically convert the solar energy of sunlight into electricity. This process takes place with no moving parts, no adverse forms of pollution and it uses one of the most sustainable abundant natural resources – the light of the sun.

PV is utilized in basically two ways – as a grid tied interconnection or off-grid standalone systems. The off-grid systems are not recommended for CFX at this time, as they add unnecessary expense and complexity that is uncommon among similar entities. Grid-tied systems can be used to offset load (Net Metering) or selling power to the local utility (Generation Interconnection). The net metering program is one in which customers that add a PV system to their property receive a traditional net metering benefit paid per kWh at the full retail rate. The program is provided for in Florida statutes so each utility has the same multitiered levels as shown below:

- Tier 1 Generating Facilities are less than or equal to 10 kilowatts (kW)
- Tier 2 Generating Facilities are between 10 kW and 100 kW
- Tier 3 Generating Facilities are between 100kW and 2 MW

Within the net metering program, care must be taken to stay within its boundaries on a yearly basis. If a system is over-sized and the generated energy exceeds consumption totals at the end of the calendar year, a Cost of Generation (COG) tariff is applied to the customers energy credits that is less than the full retail rate. Facilities purposely designed above the net metering threshold must be evaluated under a more rigorous generation interconnection process because they are utility scale. Taking this into consideration all recommendations in the report below are sized in such that the total generated energy for each proposed installation is less than the measured consumption needs for the associated application.

Both Duke and OUC have a three-step process with associated fees along the way: Feasibility, System Impact, and Facility Study. The Feasibility study is performed to determine if changes to the transmission system will be required. The system impact study is a more detailed analysis to identify the changes required on the transmission system and their overall impact. The facility study is the final analysis to determine the design, estimate, and physical implementation plan of a generation interconnection. The fee for the utility to perform these studies can vary and it is paid upfront, prior to the studies being performed. Given the added expense and the increased complexity not only in technical design but also contractually, net metering applications are recommended over generation interconnections.

Photovoltaic Modules (Solar Panels)

Module technologies are differentiated by the type of PV material used, resulting in a range of conversion efficiencies from light energy to electrical energy. Silicon Modules (most common) typically have a lifespan in a range of 25-30 years. In addition, the PV module's tilt angle will affect the overall energy production. These three major types of modules are discussed below:

- Monocrystalline – Typically has the highest efficiency nearing 20% resulting in slightly higher costs for the improved power density. This is the most space efficient technology, producing up to four times more power than thin film panels.
- Polycrystalline – Efficiency can be between 12% and 18% with an average efficiency of 17%.
- Thin Film – Use layers of material only a few micrometers thick so these are typically constructed into flexed modules. Efficiency ranges from 6% to 12% depending on the type of material used. These can be produced as both rigid and flexible modules. The output of some types of thin-film modules is less affected by high temperatures than crystalline modules. The lower the efficiency, the more space will be required to do a project with thin-film modules than crystalline modules. Slightly more tolerant of shading effects than crystalline modules.

Racking System Types

Generally, the two types of PV configurations utilized in commercial PV systems are fixed tilt and single axis tracking mounting structures. Below is a description of each:

- Fixed Tilt Systems – These are the most commonly installed systems for non-utility scale projects. The tilt of the panels typically approximates the latitude of the installation in order to maximize production by aligning the modules perpendicular to the sun.
- Solar Tracking – These systems include motors that move the panels in order to track the sun throughout the day to maximize energy production. Horizontal single-axis trackers that rotate the panels east to west thorough the day make up the vast majority of tracker installations and can provide a production increase of up to approximately 25% for areas with good irradiation and generally clear skies (Lopez, Denholm, & Margolis, 2013). Rather than being on a fixed tilt, the modules on single-axis trackers are flat so they become economically feasible when the increase from tracking the sun outweighs the loss from non-optimal tilt, larger acreage requirements, and slightly higher capital and O&M costs.

Single Axis Solar tracking adds a premium of over 50% for a 25% production boost. Dual axis doubles the premium with a production improvement of around 40%. Unless space constraints give no other alternatives, it seems is cheaper to add additional panels compared to using trackers in these systems (Solar Reviews, 2018).

In recent years, Single Axis Tracking System costs are generally justified only in large scale solar systems. Price reduction is achieved in these systems because of bulk purchasing, labor cost reduction benefits from learning-related improvements and developer costs spread over more installed capacity (NREL, 2018).

Inverter Systems

There are multiple options available in the market when selecting inverters:

- Microinverters – Every solar panel is provided with an inverter so these devices tend to come in sizes from 250W to 320W. They can be procured as part of panel assembly as an "ac module" and warrantied as a single device. These can have superior safety features for rooftop fire safety and improved array performance when shading is a factor, but pricing is typically much higher per watt than string or central inverters. They offer higher reliability in that the failure of one inverter would cause very minimal disruption to the system.
- String Inverters – String inverters come sizes ranging from 5 kW to 60 kW and have become a very common project choice since the NEC changes allowed ungrounded dc for PV systems so the inverters could be made 'transformerless' resulting in greatly reduced prices and weight. They are typically installed throughout the array on the racking structures. Using multiple string inverters can offer improved reliability over central inverters, as only a subarray is affected by an inverter failure.
- Central Inverters – This inverter type has the largest footprint and typically comes in ratings of 500 kW and above. They are installed on structurally designed pads or support platforms. Using a single central inverter to convert the power from an entire array is typically the lowest cost, but the lack of redundancy can result in significant revenue loss in the event of an inverter failure.

Miscellaneous Electrical Equipment

Cable runs and design should be designed per the National Electric Code (NEC) 2017. Other equipment typically used for commercial installations include an aggregation panel, array disconnect, and a separate revenue meter for the PV output. The equipment would need to be specified during detailed design.

Financing Options for Solar PV Systems

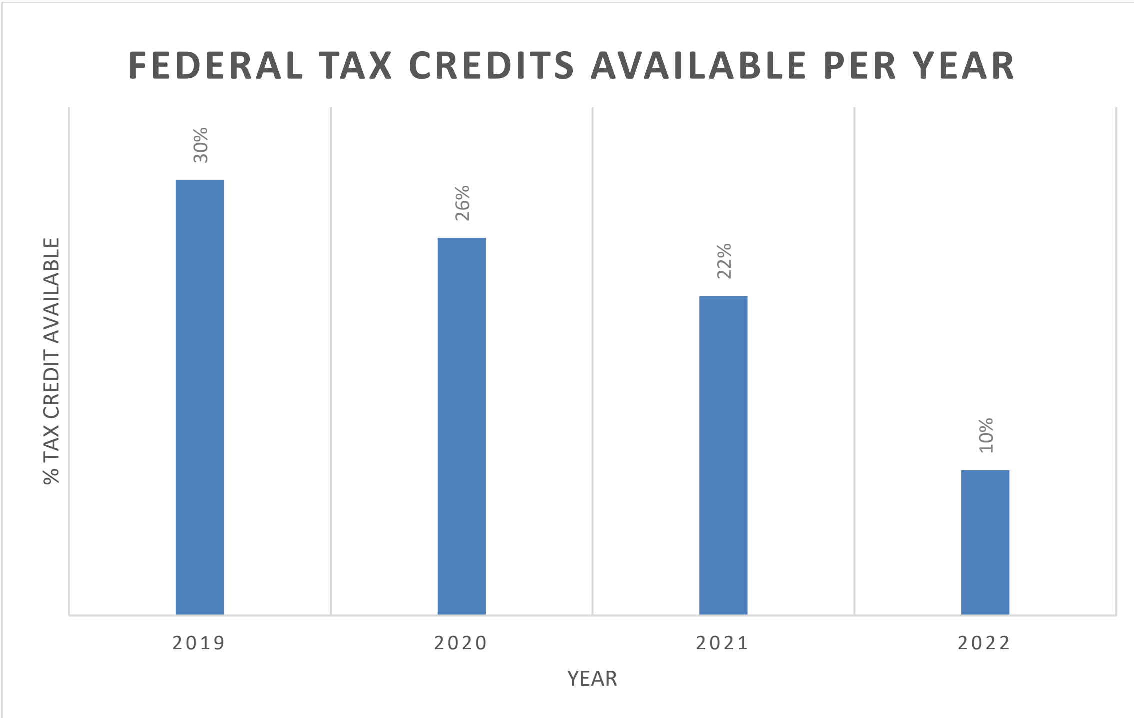
There are several options for CFX to finance the solar PV systems. Although CFX showed interest in acting as an owner, there might be alternative ways to finance solar PV systems. These alternatives could help CFX take advantage of the current Federal Solar Tax Credit if lower payback period is desired.

Review of Federal Tax Credits (ITC)

The Federal Solar Tax Credit, also known as the Investment Tax Credit (ITC), allows a 30% tax credit claimed against the investors in solar energy. The credit reduces federal tax that a person or entity would otherwise pay the federal government. Even though CFX can't take direct advantage of the credit, they can use a third-party to take indirect advantage.

In addition, to take full advantage of the 30% credit, CFX would need to start construction of the desired project(s) in 2019. As shown in Figure 5.1, the tax credit is set to be phased out in the next few years.

Figure 5.1 – Federal Tax Credits Available for Commercial Systems in the Next Few Years (10% stays constant from 2022 on)



Business Model Options to Finance Solar PV Projects

CFX Acting as Owner and Operator

For public entities like CFX that choose to finance, own, and operate a solar project, funding can be raised multiple ways:

- As part of a larger, general obligation bond.
- Standalone tax credit bond.
- Tax-exempt lease structure.
- Bank financing.
- Grant and incentive program.
- Internal cash.
- Combination of the above.

Certain structures are more common than others and grant programs for solar programs are on the decline. As tax-exempt entities, public entities are unable to benefit directly from the various tax-credit-based incentives available to private companies. This has given way to the now common use of third-party financing structures, such as the Power Purchase Agreement (PPA).

Third-Party "Flip" Agreement

The most common use of this model is a site host working with a third-party developer who then partners with a tax-motivated investor in a Special Purpose Entity (SPE) that would own and operate the project. Initially, most of the equity provided to the SPE would come from the tax investor and most of the benefit would flow to the tax investor. When the tax investor has fully monetized the tax benefits and achieved an agreed-upon rate of return, the allocation of benefits and majority ownership would "flip" to the site host. After the flip, the site host would have the option to buy out all or most of the tax investor's interest in the project at fair market value of the tax investor's remaining interest.

A "flip" agreement can also be signed between a developer and investors within an SPE, where the investor would begin with the majority ownership. Eventually, the ownership would flip to the developer once each investor's return is met. An example of this structure is provided below.

Example of Third-Party "Flip" Agreement

Oregon DOT (ODOT) and Portland General Electric (PGE) Public - Private Partnership for 104 kW Highway Demonstration Project

The Oregon DOT was responsible for studying site options and addressed legal and regulatory requirements. PGE took responsibility of project financing, ownership, coordinating design and construction, and operations and maintenance. PGE found a private sector partner and created an SPE that allowed project to take advantage of tax incentives (federal credit and accelerated depreciation). The SPE partner owned the project until tax incentives were derived and then PGE acquired the project.

Sales/Leaseback

Under the sales/leaseback model, a public agency would develop the project and sell it to a third-party tax equity investor who then leases the project back to the public agency under an operating lease. At the end of the lease period, and after the tax benefits have been absorbed by the tax equity investor, the public agency can purchase the solar project at fair market value.

Example of Sales/Leaseback

Oregon DOT (ODOT) and Portland General Electric (PGE) Public - Private Partnership for 1.75 MW Baldock Solar Station

The example includes the same type of set-up as the above Flip Agreement, but instead of setting up an SPE, a sale-leaseback agreement allowed the financial institution to fully own the project until tax benefits are derived. PGE acquired the project at fair market value after that. Avoiding SPE reduced complexity and cost of the transaction.

Third-Party Developer Power Purchase Agreement (PPA)

In exchange for access to a site through a lease or easement arrangement, third-party developers would finance, develop, own, and operate solar projects utilizing their own expertise and sources of tax equity financing and debt capital. Once the system is installed, the third-party developer will sell the electricity to the site host or local utility via a PPA – a contract to sell electricity at a negotiated rate over a fixed period. The PPA typically will be between the third-party developer and the site host if it is a retail "behind-the-meter" transaction or directly with an electric utility if it is a wholesale transaction.

The government entity could benefit by either receiving competitively priced electricity from the project via the PPA or land lease revenues for making the site available to the solar developer via a lease payment. This lease payment can take on the form of either a revenue-sharing agreement or an annual lease payment. In addition, third-party developers can utilize federal tax credits. For public entities, this arrangement allows them to utilize the benefits of the tax credits (low PPA price, higher lease payment) while not directly receiving them. The term of a PPA typically varies from 20-25 years.

Example of Third-Party Developer PPA

Massachusetts DOT (MassDOT) and AMERESCO - 6 MW Solar System

MassDOT owned the land while AMERESCO design, built, and owned the solar equipment. The project cost and maintenance was covered by AMERESCO (tax breaks were allowed). There was a fixed cost per kwh charged to MassDOT for 20 years, with an option to own or extend contract after 20 years. AMERESCO paid a fee to lease land during 20-year period.

Section 2

Environmental and Regulatory Assessment

ENGINEER reviewed all potentially applicable federal, state, and local environmental regulations for the permitting and construction of each system. In some cases, state regulations are deferred to the federal level for permitting. In other cases, joint permits exist with the State and Federal regulations. The scope of this assessment is limited to a general overview, as it is intended to be broadly applicable across the State.

Summary of Regulatory Programs

Federal Environmental Regulations

- Clean Water Act (CWA)
- Endangered Species Act (ESA)
- Migratory Bird Treaty Act (MBTA)
- Bald and Golden Eagle Protection Act (BGEPA)
- Flood Disaster Protection Act (FDPA)
- National Historic Preservation Act (NHPA)

State of Florida Environmental Regulations

- Environmental Resource Permit (ERP)
- National Pollutant Discharge Elimination System (NPDES)
- Florida Historical Resources Act (FHRA)

Local Environmental Regulations

As site selection is ongoing, and municipal boundaries vary throughout Orange and Lake counties, it is safe to assume some city and/or county permitting, for at least construction and storm water, is likely to be involved. For example, the project sites may be subject to City or County permits, such as City of Orlando Floodplain development permit, and may also be subject to storm water management requirements as part of the City building permit, as outlined in the City of Orlando Engineering Standards Manual, 5th Edition.

FAA Federal Regulation Title 14 Part 77

The FAA rule requires a proponent of a construction project within proximity to an airport to submit the required notification at least 45 days prior to the start of the proposed construction or alteration. Part 77 establishes standards and notification requirements for objects affecting navigable airspace. This notification serves as the basis for:

- Evaluating the effect of the construction or alteration on operating procedures.
- Determining the potential hazardous effect of the proposed construction on air navigation.
- Identifying mitigating measures to enhance safe air navigation.
- Charting of new objects.

Notification allows the FAA to identify potential aeronautical hazards in advance, thus preventing or minimizing the adverse impacts to the safe and efficient use of navigable airspace.

Summary of Regulatory and Environmental Assessment Results

The goal of this assessment is to identify potential permits, permitting durations, and other possible regulatory or environmental concerns. Upon project initiation, a detailed walkdown of any potential site is required to identify issues unforeseen at this time.

PV Options

Each individual sustainability option can have its own specific regulatory concerns, but the ground-mounted PV, Wet Pond PV, and Dry Pond PV are expected to have the most effort in this regard. The individual circumstances can vary based on which site is selected, but the following generally applies to the PV options:

- All projects would require an Environmental Resource Permit (ERP) and National Pollutant Discharge Elimination System (NPDES) Permit.
- Project sites may be subject to local City or County permits such as City of Orlando Floodplain development, storm water management, and city building permits.
- If field surveys delineate any wetlands, potential permitting could take 2-12 months and cost $5,000-$15,000 pursuant to CWA.
- If site wildlife assessment finds applicable species, a suitable remedy could take an additional 1-12 months and cost $5,000-$25,000 pursuant to ESA.
- If during vegetation clearing, nesting of applicable migratory or protected bird nests are found, a suitable remedy could take an additional 1-2 months and cost $2,000-$10,000.
- Any significant change to those sites that fall within a floodplain require 2 weeks-2 months and $3,000-$10,000 for required permitting.
- Ground disturbing activities associated with site construction could require storm water permitting and development of the Storm Water Pollution Prevention Plan (SWPPP), which is projected to take 1-3 months and cost $5,000-$15,000.
- Basic City or County local permitting is estimated to take 2-4 weeks and cost $2,000-$5,000.

Non-PV Options

Based on initial conceptual analysis of the non-PV sustainability options, the installation of the charging stations seems to be the most likely project to be impacted by permitting and regulations. It is expected the project would fall under local City or County ordinance for permitting and inspections that would take the typical 2-4 weeks and cost $500-$5,000.

FAA Compliance

The key to FAA adherence lies in recognizing when perspective projects fall within FAA guidelines, and beginning the process of FAA notification and approval in a timely manner. Compliance requirements under §77.9 says that any person/organization who intends to sponsor any of the following construction or alterations must notify the Administrator of the FAA:

- Any construction or alteration exceeding 200-feet above ground level.
- Any construction or alteration:
    - within 20,000-feet of a public use or military airport which exceeds a 100:1 surface from any point on the runway of each airport with at least one runway more than 3,200-feet;
    - within 10,000-feet of a public use or military airport which exceeds a 50:1 surface from any point on the runway of each airport with its longest runway no more than 3,200-feet;
    - within 5,000-feet of a public use heliport which exceeds a 25:1 surface.
- Any highway, railroad, or other traverse way whose prescribed adjusted height would exceed that above noted standards.
- When requested by the FAA.
- Any construction or alteration located on a public use airport or heliport regardless of height or location.

Persons failing to comply with the provisions of FAR Part 77 are subject to Civil Penalty under Section 902 of the Federal Aviation Act of 1958, as amended and pursuant to 49 U.S.C. Section 46301(a).

Section 3

Ground-Mounted PV System

Description

The ground-mounted PV solar system describes those free-standing installations that are directly anchored to the ground as opposed to a roof, generates small to large scale energy, and whose PV array are typically used grid-tied systems rather than residential.

Site Selection

To maximize energy savings for CFX, ENGINEER utilized customer-provided metering data to find out where high energy consumption was located within their system. ENGINEER sized the PV systems large enough to offset the bills, while minimizing excess solar generation. CFX provided a list of all electric meters and the associated billing data. The list included a total of 93 electric meters located in both Duke Energy and OUC territory. ENGINEER reviewed the meters and account types and found the following:

- OUC Accounts
  - Commercial Non-Demand Electric Rate Accounts – smaller commercial accounts.
  - General Service Demand (GSD) Secondary Demand Electric Rate Accounts (larger accounts) – GSD accounts are charged at a fixed rate Energy kWh and Demand Peak kW consumption.

  Because GSD the accounts were larger, ENGINEER targeted only GSD accounts for this study.

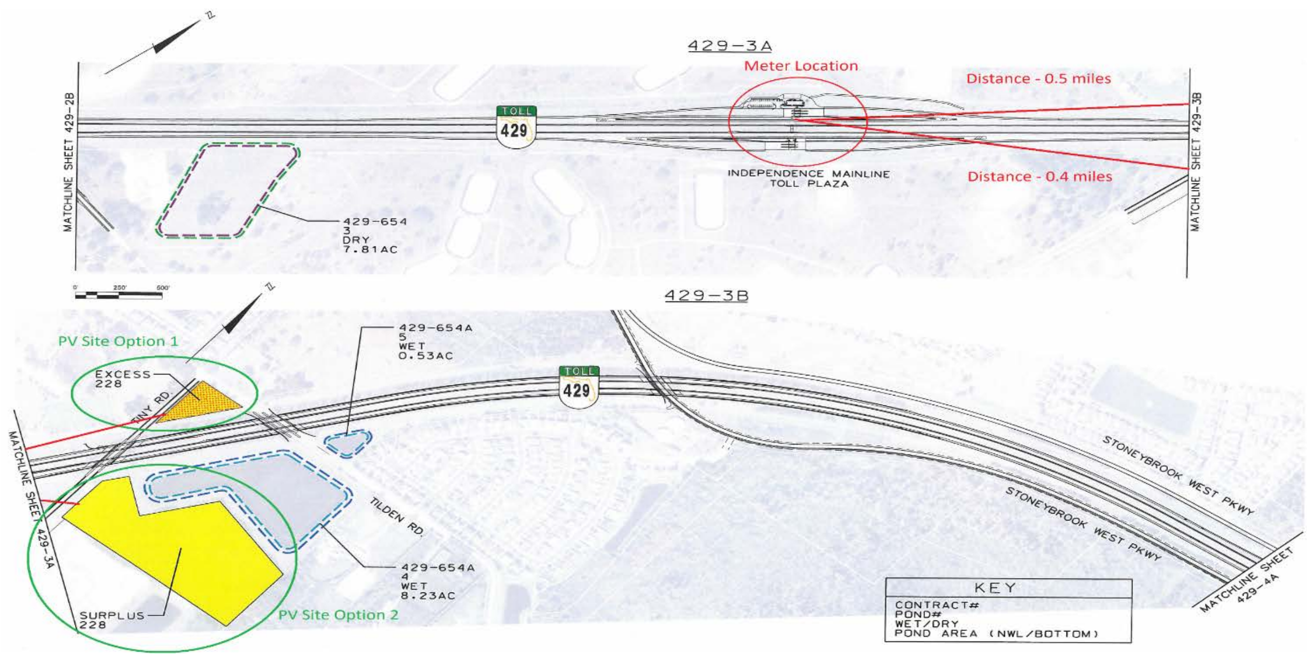
- Duke Energy Accounts
  - Commercial Non-Demand GS-1 – smaller commercial accounts (Data Center is the only exception).
  - Commercial Demand Optional Time of Use GSDT-1 – Secondary Demand Electric Rate Accounts – larger accounts.

ENGINEER targeted mainly GSDT-1 accounts for this study. The only exception was the GS-1 Data Center account.

After compiling the meter data, ENGINEER utilized the provided CFX land inventory to identify sites located near those meters. The criteria used for selection were as follows:

- Land within .5 miles of a high consumption meter was considered to avoid significant losses and the increased costs to compensate for it as a potential issue (Appendix A).
- Sites larger than .5 acres were considered to ensure enough land is available to fit the PV systems.

Figure 3.2.1 – Example of Site Selection for an Electric Meter



CFX has 65 land plots to be considered for the Ground-Mounted Solar PV, but only 12 matched the criteria. Figure 3.2.1 shows a visual representation of how meters and sites where matched as possible PV system opportunities. The rest of the high consuming electric meters were disqualified, because they either had no usable land nearby or no nearby meter.

Site Engineering Assessment

The site engineering assessment includes identification of engineering equipment and any constraints associated with the development of Ground-Mounted PV option.

Estimated Energy Potential of Each Site

ENGINEER calculated the energy potential of each recommended site. The potential was estimated to be approximately 4 acres/Megawatt based on both National Renewable Energy Laboratory (NREL) average size data and ENGINEER experience with solar systems.

To obtain the max energy potential of each site, ENGINEER assumed at least 80% of the land was usable and applied the following formula:

$$\textbf{Energy Potential }(kW) = 80\%\ \mathrm{x}\ \textbf{Area of site }(Acres) \times \frac{1\ MW}{4\ Acres} \times \frac{1,000\ KW}{1\ MW}$$

Meter Location Description	Nearest Meter(s)	Land No.	Area (Acres)	Energy Potential (kW) (Assuming 250kW per Acre)
DMS - 510 N Powers Dr	5CM10371	52-175/ 52-351	1.34	268
Coral Hills Mainline Plaza	2822587	243/251	2.14	428
		248/247	1.49	298
John Young Mainline Plaza	2818014	45-179	2.18	436
		45-191/45-192	2.89	578
		45-198/45-1102	0.59	118
Curry Ford Main Plaza	2819493	42-101	2.69	538
University Mainline Plaza	2371197	150	2.18	436
Independence Mainline Plaza	2815110	228	14.35	2870
		228	2.13	426
Forest Lake Mainline Plaza	2816670, 2803386	63-101	12	2400
		62-157	7.67	1534
		62-172	4.85	970
Load CTR C - 8009 Tradeport Dr	5CM10232	7	4.96	992

Conceptual Design and Specifications

Photovoltaic Module Selection

Since monocrystalline modules provide highest efficiency, durability, and is more suited for commercial sized systems this type of module was selected. Additionally, a monocrystalline module can be utilized in other options that are part of this study and achieve reduced pricing by economies of scale.

Note that significant differences between mono and polycrystalline modules have begun to disappear in recent years and have become less of a decision factor when executing a project.

Racking System Selection

Fixed tilt systems provide the most economical option for the sites under study.

Inverter System Selection

ENGINEER recommends the use of string inverters for commercial size systems. These inverters provide economic advantages and enough flexibility to use in different size applications.

Structural and Civil

The structural design for ground-mount systems (fixed-tilt, trackers) is typically performed by the selected racking vendor who will utilize geotechnical information in conjunction with site-specific "pull-out" tests to determine foundation requirements and embedment depths. Ground-mounted systems can be anchored into concrete footings, have steel support posts driven directly into the ground, utilize screw anchors, or be ballasted directly on grade by either single cast concrete blocks with embedded supports, multiple concrete blocks incorporated into a racking system, or by aggregate in engineered bins. Systems will be designed in accordance with local building code requirements. The racking system design and construction drawings need to be stamped by a Professional Engineer licensed in the State of Florida.

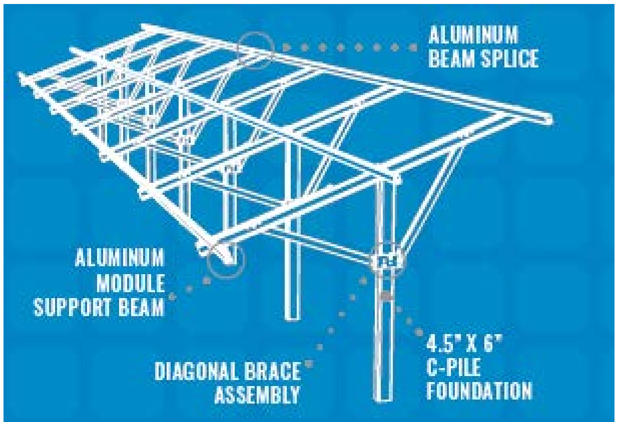


Figure 3.4.1

Figure 3.4.1 is an example of a typical fixed tilt racking design for reference.

Little site work is anticipated at each location. Site work required typically involves clearing, some minor grading, and installation of access drives.

PV System Size, Conceptual Design, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and describe design elements and specifications appropriate for each system.

PV System Size Options

Based on one-year consumption data of each electric meters selected for this study and CFX's location, ENGINEER was able to obtain appropriate PV system size for each meter. ENGINEER used National Renewable Energy Lab's (NREL) System Advisory Model (SAM) Detailed performance model (PM) to estimate how much energy would be generated from each PV system and ensure they fed no more than 100% of its total yearly consumption to avoid Cost of Generation tariffs applied by the utility providers. Detailed system models for 100 kW and 200 kW system were developed for production and cost details. These building blocks were then applied as appropriate to each of the numerous sites. Detailed models for each site would be developed at the detailed design phase.

Conceptual Design Elements

The type of PV panels and mounting structures are the major design elements for solar PV systems. ENGINEER selected panels and inverters for the conceptional design based on ENGINEER preference and experience. Panels manufactured by SunPower were selected based on cell efficiency, low degradation rate, longevity, and 25-year warranty.

PV panels would be mounted on racks, facing due south, at a tilt angle of approximately 28 degrees to maximize annual energy production. The mounting racks would be aligned in rows along an east to west axis across the desired area.

Depending on the height of the panels off the ground, it is estimated that 10-feet of spacing is required to prevent shading from one row of modules to the next. The spacing is based on NABCEP guidelines and is required to avoid the longest shadow casted by the panels during the winter's solstice. Adequate distance between rows also provides vehicle access for maintenance and future module replacement.

String inverters are recommended for these systems. The inverter should be sized taking into consideration cost, energy yield, and keeping in mind the amount of cable and connections needed that could increase complexity and cost of the installation. For this study, ENGINEER assumed a 60 kW SMA inverter would be used in all systems. SMA inverters were specified based on well-received industry acceptance, lower install costs, and trending use by developers. The size was based on ENGINEER recent project design experience, but correct size and number of inverters should be studied in more detail as part of detailed design in each location. Of course, CFX will need to work closely with OUC and Duke Energy to meet all interconnection requirements for connecting with the power grid.

Appendix A includes a typical single-line diagram of the conceptual design elements of the proposed PV systems and an example layout of a traditional ground-mounted PV system.

PV Equipment Specifications

PV systems specifications will be determined later based on final panel selection, design of wiring configurations, and the inverter voltage input requirements. Below is a list of equipment components and specifications based on this preliminary assessment information:

- Solar PV Modules – assuming a 60 kW inverter selected:
  - 100 kW system – 322 modules
  - 200 kW system – 644 modules
- Inverters –
  - 100 kW system – two 60 kW inverters
  - 200 kW system – four 60 kW inverters
- Fixed tilt mount racking system angled at 28 degrees.
- Balance of system components including hardware, wiring, connectors, boxes, disconnects, metering, and NEC required components.

Please refer to Appendix A for Main Equipment Specifications.

PV Generation Output Analysis

NREL's SAM Commercial PV model was used to build a performance model at the 100 kW and 200 kW capacity cases using a ground-mount PV system. The software determines the solar radiation of the desired location incident on a tilted plane. SAM also uses weather data to account for heat transfer on the back of the PV panels, since cell temperature has an impact on power output. Using the inputs detailed in Conceptual Design and Specifications, a performance model was constructed around a specific panel, inverter, azimuth angle, and panel tilt angle. Below are the first-year results for fixed tilt installation on CFX owned property. These results were used in the economic analysis and were matched to specific CFX meter loads.

System Size (kW)	First Year Estimated AC Energy Production	Electric Rate Basis
100	147,335 kWh	OUC
100	147,335 kWh	Duke
200	320,320 kWh	OUC
200	320,320 kWh	Duke

Installed Cost Estimates

PV system prices have fluctuated recently due to new tariffs applied to solar panels. Additionally, price fluctuations of other commodities cost such as copper, steel, and concrete required for construction could affect system pricing. Despite the uncertainty of material cost, PV system prices have decreased steadily every year, and prices are not expected to increase in the near future.

ENGINEER utilized NREL's benchmark data to estimate the total cost of ground-mount PV solar systems. The installation costs include PV modules, inverters, labor, racking, balance of system, grid interconnect costs, and soft costs. Soft costs are permitting fees, developer overhead and profit, EPC overhead and profit, and contingency. An index for these costs at different capacities utilized for ENGINEER's economic analysis are shown below.

Cost	100 kW ($/W)	200 kW ($/W)	500 kW ($/W)	1000 kW ($/W)
Module	0.47	0.47	0.47	0.47
Inverter	0.08	0.08	0.08	0.08
Racking	0.22	0.22	0.22	0.22
Balance Of System	0.15	0.14	0.13	0.12
Labor	0.14	0.11	0.09	0.08
Cost of Interconnection	0.13	0.10	0.09	0.08
Soft Cost (Developer, Permitting, Contingency)	0.69	0.67	0.63	0.63
Total	**1.88**	**1.79**	**1.71**	**1.69**

The above costs are based on the Florida benchmark data for commercial systems. Because NREL assumes a rooftop installation in their commercial system benchmark data, ENGINEER modelled labor and material costs may be slightly higher than actual labor and material at each CFX site. The benchmark costs also do not include sales tax. The table below summarizes the total installation cost for each capacity analyzed with sales tax.

System Size (kW)	Installed Cost
100	$191,419
200	$364,207

In addition to the installation cost, operation and maintenance costs were utilized in ENGINEER's economic analysis described in Economic Analysis. A ground-mount PV system has O&M costs associated with periodically cleaning and inspecting panels, adjusting drifted tilts, and landscape maintenance. O&M costs were estimated from a developer's quote on a previous ENGINEER project with a similar system size. Annual O&M costs used in the SAM models are shown below:

- 100 kW PV System: $15 per kWdc per year
- 200 kW PV System: $15 per kWdc per year

Economic Analysis

The final part of the sustainability assessment of the proposed ground-mount PV solar systems was to determine economic value. Since CFX expressed interest in building and owning the solar PV systems a model was created in which CFX incurred all of the project's capital expenses. However, since CFX is a tax-exempt government entity, CFX is not able to take advantage of federal tax incentives. ENGINEER assumed CFX would take full benefit from the ITC through a third-party developer. Through a "Build Own Transfer" model, the developer would sell the system to CFX after several years of operation. The developer would pass any tax benefit received to CFX. This approach was used to build the SAM models and conduct the economic analysis.

It is important to note that SAM performs economic analysis from a developer's point of view, so the results should be utilized accordingly. Main assumptions utilized to complete the analysis in all simulations are shown below:

- Life of PV System: 30 years
- Annual PV System Degradation: 0.4% per year (based on the PV module performance data)
- Federal Investment Tax Credit: 30% of system capital cost in Year 1 of operation (only available in 2019)
- Energy Bill Escalation Rate: 4% (this is based on a five-year history of Consumer Price Index for electricity in Florida)
- Inflation Rate: 2.5% per year
- Debt Percent for Project Financing: 0%
- Load Growth: 0%
- MACRS Depreciation: 5 Years
- Federal Income Tax Rate for Developer: 21%
- State Income Tax Rate for Developer: 7%

- Sales Tax: 6% (Tax Exemption is available in Florida for PV. However, assumed cost is still incurred by developer)

To recognize the value of electricity savings for the Ground-Mounted PV System, customer electricity rates were placed in SAM. Below is a summary of the electric rates. Based on Florida law, it was assumed CFX would take advantage of net metering if any excess generation took place in a month. This energy credit would be applied to a future energy charges from the utility.

	OUC	**Duke**
Fixed Charges ($/month)	38	12.78
Energy Charges ($/kWh)	0.069	0.08843
Demand Charges ($/kW)	9	10.70

SAM also considers the hourly load profile of an energy user. CFX's monthly bill data is used to estimate the hourly load profile of a meter. SAM will conduct an hourly simulation to determine hourly energy consumption. Bill data from the Conway Plaza and Dean Road Mainline Plaza were used as a basis for the SAM models. ENGINEER made this assumption since demand cost relative to energy costs at each CFX meter is relatively constant. This approach simplifies the economic analysis, yet is valid since each meter will be paired with a PV system that offsets, but does not exceed annual energy consumption.

Based on the listed assumptions, a cash flow analysis was conducted for each capacity case and at each utility rate. Below is a summary of the analysis over 30 years.

System Size (kW)	**Payback**	**Lifetime AC Energy Production (kWh)**	**Lifetime Savings**	**Avoided CO_2 Emissions (lbs./year)**	**Electricity Rate**
100	10.7 years	4173017	$919,479.00	141326	OUC
200	9.9 years	9072510	$1,895,872.00	307256	OUC
100	8.3 years	4173017	$1,201,056.00	141326	Duke
200	7.7 years	9072510	$2,456,278.00	307256	Duke

ENGINEER also considered a case where CFX would develop a ground-mount PV system without a third-party developer, such as a "Design Bid Build" model. This would simplify the project and CFX would be exempt from sales tax, however, CFX cannot claim the ITC. Below is a summary of the results without sales tax and without claiming the ITC. Without the ITC, three to four years will be added to the payback period.

System Size (kW)	Payback	Electricity Rate
100	14.0 years	OUC
200	13.2 years	OUC
100	11.4 years	Duke
200	10.5 years	Duke

Based on the site assessment portion of the study described in Site Engineering Assessment, below is a table of ideal sites for ground-mount PV installation with solar potential. Solar potential is based on PV Watts estimate of 1538 kWh/year in Orlando, Florida, for each 1 kW of PV capacity. Also, listed is a recommended PV size for each meter to offset annual energy use. Since Duke demand cost data was not made available, ENGINEER assumed 25% of the CFX's Duke bills were associated with peak demand costs. An assumption was taken to back calculate the annual energy use at each Duke meter. Capital costs for the recommended PV capacity was estimated by interpolating the estimate in Section 2-0.

Meter Number	Description	Utility	Maximum Potential PV Capacity Behind Meter (kW)	Potential Annual PV Energy Production (kWh)	Meter Annual Energy Usage (kWh)	Max PV Potential % of Annual Usage	Minimum Recommended PV Capacity to Offset Annual Usage (kW)	Estimated Capital Cost of Minimum Recommended Capacity	Estimated Payback period	Estimated Lifetime savings
2822587	*Coral Hills Mainline Plaza	DUKE	726	1116588	291049	384%	190	$347,000	10.6	$2,331,000
2371197	*University Mainline Plaza	DUKE	436	670568	261130	257%	170	$313,000	10.8	$2,080,000
2818014	*John Young Mainline Plaza	DUKE	1132	1741016	249662	697%	170	$313,000	10.8	$2,080,000
2803386	Forest Lake Mainline Plaza	DUKE	4904	7542352	236114	3194%	160	$296,000	10.9	$1,955,000
2815110	Independence Mainline Plaza	DUKE	3296	5069248	242238	2093%	160	$296,000	10.9	$1,955,000
2816670	Forest Lake Mainline Plaza	DUKE	4904	7542352	236114	3194%	160	$296,000	10.9	$1,955,000
2819493	Curry Ford Main Plaza	DUKE	538	827444	241851	342%	160	$296,000	10.9	$1,955,000
5CM10232	Load CTR C – 8009 Tradeport Dr	OUC	992	1525696	217194	702%	150	$278,000	13.6	$1,408,000
5CM10371	DMS - 510 N Powers Dr	OUC	268	412184	163577	252%	110	$209,000	14.0	$1,018,000

* Top recommended choices based on lower payback periods

Conclusions

As can be seen from the analysis presented in this study, the development of Ground-Mounted PV solar systems at various sites is both environmentally and technically feasible.

The following conclusions were drawn from the evaluation of traditional Ground-Mounted solar systems in CFX properties:

- ENGINEER recommends CFX to utilize Florida's Net Metering program to offset high consumption loads in their systems.
- Nine electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
- Top site recommended choices (based on shorter payback periods) are Coral Hills, University and John Young Mainline Plazas.
- ENGINEER recommends a ground-mounted, fixed tilt, monocrystalline PV system with string inverters.
- For these systems to be constructed, CFX must review and ensure compliance with listed environmental regulations in Section 2 of this report. Priority should be to comply with Clean Water Act (CWA), Bald and Golden Eagle Protection Act (BGEPA).
- All projects would require an Environmental Resource Permit (ERP), National Pollutant Discharge Elimination System (NPDES) Permit, and local permit.
- CFX could reduce payback periods around three to four years by benefiting from tax breaks available if alternative financial options are considered (listed in PV Systems section of this study).

Section 4

Floating PV Solar (Wet Pond)

Description

A floating PV solar farm is an array of solar panels on a structure that floats on a man-made or naturally occurring body of water. Floating PVs can generate small to large scale energy that could be utilized by CFX.

Site Selection

ENGINEER utilized the high consumption metering data and methodology as described in Section 3 to select the appropriate wet ponds. CFX has 228 wet ponds to be considered for Floating Solar Farm Sites, but only 39 matched the criteria. Figure 3.2.1 shows a visual representation of how meters and sites where matched as possible PV system opportunities. The rest of the high consuming electric meters were disqualified because they either had no usable wet pond nearby or we were unable to locate meter.

Site Engineering Assessment

The site engineering assessment includes identification of engineering equipment and any constraints associated with the development of floating PV option.

Estimated Energy Potential of Each Site

ENGINEER calculated the energy potential of each recommended site. The potential was estimated to be approximately 4 acres/MW based on both National Renewable Energy Laboratory (NREL) average size data and ENGINEER experience with solar systems.

To obtain energy potential of each site, ENGINEER assumed at least 80% of the land was usable and applied the following formula:

$$\textit{Energy Potential}\ (kW) = 80\%\ \text{x}\ \textit{Area of site}\ (\textit{Acres}) \times \frac{1\ MW}{4\ \textit{Acres}} \times \frac{1{,}000\ KW}{1\ MW}$$

Location Description	Nearest Meter(s)	Wet Pond No.	Depth (Normal Water Level) (Acres)	Energy Potential (kW) (Assuming 250kW/acre)
Dean Rd Mainline Plaza	2370607	408-304; 306A, 2	1.53	306
University Mainline Plaza	2371197	417-103; 104; 109, 4	1.34	268
Independence Mainline Plaza	2815110	429-654A, 4	8.23	1646
John Young Mainline Plaza	2818014	417-450, 14	5.7	1140
Curry Ford Main Plaza	2819493	417-107; 402, 4	5.77	1154
Boggy Creek Mainline Plaza	2821260	417-453, 6	5.06	1012
		417-453, 4	3.77	754
		417-453, 5	2.98	596
3454 J Lawson BLVD	7226207	417-301C; 454, 4	14.14	2828
		417-301C; 454, 3	5.91	1182
		417-301C; 454, 2	2.45	490
Goldenrod Mainline Plaza	1JR01475	528-903, 1B	3.44	688
		528-903, 1C	1.18	236
		528-903, 1A	0.86	172
Dallas Mainline Plaza	1ZR10846	528-403, 3-A	4.74	948
		528-403, 2-A	4.11	822
Pine Hills Main Plaza	1ZR11291	408-252B, L	2.39	478
Conway West/East Main Plazas	1ZR11403, 1ZR12868	408-253C, 1	6.49	1298
		408-253C, Sedimentation	0.95	190
Load CTR C - 8009 Tradeport Dr	5CM10232	528-405, A	4.42	884
		528-405, G3	0.58	116
Beachline Main Plaza	5CM10255, 1ZR12711	528-401, 23	2.89	578
		528-401, 21	2.75	550
		528-401, 22	2.39	478
Beachline Airport Main Plaza	5CM10272	528-300, B-1	7.48	1496
		528-300, E-1	3.19	638
		528-300, F	2.97	594
		528-300, A-1	2.60	520
		528-300, A-6	1.73	346
		528-300, E-2	1.19	238
		528-300, D-1	1.13	226
		528-300, A-3	0.78	156

Load CTR A - 8602 State Road 417	5CM10285	417-455A, B	10.46	2092
		417-455A, C	9.53	1906
		417-455A, A	8.48	1696
		417-455A, D	8.42	1684
DMS - 510 N Powers Dr	5CM10371	408-505, 2H	2.02	404
Load CTR B - 11000 Innovation Way East Toll	5CM10389	417-457; 302, 3	5.15	1030
		417-302, 200	2.12	424
		417-302, 100	1.83	366
Load CTR B - 5439 Lake Underhill Rd.	5ZR18941	408-253C, Loop	0.65	130
8201 S Semoran Blvd	1JR01474	408-253C, Loop	0.65	130
Headquarters	1ZR12894	408-253C, 1	6.49	1298
Load CTR G - 1220 East West Expy	5CM10325	408-220; 423, 1	0.76	152
Load CTR E (ROW Lights) - 13255 Boggy Creek Rd Lights	5CM10373	417-457, 2	1.92	384
		417-457: 301C, 3	5.15	1030
		417-457, 4	3.23	646

Conceptual Design and Specifications

PV System Size, Conceptual Design Elements, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and describe design elements and specifications appropriate for each system.

PV System Size Options

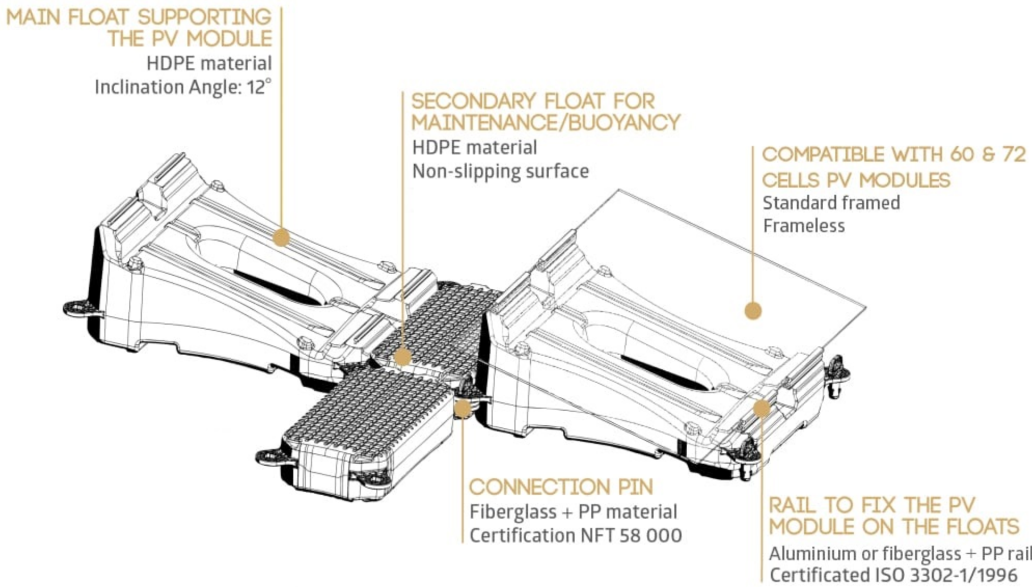
Based on one-year consumption data of each electric meters selected for this study and CFX's location, ENGINEER was able to obtain appropriate PV system size for each meter. ENGINEER used National Renewable Energy Lab's (NREL) SAM Detailed commercial model to estimate how much energy would be generated from each PV system and ensure they fed no more than 100% of its total yearly consumption. Systems of 85 kW,100 kW, 200 kW, and 1,500 kW were assigned to each meter. Only PV system capacities were selected to allow modular installations that can be repeated in different locations.

Conceptual Design Elements

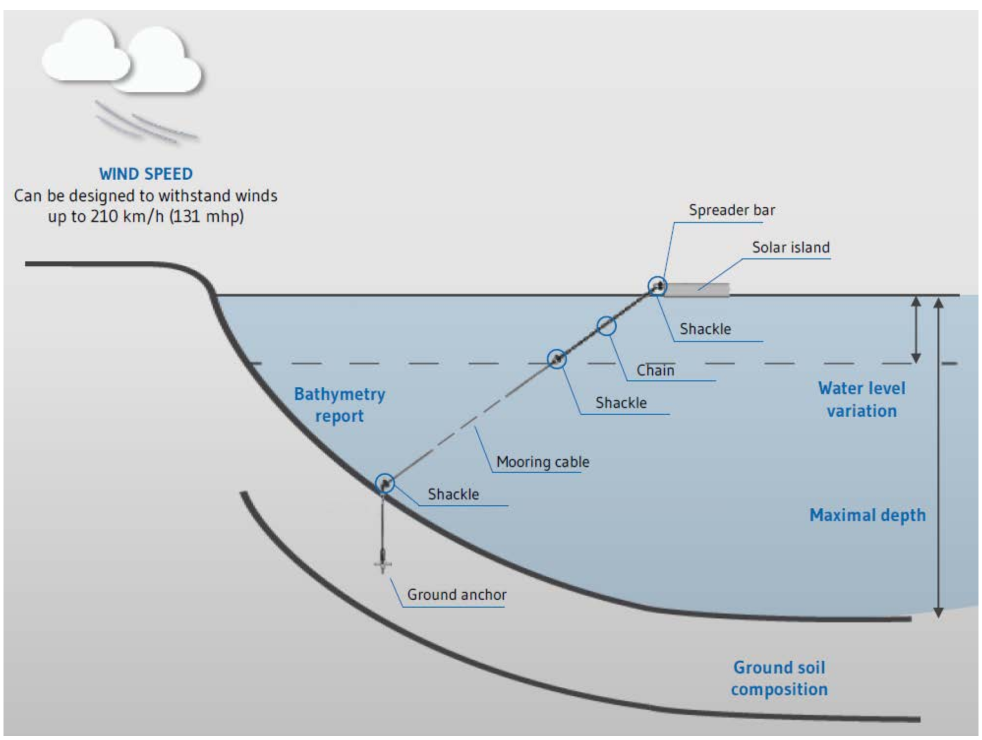
The type of PV panels and mounting structures are the major design elements for this project. The floating PV developer D3 Energy was contacted to coordinate the selection of desired **panels in the Floating PV systems**. D3 Energy provided ENGINEER with specifications of solar panels used in recent projects and ENGINEER confirmed that the same panel could be used for the proposed system installations in the study. JA Solar modules with a rating of 375W were specified. Additional panel information can be found in Appendix B.

These panels would be mounted on Hydrelio® f**loating racks, facing due south**. The mounting racks would be aligned in rows along east to west axis across the desired area.

Hydrelio® racking systems come with a predefined 12 degrees tilt angle and adequate panel row spacing. Also, the panels are not stacked like other ground-mounted racking systems. Because only one panel per row is used a shorter distance is required between panels to avoid inter-row shading. The spacing of rows is based on the longest shadow casted by the panels during the winter's solstice.



Additionally, Hydrelio® racking systems would be anchored to the ground and are able to withstand winds of 131 mph.



String inverters are recommended for these systems. The inverter should be sized taking into consideration cost, energy yield, and keeping in mind the amount of cable and connections needed that could increase complexity and cost of the installation. For this study, ENGINEER assumed a 60-kW SMA inverter would be used in all systems. SMA inverters were specified based on well received industry acceptance, lower install costs, and trending use by developers. The size was based on ENGINEER recent project design experience, but correct size and number of inverters should be studied in more detail as part of detailed design later on to fit desired results in each location.

Furthermore, CFX will need to work closely with OUC and Duke Energy to meet all interconnection requirements for connecting with the power grid.

PV Equipment Specifications

PV systems specifications will be determined later based on panel selection, design of wiring configurations and the inverter voltage input requirements. Below is a list of equipment components and specifications based on this preliminary assessment information:

- Solar PV Modules –
  - 100 kW system – 270 modules
  - 200 kW system – 540 modules
  - 1500 kW system – 4,000 modules
- Inverters –
  - 100 kW system – two 60 kW inverters
  - 200 kW system – four 60 kW inverters
  - 1500 kW system – thirty 60 kW inverters
- Fixed tilt mount racking system angled at 12 degrees.
- Balance of system components including hardware, wiring, connectors, boxes, disconnects, metering, and NEC required components.

Please refer to Appendix B for Main Equipment Specifications.

PV Generation Output Analysis

NREL's SAM Commercial PV model was used to build a performance model at the three capacity cases (100 kW, 200 kW, and 1500 kW) using a floating PV system. The software determines the solar radiation of the desired location incident on a tilted plane. SAM also uses weather data to account for heat transfer on the back of the PV panels, since cell temperature has an impact on power output. Using the inputs detailed in Conceptual Design and Specifications, a performance model was constructed around a specific panel, inverter, azimuth angle, and panel tilt angle.

Floating PV performs differently than ground- or roof-mounted PV. Since the back of the panel is near the surface of the water, the module experiences a cooling effect which helps improve power output for a given ambient temperature. To model this in SAM, the temperature on the back of the panel was assumed to be at wet bulb temperature. This improved annual output by about 4% compared to a ground or roof mounted PV module. ENGINEER also adjusted albedo for a water environment.

Installed Cost Estimates

PV system prices have fluctuated recently due to new tariffs applied to solar panels. Additionally, price fluctuations of other commodities cost such as copper, steel and concrete required for construction could affect system pricing. Despite the uncertainty of material cost, PV system prices have decreased steadily every year and they are not expected to increase any time soon.

ENGINEER utilized quotes provided by floating solar developer D3 Energy's to estimate the price of solar systems. The cost includes PV modules, floating solar racking system, inverter, EPC/Developer overhead and net profit, labor, all other equipment associated with the system.

System Cost	100 kW ($/W)	200 kW ($/W)	1500 kW ($/W)
Module	$0.40	$0.40	$0.38
Inverter	$0.08	$0.08	$0.07
Floating Structure and BOS	$1.06	$0.90	$0.70
Installation	$0.50	$0.45	$0.20
Grid Int.	$0.05	$0.05	$0.05
Total	**$2.09**	**$1.88**	**$1.40**

Taxes and a 4% contingency are not included in the costs above. However, contingency and taxes are considered in the economic analysis section and the installed costs in the table below.

System Size (kW)	Installed Cost
100	$225,269
200	$405,186
1500	$2,261,444

In addition to the installation cost, operation and maintenance costs were utilized in ENGINEER's economic analysis described in Section 2-8. A floating PV system has O&M similar to a ground mound PV system such as periodically cleaning, inspecting panels, and adjusting any maintenance on the support structure. However, ENGINEER assumed higher O&M costs for a floating PV system due to lack of published data. The costs were assumed to be 50% higher.

- 100 kW PV System: $22.5 per kWdc per year
- 200 kW PV System: $22.5 per kWdc per year
- 1,500 kW PV System: $22.5 per kWdc per year

Conduct Economic Analysis of the Proposed Solar Systems

The final part of the sustainability assessment of the proposed floating PV solar systems was to determine economic value. Since CFX is a tax-exempt government entity, CFX is not able to take advantage of federal tax incentives. ENGINEER assumed CFX would take full benefit from the ITC through a 3rd party developer. Through a “Build Own Transfer” model, the developer would sell the system to CFX after several years of operation. The developer would pass any tax benefit received to CFX. This approach was used to build the SAM models and conduct the economic analysis.

It is important to note that SAM performs economic analysis from a developer’s point of view, so the results should be utilized accordingly. Main assumptions utilized to complete the analysis in all simulations are shown below:

- Life of PV System: 30 years
- Annual PV System Degradation: 0.6% per year (based on the PV module performance data)
- Federal Investment Tax Credit: 30% of system capital cost in Year 1 of operation (only available in 2019)
- Energy Bill Escalation Rate: 4% (this is based on a five-year history of Consumer Price Index for electricity in Florida)
- Inflation Rate: 2.5% per year
- Debt Percent for Project Financing: 0%
- Load Growth: 0%
- MACRS Depreciation: 5 Years
- Federal Income Tax Rate for Developer: 21%
- State Income Tax Rate for Developer: 7%
- Sales Tax: 6% (Tax Exemption is available in Florida for PV. However, assumed cost is still incurred by developer.)

To recognize the value of electricity savings for the floating PV System, customer electricity rates were placed in SAM. Below is a summary of the electric rates. Based on Florida law, it was assumed CFX would take advantage of net metering if any excess generation took place in a month. This energy credit would be applied to a future energy charges from the utility.

	OUC	**Duke**
Fixed Charges ($/month)	38	12.78
Energy Charges ($/kwh)	0.069	0.08843
Demand Charges ($/kw)	9	10.70

SAM also considers the hourly load profile of an energy user. CFX's monthly bill data is used to estimate the hourly load profile of a meter. SAM will conduct an hourly simulation to determine hourly energy consumption. Bill data from the Conway plaza and Dean Road Mainline Plaza were used as a basis for the SAM models. ENGINEER made this assumption since demand cost relative to energy costs at each CFX meter is relatively constant. This approach simplifies the economic analysis, yet is valid since each meter will be paired with a PV system that offsets, but does not exceed annual energy consumption.

Based on the listed assumptions, a cash flow analysis was conducted for each capacity case and at each utility rate. Below is a summary of the analysis over 30 years.

System Size (kW)	**Payback**	**Lifetime AC Energy Production (kWh)**	**Lifetime Savings**	**Avoided CO_2 Emissions (lbs./year)**	**Electricity Rate**
100	15.9 years	4213852	$826,420.00	OUC	100
200	13.6 years	9593358	$1,763,698.00	OUC	200
100	10.8 years	4213852	$1,204,788.00	Duke	100
200	9.1 years	9593358	$2,568,785.00	Duke	200
1500	10.4 years	69603147	$13,245,324.00	OUC	1500

Since CFX expressed interest in building and owning the solar PV systems, a case was analyzed in which CFX incurred all of the project's capital expenses. This would simplify the project and CFX would be exempt from sales tax, however, CFX cannot claim the ITC. ENGINEER modeled this case as a "Design Bid Build" model. Below is a summary of the results without sales tax and without claiming the ITC. Without the ITC, 1-2 years will be added to the payback period.

System Size (kW)	Payback	Electricity Rate
100	19.4 years	OUC
200	16.9 years	OUC
100	13.9 years	Duke
200	11.9 years	Duke
1500	13.4 years	OUC

Based on the site assessment portion of the study described in Section 3, below is a table of ideal sites for floating PV installation with the site solar potential. Solar potential is based on PV Watts estimate of 1538 kwh/year in Orlando, Florida, for each 1 kW of PV capacity. Also, listed is a recommended floating PV size for each meter to offset annual energy use. Since Duke demand cost data was not made available, ENGINEER assumed 25% of the CFX's Duke bills were associated with peak demand costs. An assumption was taken to back calculate the annual energy use at each Duke meter. Capital costs for the recommended PV capacity was estimated by interpolating the estimate in Section 4-6.

Meter Number	Description	Utility	Maximum Potential PV Capacity Behind Meter (kW)	Potential Annual PV Energy Production (kWh)	Meter Annual Energy Usage (kWh)	Max PV Potential % of Annual Usage	Minimum Recommended PV Capacity to Offset Annual Usage (kW)	Estimated Capital Cost of Minimum Recommended Capacity	Estimated Payback period	Estimated Lifetime savings
2370607	Dean Rd Mainline Plaza	DUKE	306	470628	219412	214%	150	$316,000	12.9	$1,887,000
2371197	University Mainline Plaza	DUKE	268	412184	261130	158%	170	$352,000	12.5	$2,160,000
2815110	Independence Mainline Plaza	DUKE	1646	2531548	242238	1045%	160	$334,000	12.7	$2,024,000
2818014	John Young Mainline Plaza	DUKE	1140	1753320	249662	702%	170	$352,000	12.5	$2,160,000
2819493	Curry Ford Main Plaza	DUKE	1154	1774852	241851	734%	160	$334,000	12.7	$2,024,000
2821260	*Boggy Creek Mainline Plaza	DUKE	2362	3632756	264943	1371%	180	$370,000	12.3	$2,296,000
7226207	*3454 J Lawson BLVD SR-417 SB, Boggy Creek	DUKE	4500	6921000	225910	3064%	150	$316,000	12.9	$1,887,000
1JR01474	8201 S Semoran Blvd	OUC	130	199940	206989	97%	130	$280,000	18.7	$1,108,000
1JR01475	Goldenrod Mainline Plaza	OUC	1096	1685648	283236	595%	190	$388,000	17.2	$1,670,000
1ZR10846	Dallas Mainline Plaza	OUC	1770	2722260	391536	695%	260	$514,000	15.4	$2,327,000
1ZR11291	*Pine Hills Main Plaza	OUC	478	735164	406632	181%	270	$532,000	15.2	$2,420,000
1ZR11403	Conway West Main Plaza	OUC	1488	2288544	423427	540%	280	$550,000	14.9	$2,514,000
1ZR12711	Beachline Main Plaza	OUC	1500	2307000	398844	578%	260	$514,000	15.4	$2,327,000
1ZR12868	Conway East Main Plaza	OUC	1488	2288544	348557	657%	230	$460,000	16.2	$2,045,000
1ZR12894	Headquarters	OUC	1298	1996324	3924517	51%	1300	$1,976,000	13.4	$13,245,324
5CM10232	Load CTR C – 8009 Tradeport Dr	OUC	1000	1538000	217194	708%	150	$316,000	18.2	$1,296,000
5CM10255	Beachline Main Plaza	OUC	1606	2470028	200644	1231%	140	$298,000	18.4	$1,202,000
5CM10272	Beachline Airport Main Plaza	OUC	4214	6481132	149686	4330%	100	$226,000	19.4	$827,000
5CM10285	Load CTR A – 8602 State Road 417	OUC	7378	11347364	190203	5966%	130	$280,000	18.7	$1,108,000
5CM10325	Load CTR G – 1220 East West Expy	OUC	152	233776	243624	96%	160	$334,000	17.9	$1,389,000

5CM10371	DMS - 510 N Powers Dr	OUC	404	621352	163577	380%	110	$244,000	19.2	$921,000
5CM10373	Load CTR E (ROW Lights) – 13255 Boggy Creek Rd lights	OUC	2060	3168280	354620	893%	240	$478,000	15.9	$2,139,000
5CM10389	Load CTR B – 11000 Innovation Way East Toll	OUC	1820	2799160	170762	1639%	120	$262,000	18.9	$1,014,000
5ZR18941	Load CTR B – 5439 Lake Underhill Rd.	OUC	130	199940	159953	125%	110	$244,000	19.2	$921,000

* Top recommended choices based on lower payback periods. Options with lower payback periods are available but a preferable option is listed in a different section of the report. Headquarters was not considered because available pond is not available for use as an option.

Conclusions

As can be seen from the analysis presented in this study, the development of floating PV solar systems at various sites is both environmentally and technically feasible.

The following conclusions were drawn from the evaluation of floating solar systems in CFX properties:

- ENGINEER recommends CFX to utilize Florida's Net Metering program to offset high consumption loads in their systems.
- Twenty-four electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
- Top site recommended choices (based on shorter payback periods) are Boggy Creek and Pine Hills Mainline Plazas and meter locater at J Lawson BLVD.
- ENGINEER recommends a ground-mounted, fixed tilt, monocrystalline PV system with string inverters.
- For these systems to be constructed, CFX must review and ensure compliance with listed environmental regulations in Section 2 of this report. Priority should be to comply with Clean Water Act (CWA), Bald and Golden Eagle Protection Act (BGEPA), Flood Disaster Protection Act (FDPA).
- All projects would require an Environmental Resource Permit (ERP), National Pollutant Discharge Elimination System (NPDES), and local permits.
- CFX could reduce payback periods around three to four years by benefiting from tax breaks available if alternative financial options are considered (listed in PV Systems section of this study).

Section 5

Elevated Pond PV Solar (Dry Pond)

Description

An elevated PV solar system is hybrid of the ground mounted and floating PV system. It is installed in the dry bed of a retention pond, but must be elevated above the rain water fill level. Elevated Pond PVs can generate small to large scale energy that could be utilized by CFX.

Site Selection

ENGINEER utilized the high consumption metering data and methodology as described in Section 3 to select the appropriate dry ponds.

CFX has 157 dry ponds to be considered for Elevated Solar Farm Sites but only 14 matched the criteria. **Figure 3.2.1** shows a visual representation of how meters and sites where matched as possible PV system opportunities. The rest of the high consuming electric meters were disqualified because they either had no usable land nearby or we were unable to locate meter.

Site Engineering Assessment

The site engineering assessment includes identification of engineering equipment and any constraints associated with the development of traditional ground-mounted PV option.

Estimated Energy Potential of Each Site

ENGINEER calculated the energy potential of each recommended site. The potential was estimated to be approximately 4 acres/MW based on both National Renewable Energy Laboratory (NREL) average size data and ENGINEER experience with solar systems.

To obtain energy potential of each site, ENGINEER assumed at least 80% of the land was usable and applied the following formula:

$$\textbf{Energy Potential } (kW) = 80\% \text{ x } \textbf{Area of site } (Acres) \times \frac{1\ MW}{4\ Acres} \times \frac{1,000\ KW}{1\ MW}$$

Location Description	Nearest Meter(s)	Dry Pond ID NO.	Bottom Area (Acres)	Energy Potential (kW) (Assuming 250kW per acre)
Conway West/East Main Plazas	1ZR11403, 1ZR12868	408-253A, 5	2.39	478
Dean Rd Mainline Plaza	2370607	408-304; 306A	0.72	144
Hiawassee Mainline Plaza and Data Center	2791026, 2821772	408-504; 506A, C	2.89	578
		408-504; 506A, A	0.26	52
DMS - 510 N Powers Dr	5CM10371	408-505, G	2.93	586
		408-505, F	2.9	580
		408-505, 2E	2.49	498
		408-505, 1E	0.72	144
Coral Hills Mainline Plaza	2822587	414-210, 1A	4.15	830
		414-210, 1B	4.71	942
Forest Lake Mainline Plaza	2803386, 2816670	429-603, F	8.51	1702
Independence Mainline Plaza	2815110	429-654, 3	7.81	1562
Beachline Airport Main Plaza	5CM10272	528-405, C	0.72	144
		528-405, B	0.37	74

Conceptual Design and Specifications

Photovoltaic Module Selection

As stated previously, monocrystalline modules provide highest efficiency, durability, and is more suited for commercial sized systems this type.

Racking System Selection

Generally, the dry pond solar PV will use the same or similar racking system as the traditional ground-mounted PV, with the exception of a taller rack. The fixed tilt system is again the most economical option.

Inverter System Selection

ENGINEER recommends the use of string inverters for commercial size systems. These inverters provide economic advantages and enough flexibility to use in different size applications.

Structural and Civil

The structural design for ground-mount systems (fixed-tilt, trackers) is performed by the selected racking vendor who will utilize geotechnical information in conjunction with site-specific "pull-out" tests to determine foundation requirements and embedment depths. Ground-mounted systems can be anchored into concrete footings, have steel support posts driven directly into the ground, utilize screw anchors, or be ballasted directly on grade by either single cast concrete blocks with embedded supports, multiple concrete blocks incorporated into a racking system, or by aggregate in engineered bins. Systems will be designed in accordance with local building code requirements. The racking system design and construction drawings need to be stamped by a professional engineer licensed in the state of Florida.

Figure 5.5.1 is an example of a typical fixed tilt racking design for reference

Little site work is anticipated at each location. Site work required typically involves clearing, some minor grading, and installation of access drives. Low height grasses and wildflowers can be used for the undergrowth at these sites.

PV System Size, Conceptual Design, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and describe design elements and specifications appropriate for each system.

PV System Size Options

Based on one-year consumption data of each electric meters selected for this study and CFX's location, ENGINEER was able to obtain appropriate PV system size for each meter. ENGINEER used National Renewable Energy Lab's (NREL) SAM Detailed PM model to estimate how much energy would be generated from each PV system and ensure they fed no more than 100% of its total yearly consumption. Detailed system models for 100 kW and 200 kW system were developed for production and cost details. These building blocks were then applied as appropriate to each of the numerous sites. Detailed models for each site would be developed at the detailed design phase.

Conceptual Design Elements

The type of PV panels and mounting structures are the major design elements for solar PV systems. ENGINEER selected panels and inverters for the conceptional design based on ENGINEER preference and experience. Panels manufactured by SunPower were selected based on cell efficiency, low degradation rate, longevity, and 25-year warranty.

PV panels would be mounted on racks, facing due south, at a tilt angle of approximately 28 degrees to maximize annual energy production. The mounting racks would be aligned in rows along an east to west axis across the desired area.

Depending on the height of the panels off the ground, it is estimated that 10-feet of spacing is required to prevent shading from one row of modules to the next. The spacing is based on NABCEP guidelines and is required to avoid the longest shadow casted by the panels during the winter's solstice. Adequate distance between rows also provides vehicle access for maintenance and future module replacement.

String inverters are recommended for these systems. The inverter should be sized taking into consideration cost, energy yield and keeping in mind the amount of cable and connections needed that could increase complexity, and cost of the installation. For this study, ENGINEER assumed a 60 kW SMA inverter would be used in all systems. SMA inverters were specified based on well received industry acceptance, lower install costs, and trending use by developers. The size was based on ENGINEER recent project design experience, but correct size and number of inverters should be studied in more detail as part of detailed design in each location.

Of course, CFX will need to work closely with OUC and Duke Energy to meet all interconnection requirements for connecting with the power grid.

PV Equipment Specifications

PV systems specifications will be determined later based on panel selection, design of wiring configurations, and the inverter voltage input requirements. Below is a list of equipment components and specifications based on this preliminary assessment information:

- Solar PV Modules – assuming a 60 kW inverter selected:
  - 100 kW system – 322 modules
  - 200 kW system – 644 modules
- Inverters –
  - 100 kW system – two 60 kW inverters
  - 200 kW system – four 60 kW inverters

- Fixed tilt mount racking system angled at 28 degrees

- Balance of system components including hardware, wiring, connectors, boxes, disconnects, metering, and NEC-required components.

Please refer to Appendix C for Main Equipment Specifications.

PV Generation Output Analysis

NREL's SAM Commercial PV model was used to build a performance model around two capacity cases (100 kW and 200 kW) using a dry pond PV system. The software determines the solar radiation of the desired location incident on a tilted plane. SAM also uses weather data to account for heat transfer on the back of the PV panels, since cell temperature has an impact on power output. Using the inputs detailed in Conceptual Design and Specifications, a performance model was constructed around a specific panel, inverter, azimuth angle, and panel tilt angle.

To differentiate performance difference of the ground-mount PV verses dry pond PV, ENGINEER assumed the dry ponds are detention ponds. The soil's albedo characteristic was adjusted for a bare soil environment in the model. Additionally, during an extreme rain event and/or flooding, the dry ponds will fill with water and the any clay in the soil will swell. This may shift racking and the PV modules away from optimal tilt, causing a loss in annual power output. ENGINEER modeled this as a nameplate loss in SAM, assuming the PV module tilt will shift +/- 10 degrees over the life of the system.

Below are the first-year results for fixed tilt installation on CFX dry ponds. These results were used in the economic analysis in Section 5. The table below illustrates that the performance difference between the ground-mount PV verse dry pond PV is very minor and should be considered insignificant when comparing the two options.

System Size (kW)	First Year Estimated AC Energy Production	Electric Rate Basis
100	147,098 kWh	OUC
100	147,098 kWh	Duke
200	319,396 kWh	OUC
200	319,396 kWh	Duke

Installed Cost Estimates

PV system prices have fluctuated recently due to new tariffs applied to solar panels. Additionally, price fluctuations of other commodities cost such as copper, steel, and concrete required for construction could affect system pricing. Despite the uncertainty of material cost, PV system prices have decreased steadily every year, and prices are not expected to increase any time soon.

ENGINEER utilized NREL's benchmark data to estimate the total cost of ground-mount PV solar systems. The installation costs include PV modules, inverters, labor, racking, balance of system, grid interconnect, and soft costs. Soft costs are permitting fees, developer overhead and profit, EPC overhead and profit, and contingency. An index for these cost at different capacities utilized for ENGINEER's economic analysis are shown below.

Cost	100 kW ($/W)	200 kW ($/W)	500 kW ($/W)	1000 kW ($/W)
Module	0.47	0.47	0.47	0.47
Inverter	0.08	0.08	0.08	0.08
Racking	0.22	0.22	0.22	0.22
Balance Of System	0.15	0.14	0.13	0.12
Labor	0.14	0.11	0.09	0.08
Cost of Interconnection	0.13	0.10	0.09	0.08
Soft Cost (Developer, Permitting, Contingency)	0.69	0.67	0.63	0.63
Total	**1.88**	**1.79**	**1.71**	**1.69**

The above costs are based on the Florida benchmark data for commercial systems. Because NREL assumes a rooftop installation in their commercial system benchmark data, ENGINEER labor and material costs may be slightly higher than actual labor and material at each CFX site. The benchmark costs also do not include sales tax.

To differentiate the capital costs of the dry pond option, ENGINEER assumed there would be additional civil costs associated with preparing the dry pond for PV racking installation. ENGINEER assumed $10,000 per acre for earthworks and access road preparation. The table below summarizes the total installation cost for each capacity analyzed with sales tax.

System Size (kW)	Installed Cost
100	$193,581
200	$368,533

In addition to the installation cost, operation and maintenance costs were utilized in ENGINEER's economic analysis described in Section 5-7. A dry pond PV system has O&M costs associated with periodically cleaning and inspecting panels, adjusting drifted tilts, and maintenance issue with the clay liner. O&M costs were estimated from a developer's quote on a previous ENGINEER project with a similar system size. Annual O&M costs used in the SAM models are shown below:

- 100 kW PV System: $15 per kWdc per year
- 200 kW PV System: $15 per kWdc per year

Economic Analysis

The final part of the sustainability assessment of the proposed dry pond PV solar systems was to determine economic value. Since CFX is a tax-exempt government entity, CFX is not able to take advantage of federal tax incentives. ENGINEER assumed CFX would take full benefit from the

ITC through a 3rd party developer. Through a "Build Own Transfer" model, the developer would sell the system to CFX after several years of operation. The developer would pass any tax benefit received to CFX. This approach was used to build the SAM models and conduct the economic analysis.

It is important to note that SAM performs economic analysis from a developer's point of view, so the results should be utilized accordingly. Main assumptions utilized to complete the analysis in all simulations are shown below:

- Life of PV System: 30 Years
- Annual PV System Degradation: 0.4% per year (based on the PV module performance data)
- Federal Investment Tax Credit: 30% of system capital cost in Year 1 of operation (only available in 2019)
- Energy Bill Escalation Rate: 4% (this is based on a five-year history of Consumer Price Index for electricity in Florida)
- Inflation Rate: 2.5% per year
- Debt Percent for Project Financing: 0%
- Load Growth: 0%
- MACRS Depreciation: 5 Years
- Federal Income Tax Rate for Developer: 21%
- State Income Tax Rate for Developer: 7%
- Sales Tax: 6% (Tax Exemption is available in Florida for PV. However, assumed cost is still incurred by developer.)

To recognize the value of electricity savings for the dry pond PV System, customer electricity rates were placed in SAM. Below is a summary of the electric rates. Based on Florida law, it was assumed CFX would take advantage of net metering if any excess generation took place in a month. This energy credit would be applied to a future energy charges from the utility.

	OUC	**Duke**
Fixed Charges ($/month)	38	12.78
Energy Charges ($/kwh)	0.069	0.08843
Demand Charges ($/kw)	9	10.70

SAM also considers the hourly load profile of an energy user. CFX's monthly bill data is used to estimate the hourly load profile of a meter. SAM will conduct an hourly simulation to determine hourly energy consumption. Bill data from the Conway plaza and Dean Road Mainline Plaza were used as a basis for the SAM models. ENGINEER made this assumption since demand cost relative to energy costs at each CFX meter is relatively constant. This approach simplifies the economic analysis, yet is valid since each meter will be paired with a PV system that offsets, but does not exceed annual energy consumption.

Based on the listed assumptions, a cash flow analysis was conducted for each capacity case and at each utility rate. Below is a summary of the analysis over 30 years.

System Size (kW)	Payback	Lifetime AC Energy Production (kWh)	Lifetime Savings	Avoided CO_2 Emissions (lbs./year)	Electricity Rate
100	10.8 years	4166301	$918,071	141099	OUC
200	10.0 years	9046330	$1,890,642	306369	OUC
100	8.4 years	4166301	$1,199,302	141099	Duke
200	7.8 years	9046330	$2,449,671	306369	Duke

Since CFX expressed interest in building and owning the solar PV systems, a case was analyzed in which CFX incurred all of the project's capital expenses. This would simplify the project and CFX would be exempt from sales tax, however, CFX cannot claim the ITC. ENGINEER modeled this case as a "Design Bid Build" model. Below is a summary of the results without sales tax and without claiming the ITC. Without the ITC, one to two years will be added to the payback period.

System Size (kW)	Payback	Electricity Rate
100	14.2 years	OUC
200	13.3 years	OUC
100	11.3 years	Duke
200	10.7 years	Duke

Based on the site assessment portion of the study described in Section 2.2 below is a table of ideal sites for dry pond PV installation with the site solar potential. Solar potential is based on PV Watts estimate of 1538 kwh/year in Orlando, Florida, for each 1 kW of PV capacity. Also, listed is a recommended dry pond PV size for each meter to offset annual energy use. Since Duke demand cost data was not made available, ENGINEER assumed 25% of the CFX's Duke bills were associated with peak demand costs. An assumption was taken to back calculate the annual energy use at each Duke meter. Capital costs for the recommended PV capacity was estimated by interpolating the estimate in Section 2-0.

Meter Number	Description	Utility	Maximum Potential PV Capacity Behind Meter (kW)	Potential Annual PV Energy Production (kWh)	Meter Annual Energy Usage (kWh)	Max PV Potential % of Annual Usage	Minimum Recommended PV Capacity to Offset Annual Usage (kW)	Estimated Capital Cost of Minimum Recommended Capacity	Estimated Payback period	Estimated Lifetime savings
2370607	Dean Rd Mainline Plaza	DUKE	144	221472	219412	101%	150	$282,000	11.0	$1,825,000
2791026	*Hiawassee Mainline Plaza	DUKE	1130	1737940	379253	458%	250	$457,000	10.4	$3,075,000
2803386	Forest Lake Mainline Plaza	DUKE	1702	2617676	236114	1109%	160	$299,000	11.0	$1,950,000
2815110	Independence Mainline Plaza	DUKE	1562	2402356	242238	992%	160	$299,000	11.0	$1,950,000
2816670	Forest Lake Mainline Plaza	DUKE	1702	2617676	236114	1109%	160	$299,000	11.0	$1,950,000
2821772	Hiawassee Mainline Plaza (Data Center)	DUKE	630	968940	485395	200%	320	$579,000	10.0	$3,951,000
2822587	Coral Hills Mainline Plaza	DUKE	1772	2725336	291049	936%	190	$352,000	10.8	$2,325,000
1ZR11403	*Conway West Main Plaza	OUC	478	735164	423427	174%	280	$509,000	12.6	$2,669,000
1ZR12868	Conway East Main Plaza	OUC	400	615200	348557	176%	230	$422,000	13.1	$2,183,000
5CM10325	*SR-408 EB ramp - 1220 East West Expy	OUC	120	184560	243624	76%	120	$229,000	14.1	$1,113,000
5CM10371	DMS - 510 N Powers Dr	OUC	1808	2780704	163577	1700%	110	$212,000	14.2	$1,016,000

* Top recommended choices based on lower payback periods. Options with lower payback periods are available but a preferable option is listed in a different section of the report.

Conclusions

As can be seen from the analysis presented in this study, the development of dry pond PV solar systems at various sites is both environmentally and technically feasible.

The following conclusions were drawn from the evaluation of floating solar systems in CFX properties:

- ENGINEER recommends CFX to utilize Florida's Net Metering program to offset high consumption loads in their systems.
- Twelve electric meters with high consumption were identified as suitable net-metering opportunities for CFX.
- Top site recommended choices (based on shorter payback periods) are Hiawassee and Conway West Mainline Plazas and meter for Load Center G.
- ENGINEER recommends a ground-mounted, fixed tilt, monocrystalline PV system with string inverters.
- For these systems to be constructed, CFX must review and ensure compliance with listed environmental regulations listed in Section 2 of this report. Priority should be to comply with Clean Water Act (CWA) and Bald and Golden Eagle Protection Act (BGEPA).
- All projects would require an Environmental Resource Permit (ERP), National Pollutant Discharge Elimination System (NPDES), and local permits.
- CFX could reduce payback periods around three to four years by benefiting from tax breaks available if alternative financial options are considered (listed in PV Systems section of this study).

Section 6

Rooftop PV

Description

A Rooftop PV solar system is one that is mounted on the roof of residential homes or commercial buildings. As referenced in this report, it can be used to generate small to large scale energy that could be utilized by CFX to offset or meet its energy consumption.

Site Selection

ENGINEER reviewed all CFX buildings and the following buildings were considered for this study: CFX Headquarters, Conway East and West Mainline Plazas, all other Mainline Plazas; and corresponding administration buildings of each Plaza. The rest of the buildings were disqualified since they are either a rented building or too small for a commercial size solar PV system.

ENGINEER recommends only installing PV systems on new roofs to avoid having to replace the roof (which has a 20-year life) during the PV array's lifetime of 25 to 30 years. Therefore, only roofs that will be replaced soon should be considered as part of this study. In addition, CFX Headquarters was studied based on its larger energy potential. Because the roof of this building is around 10 years old, CFX should consider doing this project only if solar PV system is installed within 3 years of the roof replacement.

Site Engineering Assessment

The site engineering assessment includes identification of engineering equipment and any constraints associated with the development of traditional PV option.

Estimated Energy Potential of Each Site

ENGINEER calculated the energy potential of each recommended site. The potential was estimated based on the number of solar panels that can fit each location. Optimal layout of solar panels was achieved through Unirac software utilizing Google images of plazas. Below is a summary of system sizes based on optimal layout of panels and racking.

Meter Number	Description	Utility	State Road	Roof Projected Replacement year	Maximum Potential PV Capacity Behind Meter (kW)
2816670, 2803386	Forest Lake Mainline Plaza	Duke	429	2020	40
2821772, 2791026	Hiawassee Mainline Plaza	Duke	408	2021	55
1JR01475	Goldenrod Mainline Plaza	OUC	528	2021	40
2371197	University Mainline Plaza	Duke	417	2021	55
2370607	Dean Rd Mainline Plaza	Duke	408	2024	55

Meter Number	Description	Utility	State Road	Roof Age (years)	Maximum Potential PV Capacity Behind Meter (kW)
1ZR12894	CFX Headquarters	OUC	**408**	10-11	130

All plazas where assumed to have the same potential, which is estimated from PVWatts. Administration buildings were included if no highway crossing walkway was present. Results may vary depending on conditions and shading limitations of all locations.

Conceptual Design and Specifications

Photovoltaic Module Selection

Due to space limitations in this option, ENGINEER selected monocrystalline modules for all rooftop solar locations to increase energy density (highest efficiency translates into more MW per square feet).

Racking System Selection

Generally, rooftop solar PV will use a racking system similar to ground-mounted PV systems. Main difference consists in simpler and faster mounting equipment and reduced material costs. No foundations are typically required for this option.

The fixed tilt system is again the most economical option. Because roof size is a limiting factor, the economic benefit doesn't come from maximizing the angle of the solar modules (28 degrees tilt angle requires too much spacing between rows). Extensive studies have been conducted to understand the best tilt angle configuration to balance system capacity and cost. Industry's typical tilt angle on rooftop systems is 10 or 12 degrees. Additionally, lower angles increase the array's resistance to high winds.

Inverter System Selection

For final design, ENGINEER recommends the use of string inverters for rooftop commercial size systems. As part of the conceptual design, ENGINEER modeled the rooftop PV system with string 30kW inverters.

Structural and Civil

The structural design for rooftop-mounted systems is performed by the selected racking vendor in conjunction with an analysis of the existing building and roof system. Roof systems typically consist of wood, metal, or concrete decks and can be covered with tar, asphalt, gravel, or membrane type liners. The support system can be anchored to the roof decks or use ballasted type foundations to support the system and resist wind or other loads on the panels. Systems that are anchored through a covered deck would require additional work to seal the roof at each anchor location. A ballasted type, or self-supporting foundation (i.e. concrete block footings), are common for supporting the racking system on roofs with asphalt or membranes to avoid penetrations. Typical ballasted rooftop arrays are designed to add approximately 5 pounds per square foot (psf) of load to the existing roof system.

The only locations that have information needed to determine if the existing structure is sufficient for the additional loads imposed by the PV system, are for the SR 528 Dallas Mainline and Ramp Toll Plaza, the CFX Back-Up Data Center and CFX Headquarters Building. The SAM model was used for the CFX HQ building, however roof replacement is due in over 10 years so the location is not currently recommended for rooftop PV in the near term. The SR 528 Mainline roof was installed in 2011 and not scheduled for replacement until 2031. Due to the age and planned replacement date, we do not recommend installing a rooftop PV system at SR 528 Mainline. The Data Center drawings provided indicate that it was likely installed in late 2016 or 2017. This roof system is new and should be in good enough condition for installing the PV system. The size of the building, however, will not provide enough space for a sufficient amount of panels to be installed, as noted in other sections. Both roof systems have a membrane type liner installed, where a ballasted foundation would be recommended. Both roof systems also appear to be sufficient to support an additional 5 psf load. Any existing mechanical systems on the roof, however, will not allow for the addition of the PV system loads adjacent to the equipment. The racking system could be laid out around existing mechanical systems.

Based on information provided on the office, service center, and toll plaza roof ages (or year the roof replacement is expected be completed), the following summary details which locations are viable for consideration of installing the PV systems. Only locations where the roof was replaced in the last 2-3 years or roofs that will be replaced in the next 4-5 years should be considered as viable options. Any location not listed below, is not recommended due to the age of the roof or due to not planning on replacing the roof in the next few years. In addition to these locations, any on/off ramp location has been excluded due to the limited area available for the PV system.

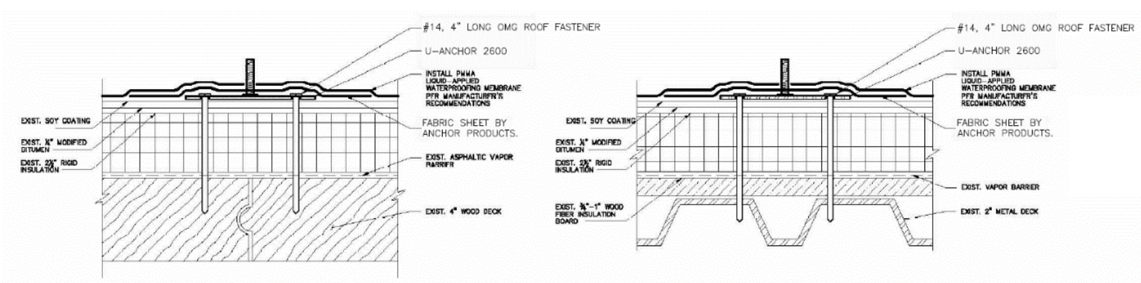
Based on the locations noted in this report as potential candidates for the PV system, any location planned for a PV system should not be installed until the roof is replaced. Drawings/details for these locations would need to be provided for an analysis the existing structure and to determine the roof type for the PV support system recommendations. Any location where a rooftop system is installed, unless installed in conjunction with a new roof, would also require an inspection of the roof system.

The information provided included a list of reference locations with the year installed listed. These dates show that they were installed between 1973 and 2010 but does not indicate the year the roof is to be replaced. If any of these locations that are expected to have new roofs installed in the next four to five years, could be considered for installation of the PV systems.

The racking system design and construction drawings will be stamped by a Professional Engineer licensed in the State of Florida.

The picture below is an example of a ballasted PV system that could be installed on a roof without penetrating through a liner. This type of system consists of rails that hold the solar array or rails and concrete type blocks, set directly on top of the roof liner.

The picture below is an example of how the PV system can be anchored to a roof deck with a liner.



PV System Size, Conceptual Design, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and described design elements and specifications appropriate for each system.

PV System Size Options

Based on one-year consumption data of each electric meters selected for this study and CFX's location, ENGINEER was able to obtain appropriate PV system size for each meter. ENGINEER used National Renewable Energy Lab's (NREL) SAM Detailed PM model to estimate how much energy would be generated from each PV system. Detailed system models were developed for production and cost details. Detailed models for each site would be developed at the detailed design phase.

Conceptual Design Elements

Panels manufactured by SunPower were selected based on cell efficiency, low degradation rate, longevity, and 25-year warranty.

PV panels would be mounted on racks, facing due south, at a tilt angle of approximately 10 degrees to maximize annual energy production within the limited space of each location. The mounting racks would be aligned in rows along an east to west axis across the desired area.

Depending on the height of the panels off the ground, it is estimated that 2-feet of spacing is required to prevent shading from one row of modules to the next. The spacing is based on NABCEP guidelines and is required to avoid the longest shadow casted by the panels during the winter's solstice. Adequate distance between rows also provides access for maintenance and future module replacement.

Like other options, ENGINEER assumed SMA STP inverters would be used for rooftop systems. ENGINEER selected the inverter capacity to maintain a DC to AC ratio of 1.3. Correct size and number of inverters should be studied in more detail as part of detailed design in each location.

Of course, CFX will need to work closely with OUC and Duke Energy to meet all interconnection requirements for connecting with the power grid.

Estimated Potential and PV Generation Output Analysis

Similar to previous Sections 3, 4, and 5, NREL's SAM Commercial PV model was used to build a performance model around various capacity cases using a Rooftop PV system. To account for the performance impact of panel heat transfer, the roof was assumed to be two stories or higher. Albedo was modeled to reflect a tar and gravel roof.

Below are the first-year results for fixed tilt installation on CFX roof top systems. These results were used in the economic analysis.

Building	Modelled System Size (kW)	1st Year Estimated AC Energy Production	Electric Rate Basis
CFX Headquarters	110	174,639 kWh	OUC
Mainline Plazas (including Admin Bldgs.)	64	100,269 kWh	OUC
Mainline Plazas (including Admin Bldgs.)	64	100,269 kWh	Duke
Mainline Plazas (Exc. Admin Bldgs.)	40	63,440 kWh	OUC
Mainline Plazas (Exc. Admin Bldgs.)	40	63,440 kWh	Duke

Installed Cost Estimates

ENGINEER also utilized NREL's benchmark data to estimate the total cost of roof-mounted PV solar systems. An index for these cost at different capacities utilized for ENGINEER's economic analysis are shown below.

Cost	40 ($/kW)	65 ($/kW)	100 ($/kW)
Module	0.47	0.47	0.47
Inverter	0.08	0.08	0.08
Racking	0.22	0.22	0.22
BOS	0.15	0.15	0.15
Labor	0.15	0.15	0.14
Grid Int.	0.13	0.13	0.13
Soft Cost (Developer, Permitting, Contingency)	0.69	0.69	0.69
Total	**1.89**	**1.89**	**1.88**

The above costs are based on the Florida benchmark data for commercial systems. Because NREL assumes a rooftop installation in their commercial system benchmark data, ENGINEER labor and material costs may be slightly higher than actual labor and material at each CFX site. The benchmark costs also do not include sales tax.

In addition to the installation cost, operation and maintenance costs were utilized in ENGINEER's economic analysis. Annual O&M costs used in the SAM models are $15 per kWdc per year.

Economic Analysis

The final part of the sustainability assessment of the proposed Rooftop PV solar systems was to determine economic value. Similar approach to other sections was used; a "Build Own Transfer" model was used and then additional cases assuming CFX builds and own the systems was completed. Assumptions and electric rates were also the same used in previous sections with the following exceptions:

- Life of PV was assumed to be 20 years since life of roof is only 20 years.
- A 10% salvage value was assumed at year 20 since system still has remaining life.

Based on the listed assumptions, a cash flow analysis was conducted for each capacity case and at each utility rate. Below is a summary of the analysis over 20 years:

System Size (kW)	Payback	Lifetime AC Energy Production (kWh)	Lifetime Savings	Avoided CO_2 Emissions (lbs/year)	Electricity Rate
40	9.8 years	1221721	$196,079.00	61086	OUC
64	10.2 years	1930976	$297,594.00	96549	OUC
40	7.6 years	1221721	$254,922.00	61086	Duke
64	7.9 years	1930976	$386,956.00	96549	Duke
110	10.5 years	3363184	$496,163.00	168159	OUC

Below are the case results in which CFX incurred all the project's capital expenses. As mentioned before, this model assumes no sales tax and ITC can't be claimed with this financial method. Without the ITC, two to three years will be added to the payback period.

System Size (kW)	Payback Without ITC	Electricity Rate
40	13.0 years	OUC
64	13.5 years	OUC
40	10.4 years	Duke
64	10.8 years	Duke
110	13.5 years	OUC

Table below shows final site assessment also including corresponding meter information and percentage of load offset by each proposed system. The table also shows building assessment of locations that have planned roof replacements within the next three years. These options should be considered at the time of replacement.

Meter Number	Description	Utility	State Road	Roof Projected Replacement year	Maximum Potential PV Capacity Behind Meter (kW)	Potential Annual PV Energy Production (kWh)	Meter Annual Energy Usage (kWh)	Max PV Potential % of Annual Usage	Estimated Capital Cost	Estimated Payback period	Estimated Lifetime savings
2816670, 2803386	*Forest Lake Mainline Plaza	Duke	429	2020	55.6	85473.0	236114	36%	$121,000	10.8	$365,000
2821772, 2791026	*Hiawassee Mainline Plaza	Duke	408	2021	55.8	85799.6	485395	18%	$121,000	10.8	$365,000
1JR01475	Goldenrod Mainline Plaza	OUC	528	2021	55.6	85473.0	283236	30%	$121,000	13.5	$281,000
2371197	University Mainline Plaza	Duke	417	2021	55.8	85799.6	261130	33%	$121,000	10.8	$365,000
2370607	Dean Rd Mainline Plaza	Duke	408	2024	55.8	85799.6	219412	39%	$121,000	10.8	$365,000
1ZR12894	CFX Headquarters	OUC	408	10-11	110.0	169180.0	3924517	4%	$221,000	13.5	$497,000

These are the locations with closest expected replacement time

* Other more cost-efficient alternatives are available for Forest Lake and Hiawassee meters.

Summary and Recommendations

As can be seen from the analysis presented in this study, the development of rooftop PV solar systems at various sites is both environmentally and technically feasible.

The following conclusions were drawn from the evaluation of floating solar systems in CFX properties:

- ENGINEER recommends CFX to utilize Florida's Net Metering program to offset high consumption loads in their systems.
- ENGINEER recommends coordinating roof replacements with solar system installations. Based on data provided by CFX, two locations were identified as suitable net-metering opportunities for CFX within the next few years.
- Top site recommended choices (based on shorter payback periods) are Forest Lake, Hiawassee, Goldenrod and University Mainline Plazas. Other more cost-efficient alternatives are available for these two meters. These are the locations with closer expected replacement time and rooftop should be considered as backup options for these meters.
- Eight locations were identified as possible net-metering opportunities for CFX, but roof condition would need to be evaluated. These options are not recommended if CFX is planning to replace the roofs during the solar array's lifetime.
- CFX Headquarters provides the largest available roof space and is able to accommodate a system of approximately 110 kW. This system can only offset around 4% of the load. Installation not recommended until existing roof is replaced.
- For these systems to be constructed, CFX must review and ensure compliance with listed environmental regulations.

Section 7

Sound Barrier PV

Description

A Sound Barrier PV solar system is one which is installed on sound/noise walls along roadways to generate small to large scale energy that could be utilized by CFX to offset or meet its energy consumption. Sound barriers are typically installed along one or both sides of roadways and highways. This type of PV system is not currently installed in the United States, but has been used in Europe for several years.

Site Selection

Two locations have been identified for consideration for the PV systems to be installed. SR 408, Hiawassee Mainline and Dean Mainline Toll Plazas both have existing sound barriers near the corresponding meter locations. ENGINEER has not reviewed any other specific locations with existing sound barriers at this time, as these initial selections were identified by CFX as possible pilot sites. Locations to be considered would generally be any existing sound walls installed within 1/2 mile of existing Mainline Plazas or other meter locations; existing walls that are located along the north side of roadways, oriented in the east/west directions; or locations where walls are located off the road/shoulders to allow for panels to be installed. The PV system could potentially be installed up to one mile in length (1/2 mile either side of the meter).

Hiawassee Mainline Plaza (northwest sound barrier)

Typical sound walls consist of precast panels or cast in-place concrete walls. PV panels could be attached to the top of the walls, to the south face, or on the ground directly in front of the walls. Any existing wall used would have to be analyzed to confirm there is adequate capacity for installation of the PV system. The table below summarizes the existing wall sections for the Hiawassee and Dean Road Plaza considered for a PV system. Lengths and azimuth of wall face were estimated form Google Maps.

Hiawassee West Wall		
	Length (feet)	**Face Azimuth (Degree)**
West Section	365.7	175.6
Middle Section	103.8	262
East Section	1070.5	168.9

Hiawassee East Wall		
	Length (feet)	**Face Azimuth (Degree)**
West Section	32	167.2
Middle Left	32.95	260
Middle Right	564	170.8
East Section	220	159.5
Dean Road West Wall		
	Length (feet)	**Face Azimuth (Degree)**
West Section	1547	178.6

Dean Road East Wall		
	Length (feet)	**Face Azimuth (Degree)**
East Section	1151	179.7
West Section	644	184.8

Any location within 1/2 mile of existing Plazas, that does not have an existing sound barrier could also be considered. New sound barriers could be designed to support the PV system or the PV system itself could be used as the sound barrier. The picture below shows various configurations to be considered.

Installation of top-mounted panels should also take into consideration on what is located behind the walls. Existing sound barriers also typically act as screen walls for neighborhoods and businesses.

Any location where the PV system is considered should also have a glare analysis performed as the panels would be located along highways, and a sound study performed to confirm the panels will not compromise the wall's ability to reduce noise levels. A PV system installed along the top of the walls would likely redirect noise over the wall. This option has not been considered for further evaluations.

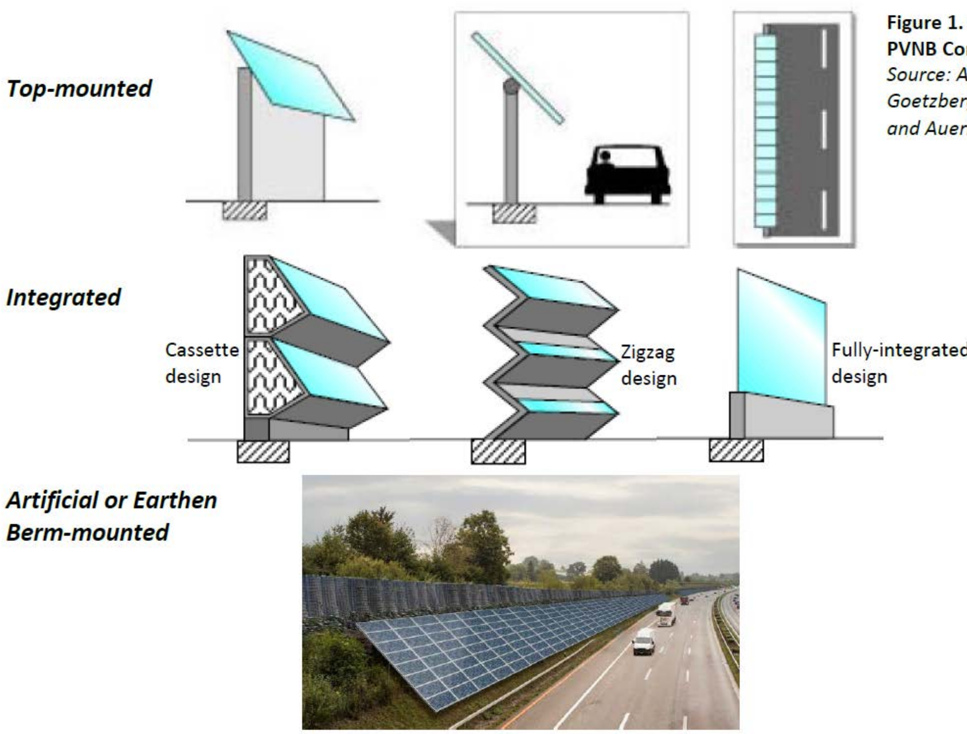
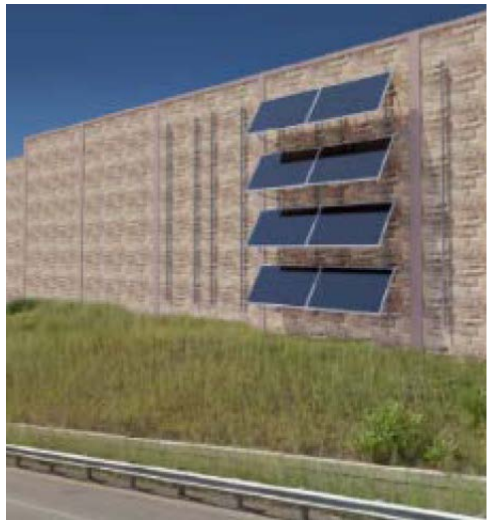


Figure 1. Different Possible PVNB Configurations.
Source: Adapted from Goetzberger et al. (1999) and Auerbach presentation



Site Engineering Assessment

The site engineering assessment includes identification of engineering equipment and any constraints associated with the development of the sound wall PV option.

Estimated Potential Size of Each Site

ENGINEER determined the maximum system size based on the existing sound barriers within 1/2 mile distance from plazas considered. The table below summarizes the meters considered for the sound barrier PV system.

Meter Number	Description	Utility	State Road
2821772, 2791026	Hiawassee Mainline Plaza	Duke	408
2370607	Dean Rd Mainline Plaza	Duke	408

The table below summarizes the maximum solar panel concentration installed on the sound barrier. ENGINEER considered the limitations of mounting PV arrays vertically, mounting them on top of the wall, and mounting them without interfering with architectural details. ENGINEER assumed a solar module footprint of 5’ x 3.4’, with longest panel dimension oriented vertically.

Hiawasee West Wall

	Length (feet)	Face Azimuth (Degree)	Precast Panels	Panel Width (ft)	Precast Next to Arch. Columns	Possible Number of Solar Modules
West Section	366	176	19	19	10	170
Middle Section	104	262	5	21	4	42
East Section	1071	169	54	20	22	496
					Wall Total	708

Hiawasee East Wall

	Length (feet)	Face Azimuth (Degree)	Precast Panels	Panel Width (ft)	Precast Next to Arch. Columns	Possible Number of Solar Modules
West Section	32	167	2	16	2	16
Middle Left	33	260				0
Middle Right	564	171	30	19	9	282
East Section	220	160	11	20	7	96
					Wall Total	378

Dean Road West Wall

	Length (feet)	Face Azimuth (Degree)	Precast Panels	Panel Width (ft)	Precast Next to Arch. Columns	Possible Number of Solar Modules
West Section	1547	179	75	21	18	714
					Wall Total	714

Dean Road East Wall

	Length (feet)	Face Azimuth (Degree)	Precast Panels	Panel Width (ft)	Precast Next to Arch. Columns	Possible Number of Solar Modules
East Section	1151	180	62	19	20	580
West Section	644	185	29	22	12	266
					Wall Total	846

Conceptual Design and Specifications

Photovoltaic Module Selection

Review of module technologies was conducted in Section 2-5. Because of space limitations in this option, ENGINEER selected monocrystalline modules for all sound barrier solar locations to increase energy density (highest efficiency translates into more MW per square feet). To prevent the panels from degrading the effectiveness of the sound barrier, ENGINEER's conceptual design does not have panels mounted on the top of the wall. Based on existing installs, wall mounted PV modules are becoming more common. ENGINEER's design takes this approach while avoiding interference with the architectural columns and details on the wall. Each precast panel can accommodate two rows of five panels, top and bottom of the decorative strip.

Figure 7.4.1 shows an example layout of a sound barrier system, based on panels being installed on the SR 408 wall near the Hiawassee Mainline Plaza

Racking System Selection

Generally, sound barrier solar PV will use a racking system that attaches to the top or face of the wall; or the mounting could be similar to ground-mounted solar PV systems if installed on the ground directly in front of the wall. No foundations are required for mounting to the wall but would be required if mounted on the ground. The racking system will be anchored with expansion bolts or epoxy.

Inverter Selection

ENGINEER recommends the use of string inverters for final design. However, the conceptual design uses string inverters to demonstrate system size and estimated cost for install.

Structural and Civil

The structural design for sound barrier wall-mounted systems is performed by the selected racking vendor in conjunction with an analysis of the existing walls or integrated into the design new wall systems. Existing walls typically consist of concrete type wall panels. Precast concrete walls typically utilize various sizes of panels, stacked vertically between support columns. The PV system could be attached to the top of the walls or to the vertical face of the walls if the increase in loads allow. The PV racking/support system would be anchored into the existing concrete wall/panel, between the wall columns, with either expansion anchors or adhesive/epoxy anchors. Locations where sufficient space is available for ground mounted PV system would be physically and structurally similar to that system type. The racking system design and construction drawings will be stamped by a Professional Engineer licensed in the State of Florida.

PV System Size, Conceptual Design, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and describe design elements and specifications appropriate for each system.

PV System Size Options

Based on one-year consumption data of each electric meters selected for this study and the sound barriers identified by CFX, ENGINEER was able to obtain appropriate PV system size for each meter. ENGINEER used National Renewable Energy Lab's (NREL) SAM Detailed Commercial model to estimate how much energy would be generated from each PV system. Detailed system models were developed for production and cost details.

Conceptual Design Elements

Panels manufactured by SunPower were selected based on cell efficiency, low degradation rate, longevity, and 25-year warranty.

PV panels would be mounted on racks installed on wall, facing due south, with a 90-degree tilt angle. ENGINEER assumed the panels would be mounted parallel with face of wall to complement the architectural look of the sound barrier. Although, a 75- to 80-degree tilt is possible with the bottom of the panel offset further from the wall. ENGINEER did not find existing installs which incorporate a small tilt on a wall mounted application. However, an engineering racking system should be considered in detailed design to incorporate tilt and add additional system annual output.

To prevent soiling on the bottom row of panels from rain, the system should be mounted at least 2-feet off the ground, with a preference for 3-4 feet to minimize losses. Distance from architectural columns is also considered to prevent shadow casted on the panels at sunrise and sunset. Adequate spacing was set on precast panels next to architectural columns by removing a module in each row.

ENGINEER chose a 30-kW SMA inverter as an economic basis for use in the sound barrier system. Correct size and number of inverters should be studied in more detail as part of detailed design in each location.

As with other options, CFX will need to work closely with Duke Energy to meet all interconnection requirements for connecting to the power grid.

Estimated Potential and PV Generation Output Analysis

Similar to the other options, NREL's SAM Commercial PV model was used to build a performance model around various the available wall space using a Sound Barrier PV system. However, since the footprint for Sound Barrier PV is much larger than the other options, additional wire losses had to be considered. ENGINEER double the wiring losses for DC and AC wiring when modelling Sound Barrier PV.

Below are the first-year results. These results were used in the economic analysis.

Location	System Size (kW)	First-Year Estimated AC Energy Production	Electric Rate Basis
Hiawassee	320	287,420 kWh	Duke
Dean Road	156	134,295 kWh	Duke

Installed Cost Estimates

ENGINEER also utilized NREL's benchmark data to estimate the total cost of sound barrier mounted PV solar systems. An index for these costs at different capacities utilized for ENGINEER's economic analysis are shown below.

Cost	150 kW ($/W)	320 kW ($/W)
Module	0.47	0.47
Inverter	0.08	0.08
Racking	0.22	0.22
BOS	0.19	0.18
Labor	0.13	0.10
Grid Int.	0.12	0.10
Soft Cost (Developer, Permitting, Contingency)	0.68	0.66
Total	**1.88**	**1.80**

The above costs are based on the Florida benchmark data for commercial rooftop systems. However, costs are expected to be similar in a sound wall installation, with the exception of electrical BOS. Electric BOP costs were assumed to be 30% higher to account for additional wiring and material in the larger footprint. The benchmark costs also do not include sales tax. The table below summarizes the installed cost estimate for the recommended sizes.

Plaza	System Size (kW)	Installed Cost
Hiawassee	320	$590,824
Dean Road	156	$301,559

In addition to the installation cost, operation and maintenance costs were utilized in ENGINEER's economic analysis. Annual O&M costs used in the SAM models were $15 per kWdc for the 320kW and 156 kW systems.

Economic Analysis

The final part of the sustainability assessment of the proposed sound barrier PV solar systems was to determine economic value. Similar approach to other sections was used; a "Build Own Transfer" model was used and then additional cases assuming CFX builds and own the systems was completed. Assumptions and electric rates were also the same used in previous sections.

Based on the assumptions, a cash flow analysis was conducted for each capacity case and at each utility rate. Below is a summary of the analysis over 30 years.

System Size (kW)	Payback	Lifetime AC Energy Production (kWh)	Lifetime Savings	Avoided CO_2 Emissions (lbs/year)	Electricity Rate
320	13.6 years	8140680	$2,207,067.00	275698	Duke
156	14.8 years	3803668	$1,020,805.00	128818	Duke

Below are the case results in which CFX incurred all the project's capital expenses. As mentioned before, this model assumes no sales tax and ITC can't be claimed with this financial method. Without the ITC, three to four years will be added to the payback period.

System Size (kW)	Payback Without ITC	Electricity Rate
320	17.6 years	Duke
156	19.0 years	Duke

Summary and Recommendations

As can be seen from the analysis presented in this study, the development of sound barrier PV solar systems at various sites is both environmentally and technically feasible.

The following conclusions were drawn from the evaluation of sound wall mounted solar systems in CFX properties:

- ENGINEER recommends CFX to utilize Florida's Net Metering program to offset high consumption loads in their systems.
- Two possible locations have been identified as suitable for a pilot project – Hiawassee Datacenter and Dean Road Mainline Plaza (other more cost-efficient alternatives are available for these two meters).
- Sound wall PV uses existing PV technology and has a system payback slightly higher than ground-mounted or rooftop solar systems.
- Engineered racking system can provide a 75- to 80-degree tilt, improving system performance and reducing system payback further.
- Large systems are able fit on existing sound barriers, offsetting Hiawassee and Dean Road Plaza's annual electricity use.
- More detail study is required to understand the full impact to noise reduction or glare for any specific project. However, for the conceptual design used by ENGINEER, no performance degradation is anticipated from the sound barrier.
- PV system can be integrated into the wall without interfering with the architectural details of the sound barrier.
- MassDOT is currently engaged in a pilot project to install sound wall mounted solar systems. SCI recommends CFX coordinating with MassDOT to inquire about the progress of their project and employ any lessons learned.

Section 8

Street Light Solar PV

Description

A Street Light PV solar system is one in which PV modules and battery components are installed on existing lighting structures to generate small scale energy that could be utilized by CFX to offset lighting load.

Site Selection

SCI reviewed all CFX lighting systems; and only lighting posts and masts were considered for this study. High lightning masts, lighting on highway signs, underdeck lighting under bridges were disqualified because of possible shading concerns on PV equipment.

Conceptual Design and Specifications

Solar Street Lights

As the efficiency of photovoltaic panels increased and low power consuming LED lights were developed, solar lighting systems emerged as an alternative to grid powered systems.

A solar lighting system typically includes an LED lamp, solar panels and a charge controller. The lamp power is supplied from the batteries previously charged by a photovoltaic panel.

Solar street lights provide the convenience of lighting streets without connecting to the electric grid. These systems are more common in developing countries when access to the grid is limited. Additionally, communities and cities are increasing the number of installations to avoid the cost and damage caused by trenching power cables to supply lighting systems.

Photovoltaic Module Selection

Panel assembly of a lighting system typically has a range of options to accommodate five days of autonomy or more. When selecting a panel type and specifications, high efficiency and durability is preferred to follow autonomy requirements but needs to be balanced with system costs.

Battery Assembly

Provides needed power to run the light fixture all night. It can be sized to provide power at night and through inclement weather. The battery is typically installed under the solar panel to provide shading to the battery. The battery could also be in an enclosure placed in a remote location.

Light Fixture

LED lights operated from the solar charged batteries. Typically, a range of light intensity is available and is the configuration is picked depending on location requirements (measured in Lumens).

Control Options

A controller is typically used to utilize restrict lighting hours to certain hours. Typically, the controller is set to turn on from dusk to dawn. Other settings might include dimming or turning the lights on and off at certain hours. The lighting system control could also be tied to motion activated infrared detector or remote actuated switch.

Structural and Civil

Solar lighting systems are typically mounted on round poles and a large list of materials could be used depending on preference. Some options include steel, aluminum, fiberglass, and concrete. The base of the pole could be anchored or direct-buried.

PV System Size, Conceptual Design, and Specifications

This task consisted of identifying PV system sizes appropriate for each selected meter location and describe design elements and specifications appropriate for each system.

Conceptual Design Elements

After searching various manufacturers, SCI was able to get a quote from solar light installer Solar Electric Power Company (SEPCO). SEPCO has various solar light options and the following were selected:

Solar Power Assembly: SEPA550 – Panel assembly with two panels mounted together with total capacity of 550 Wdc. This is the maximum capacity offered by SEPCO and was selected to maximize power delivered to lighting system and the battery.

Battery Assembly: HM – This battery assembly has a total of 672 Amp hours. This is the largest battery assembly provided by SEPCO. By selecting this option, the system can work continuously even when sun power is not available for a minimum of 5 days.

Light Fixture: Light fixture with distribution pattern type IV (typically used in highways). The DC powered LED fixture is operated by the battery and rated for 120 Wdc. This wattage is lower than CFX current AC LED fixtures that are being installed in CFX highway system ranging from 207-244 Wac.

Fixture Bracket: SP12 – Predrilled side of pole bracket of 12-inches with no exposed wiring.

Control: MMPT2 – This tracker turns panels in order to increase power output of modules up to 30%. Load timer can be programmed to set up times when lights are on and dimming the lights. The controller stores up to two years of data logging.

Structural and Civil – SCI assumed that existing poles could be reused, and all listed above equipment can be mounted on them. A detailed study should be conducted later each individual pole where an installation is considered.

Based on the available light fixture and the corresponding panel and batteries available to power them, SCI recommends conducting a detailed photometric study and measuring the lumens to ground performance and area coverage to further analyze lighting system performance before this option is seriously pursued. The performance should be compared to current LED fixture performance and should follow FDOT guidelines.

Reducing illumination levels would affect current photometric design, which takes into consideration distance between poles and intensity of the light fixtures. Additionally, reducing lighting could decrease visibility and might lead to safety concerns.

Installed Cost Estimates

SEPCO provided a quote to SCI for the system listed above and came up with the quote below. Cost includes equipment and installation.

- SEPCO-SEPA550-HM-VPR120-MPPT21-SP12: $8,455.00 per pole

During the lifecycle of the system, certain components must be replaced. Table below shows replacement cycle and cost of equipment during replacement.

System Component	Warranty (years)	Lifecycle (years)	Equipment Replacement Cost (excluding labor)
Panels	25	30+	N/A
MPPT Controller	5	15	$549
Battery	5	5-7	$1,431
Light Fixtures	5	15	$782
Mount and Hardware	25	30	N/A

Economic Analysis

The final part of the sustainability assessment of the Solar Lights was to determine economic value. The high level economic value calculated for this section was completed to obtain a level of magnitude estimate for this option. Main assumptions are listed below:

- Est. yearly consumption of LED fixture: 12 hrs/day x 365 days/year x 244W = 1,069 KWh/year
- Est. yearly consumption of HSP fixture: 12 hrs/day x 365 days/year x 400W = 1,752 KWh/year

- Savings per year (LED) - 0.904 $/KWh x 1,069 KWh = $966/year – savings
- Savings per year (LED) - 0.904 $/KWh x 1,752 KWh = $1,583/year – savings
- Life of system: 30 Years
- Initial installation cost of $1600 (double of typical system) and $600 of equipment replacement costs during years where system components need replacement (battery, fixture and controller replacement)
- Maintenance cost excluded

Based on these assumptions, a cash flow analysis shows that replacing LED light systems with solar light systems would result in a payback period of 19 years during its 30-year lifecycle.

Summary and Recommendations

As can be seen from the analysis presented in this study, the development of a PV lighting system in CFX highways is most likely not technically feasible.

The following conclusions were drawn from the evaluation of the streetlight PV systems on CFX roadways:

- Maximum size available of light fixtures for PV lights is 120W. CFX standard LED lights are rated for 207-240 W.
- It was determined that the light fixture intensity is around half of CFX current LED standards. A photometric study would need to be completed to determine if system is viable. Study should include analyzing if FDOT photometric standards are met.
- Because CFX currently uses LED fixtures with high capacity, current panel, battery and fixture technologies available are not suitable for CFX highway applications.
- If CFX were to install these systems, estimated material cost is $8,455 per pole (excluding installation costs). A payback period of 19 years is estimated for this system.
- SCI recommends using PV street lights only in applications where LED lights with 120W of power or less is required. Some example applications include local streets, pathways, parking lots and bill boards. Based on SCI research, street light system assembly costs typically range from $5,000-$9,000.
- Technical challenges and long payback makes this option impractical.
- Because of long payback periods, solar PV lights are only recommended in new installations where cost of interconnection to utility might be prohibitive. Also, options such as dimming and remote control would help reduce panel and battery size and achieve lower costs.

Section 9

Roadway Solar

Description

The viability of Solar Roadway technology was evaluated using data submitted from Wattway's Roadway solar system as a possible application to work in concert with CFX's DMS systems.

History of Solar Roadways

The first company to install solar roads was in Krommenie, Netherlands. The project was a bike path pilot funded by SolaRoad, a consortium of government agencies and engineering firms to test the panels.

Later, a road-building conglomerate called Colas and INES (the French National Solar Institute) developed Wattway. The first major Wattway project was in France and cost around $5.2 million USD to install. This cost is equivalent to around $15.48 $/W, which is about 10 times as much as a comparative rooftop installation. After a few years of testing in different sites, results have shown that roadways are underperforming compared to their theoretical capacity and that power generated is less than half of what was originally expected. The output has been estimated to be around 33% of a typical solar installation. Most installations have been focused on parking lots and walkways.

Figure 9.2.1. Wattway Installation in Westpoint, Georgia, Used for Self-Consumption and Charging Station

The first US-based installation of this type came from a company called Solar Roadways. The concept included roadways with the ability to light LEDs for signals and signs on the road and melt snow with energy collected from the sun. The small 48W test trial, which costed around $32,363, was found to be less than 1% efficient.

Apart from the efficiency challenges faced by early tests, a main concern is still safety. DOE has not been able to evaluate if these systems can provide sufficient traction suited for rubber tires and how this traction compares to asphalt.

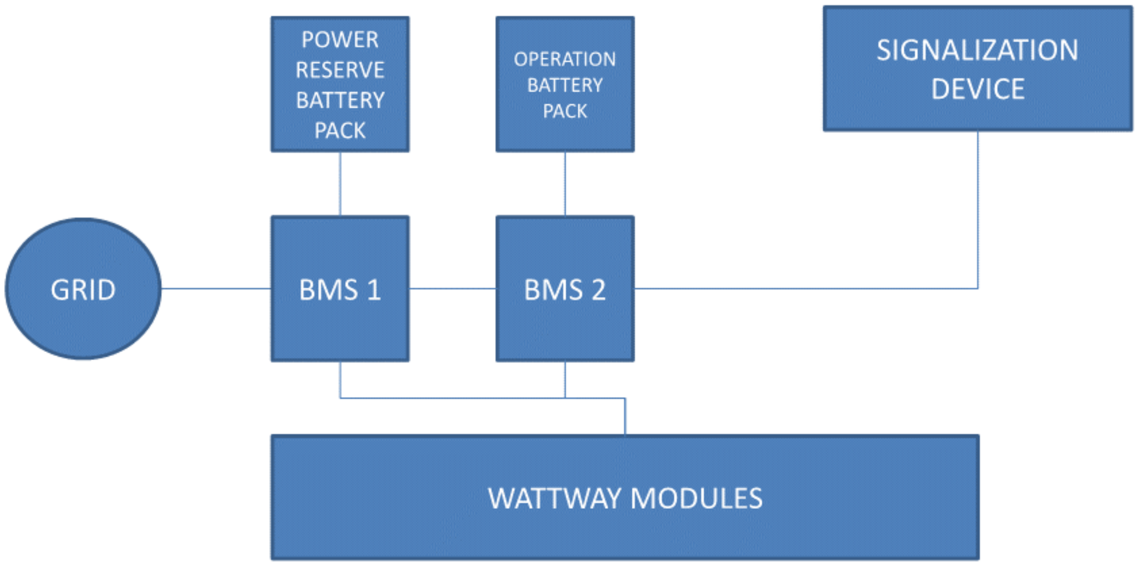
Conceptual Design and Specifications

CFX has contacted engineers from Colas, in charge of Wattway system to provide a solar solution that can be used to supply Dynamic Message Sign (DMS) systems.

DMS System

DMS systems are electronic traffic signs used on roadways to give travelers information about special events. These signs typically warn drivers about traffic events such as congestion, accidents, alerts, roadwork and speed limits. Because DMS systems are critical during emergencies, CFX is interested in creating multiple levels of backup systems to them. After conversations with Colas, the following setup was proposed:

Figure 2 DMS and Proposed Back-Up Systems



Back-Up System

Battery Management Systems (BMS) – Electronic Device that prevents power reserve from being used unless the grid is down. Also manages charge/discharge cycles for the power reserve battery in emergency mode.

Operation Battery Pack – Used on normal mode and sized 24h of power consumption.

Power Reserve Battery Pack – Used when the grid is down and should be sized around 48 hours of power consumption (more if longer grid shutdowns are expected).

In this proposed gird-tied system, Wattway PV modules supplies power to the operation battery pack. The grid supplies the pack if not enough power is available through Wattway modules.

During an emergency, if grid connection is interrupted the Operation battery pack will keep providing power to the sign while the power reserve battery pack is used after the operation battery pack is depleted. Wattway would supply power to all batteries the entire time.

CFX owns DMS systems have a load requirement of approximately 1,800 W each. CFX would like to size a solar solution that could provide uninterrupted power for 24 hours (charge the Operation Battery). Solar panels should be able to charge the Operation Battery Pack in around three days.

Wattway System Specifications

As mentioned before, CFX plans to install a PV system that charge the Operation battery pack in around three days. Considering the load of a DMS a 24-hour energy consumption would yield the amount of energy below:

$$\text{Total AC power required per day} = \frac{1{,}800\text{W}\times 24\text{Hr}}{3\ days} = 14.4\ kWh\ per\ day$$

Because Wattway panels lay flat on the ground, average solar irradiance received by the ground is less compared to a solar panel mounted in a tilted angle to maximize production. The Global Horizontal Irradiance (GHI) is the total amount of solar radiation that is received per unit area by surface that is always positioned in a horizontal manner. Orlando, Florida, has a GHI of 4.88 kWh per square meters per day (10% less than irradiance received with a maximized tilt angle).

As shown in Figure 3 below, Wattway panels have an area of 0.96 squared meters and corresponding efficiency of 12%. If we assume battery losses of 5%, the number of panels needed (N) can be calculated the following way:

$$N = \frac{P_{AC}}{\eta_{Batt} \times \eta_{panel} \times GHI \times A_{panel}} = \frac{14.4}{0.95 \times 0.12 \times 4.88 \times 0.96} \approx 26\ panels$$

Because each panel is rated for 115W, 26 panels would be a 3 kW system.

Figure 3 Wattway Technical Features and Panel Diagram

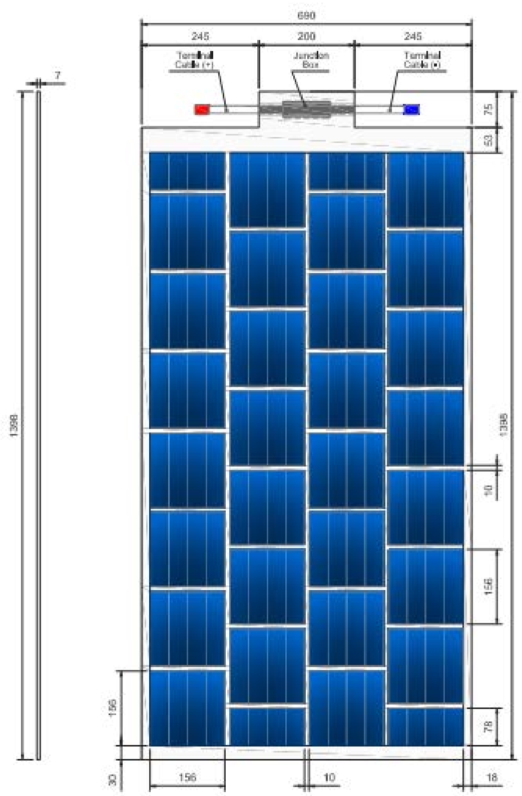
Technical features

TECHNICAL CHARACTERISTICS	WATTWAY
Dimensions of a module	1398mm x 690mm *other dimensions possible after study
Production surface/module	0.96 m²
Number of active cells	28
Nominal Power (Pnom)	115 Wc
Average Yield (module)	12%
Maximum power point Voltage (Vmpp)	14 V
Maximum power point Current (Impp)	8.14 A
Open circuit voltage (Voc)	17.5 V
Short circuit current (Isc)	8.5 A
Maximum voltage of system	60 V
Power Temp. coefficient (Pmpp)	–0.43 % / °C
Tolerance (module)	± 5%
Connector	IP68
Inverted Current max A	15
Number of bypass diodes	2

1 Under standard test conditions (1000 W/m² sunlight, AM 1.5, 25°C)
2 Based on average yield of nominal power production

MECHANICAL SETTINGS	WATTWAY
Impact resistance	IK 07
Cells	Polycristalline / mono-like
Weight	9 kg
Road performance	1 million wheel passages (13T per axle)
Grip test	SRT – PFT, CFL, Wehner & Schulze

Wattway module diagram



Cost Estimates

Cost data is not available at the time. ENGINEER was able to obtain an order of magnitude estimate based on the installation cost of the first system.

$$\$/W = \frac{\$5.2\ Million}{336\ kW} = 15.48$$

Applying the same $/W in the 3 kW system:

$$Installed\ Cost = 15.48 \times 3{,}000W = \$46{,}440$$

Please note that this is just an estimated value and Wattway's sizing and estimate could vary. It is also important to note that these figures only include the PV arrays and does not account for the underground infrastructure (conduits and cabling under pavement) or batteries required.

Summary and Recommendations

As can be seen from the analysis presented in this study, utilizing Wattway Solar Pavement as backup power for DMS systems is technically and economically feasible.

The following conclusions were drawn from the evaluation of a possible Wattway System:

- After a few years of testing, data shows that Wattway has been the most commercially successful solar pavement PV option so far.
- With an approximate cost of $15.48 per Watt, Wattway systems are around 10 times more expensive than a typical solar PV commercial system.
- Test results have shown that Wattway's output has been only 33% of expected values.
- Road testing is yet to be completed in the US although a few installations in local roads have been successful so far in other countries (installation in the Ray is not in open road).
- Assuming Wattway matching the 12% theoretical efficiency value, a 3kW system consisting of 26 panels would be able to serve a DMS system as the main source of power to charge its operation battery pack.
- The 3 kW system would cost approximately $46,440.
- Given the price and the performance of Wattway, installing the system seems impractical given the amount of available land and large number ponds suitable for more conventional PV systems owned by CFX.
- A pilot project could be created if testing the system is desired in USA but data on road performance would have to be verified first and tested against USA standards before installing in public roadways.

Section 10

Building Efficiency Study

Description

A building efficiency study is conducted to evaluate existing building's equipment and systems. An energy and water audits are typically performed to evaluate the resource intensity and develop improvement plans where needed. As referenced in this report, existing facilities were reviewed from a high level, compared against industry benchmarks, and used as a means to determine if a detailed energy audit is needed.

Energy/Water Audit and Upgrades Benchmarking

77% of US organizations in 2018 began to examine their energy efficiency and 57% made plans to increase energy efficiency. The US DOT 2016 Sustainability plan identified building energy conservation as one of its goals. A reduction of energy intensity by 30% is a common metric. Additionally, several organizations have joined the Better Buildings Challenge created by the US Department of Energy. The program aims to set water saving goals and created plans to have recorder water usage improvements and are encouraged to a goal of 20% improvement over 10 years.

Energy and Water Consumption Assessment

Energy Assessment

Building energy consumption is typically evaluated by utilizing ENERGY STAR system. This method assigns a 1-100 ENERGY STAR score to assess how the property is performing compared to similar buildings nationwide with similar primary use. A score of 50 represents median performance and a score of 75 or better indicates that the building is a top performer and eligible for an ENERGY STAR certification.

The Energy Information administration (EIA) conducts a survey every four years to gather building characteristics and energy use of commercial buildings. This survey, called Commercial Building Energy Consumption Survey (CBECS), enables EPA to normalize the data in order to obtain a real-life comparison of buildings across the nation.

CBECS tables normalize energy intensity (KWH energy consumption/total area) of buildings and energy star score can be obtained based on the intensity of the desired building compared to national averages.

ENERGY INTENSITY BENCHMARKING

***Buildings – All US Regions**

*** Buildings – South Atlantic Region**

Building	Consumption (kWh)	Total Area (sqft)	CFX ratio	US DOE EIA CBECS avg	US DOE EIA CBECS 75th pctl	US DOE EIA CBECS 50th pctl	US DOE EIA CBECS 25th pctl
Headquarters	4018000	85946	46.75	14.1	16.6	10.7	6
Headquarters	4018000	85946	46.75	16.3	21.4	10.7	5

Benchmark data from Electricity Consumption and expenditure intensities 2012 tables.

Table above shows how CFX energy intensity (ratio of kwh of energy consumed per year to building's total square footage) compared to buildings ranging 50-100K square feet (blue) and all buildings surveyed in the South Atlantic region (green). As shown, CFX has a ratio of 46.75. The percentiles are shown in the table from left to right as the national average, 75th percentile, 50th percentile, and 25 percentile rankings. The current CFX energy intensity ratio falls over the 75th percentile, which corresponds to an Energy Star Score of under 25.

Water Consumption Assessment

Even though there is not an energy star rating equivalent for water consumption, EIA does gather building water consumption data that can also be used for benchmarking purposes. Benchmark data includes buildings with over 200K square feet (CFX is below that range). Even though CFX doesn't fit the range of the data, it can still be utilized for reference. The Table below shows how CFX compares to national average numbers of buildings ranging from 200-500K square feet of total area.

WATER CONSUMPTION BENCHMARKING

Building	Consumption (gallons)	Total Area (sqft)	CFX ratio	US Average Large Building Consumption per square feet	Distribution Intensities 75th pctl	Distribution Intensities 50th pctl	Distribution Intensities 25th pctl
Headquarters	2182400	85946	25.39	20.3	21.6	12.8	7.9

Benchmark data from Water Consumption in large commercial buildings 2012 Table.

As shown in the table, CFX is falls over the 75th percentile for water intensity also. Regional data was not included because EIA information includes buildings with over 500,000-square-feet of area and accuracy could be compromised.

Overview of Energy and Water Improvement Projects

Scope of Work for Energy Audit

Typical scope of work for an Energy Audit:

- Trace load of building to determine expected building energy usage.
- Review existing drawings.
- Interviews with site operating personnel.
- Review of facility utility bills and other operating data.
- Walk-through of the facility.
- Analyze the DDC system (full access provided by owner).
- Compile data for the energy use analysis and a report detailing potential capital improvements.
- Summarize all data in report.

Cost Estimates

According to Pacific Northwest National Laboratory, costs for energy audits should not be more than $0.50 per square foot (1997 USD). Utilizing value $0.50/ft2 and adjusting for 57.3% inflation from 1997 to 2019 CFX would pay no more than approximately:

$$85{,}946\ ft^2 \times \frac{\$0.50}{ft^2} \times 1.573 = \$67{,}597$$

Economic Analysis

The final part of the sustainability assessment of CFX Headquarter Building was to determine economic value. The report will show economic values based on benchmark data for illustration purposes. Final assessment and specific values for CFX would need to be calculated later as part of the Investigation Phase of the re-commissioning process.

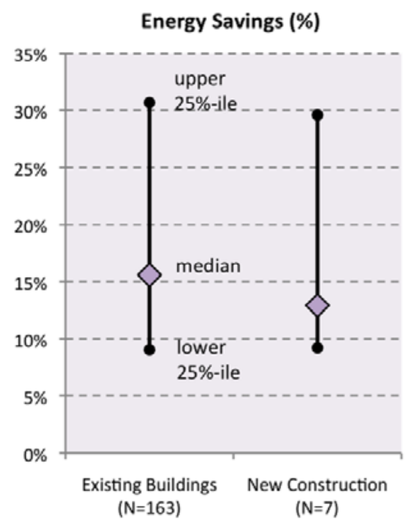
Savings

Savings are subject to which type of energy efficiency measurements (EEMs) are taken. Audit results typically shows all measures ranked from no-cost/low cost to significant cost and longer payback.

A typical low cost measure is to retro-commission the building. This process does a forensic and risk management review to identify suboptimal situations the following way:

- **Applying Operational and control measures** such as calibrating sensors and thermostats and adjusting DDC controls to match actual conditions.
- **Retrofits** such as installing more energy efficient lighting.
- **Maintenance work** such as fixing belts and valves that are not functioning properly.

2009 Berkeley National lab benchmark data shows a large range of energy savings after implementation of retro-commissioning improvements.

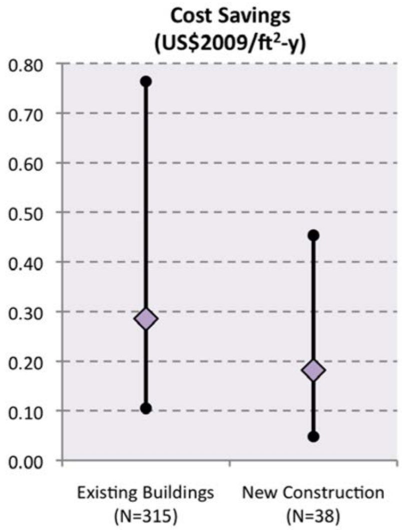


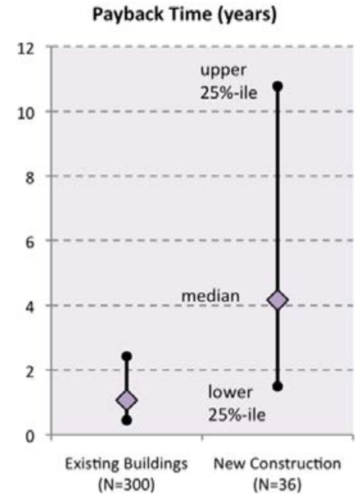
Benchmarks for Energy Savings (2009)

CFX spent around $318,000 in electricity the past year for headquarters. If CFX falls under the median of 16% of savings, it would save around $50,900 per year in energy bills only.

Total Cost Savings

Benchmark 2009 cost savings and payback are shown below. As seen, median cost savings per year provides a corresponding payback of approximately one year. Please note that these savings do not include water bill savings and CFX could benefit even more from these.





Based on energy savings only, we can deduct that payback period after low cost improvements are completed would be less than the one-year average payback.

Other larger capital investments proposed from the audit with longer paybacks can be implemented as needed to achieve CFX energy and water consumption reduction goals.

Summary and Recommendations

As can be seen from the analysis presented in this study, an energy audit/re-commissioning of CFX Headquarters is technically and economically feasible.

The following conclusions were drawn from the evaluation of a possible energy audit/re-commissioning in CFX Headquarters:

- CFX Headquarter building is below national averages in terms of energy and water consumption.
- An energy and water consumption audit of the building is recommended to improve building efficiency and systems performance.
- Energy and water consumption audit should cost no more than $67,597 depending on complexity and how detailed is the survey and analysis.
- Low cost measures such as retro-commissioning process would result in approximately $50,900 in electricity cost savings per year. It is estimated that the payback after the energy re-commissioning is less than one year.
- Larger Energy and water saving capital investments recommended after the audit would help CFX create a plan to achieve goals following typical standard metrics (30% energy and 20% water usage reduction).

Section 11

EV Charging Stations

Description

Electric Vehicle (EV) charging is a very common addition to sustainability planning around the country. As referenced in this report, EV charging stations were evaluated for viability within the CFX infrastructure and facilities.

Technical Assessment

Charging Levels

EVSE (Electric Vehicle Supply Equipment) consists of all the equipment needed to deliver electrical energy from an electricity source to a Plug-In Electric Vehicle (PEV) battery. The EVSE communicates with the PEV to ensure that the plug is securely connected to the vehicle receptacle before supplying a safe flow of electricity. There are three primary types of EVSE. Two types, AC Level 1 and AC Level 2, provided alternating current (AC) to the vehicle, which the vehicle's onboard charging equipment converts to the direct current (DC) needed to charge the batteries. The third type, DC Fast Charging, provides DC electricity directly to the vehicle's battery.

The differences and similarities of all three charging levels are illustrated below.

Charging Level	Vehicle Range and Added per Charging Time and Power	Supply Power
AC Level 1	4 mi/hour @ 1.4kW 6 mi/hour @ 1.92kW	120VAC/20A *(12-16A continuous)*
AC Level 2	10 mi/hour @ 3.4kW 20 mi/hour @ 6.6kW 60 mi/hour @ 19.2kW	208/240VAC/20-100A *(16-80A continuous)*
DC Fast Charging	24 mi/20 minutes @ 24kW 50 mi/20 minutes @ 50kW 90 mi/20 minutes @ 90kW	208/480VAC 3-phase *(input current proportional to output power; ~ 20-400A AC)*

All PEVs have a cord set that plugs into a Level 1 outlet (110-120V) and connects to the vehicle's charging port with a connector as shown in the photo. Providing Level 1 charging is the most inexpensive charging option. It can range from offering an outlet for a PEV driver to plug in a Level 1 cord set to offering an EVSE with a connector. Level 2 units are the midrange cost option most commonly in commercial applications, and DCFC is the highest cost tier. The EVSE charging power depends on the voltage from the electrical service and the EVSE unit amperage rating. Level 1 EVSE are rated from 12-16A continuous, Level 2 EVSE are commonly rated from 16-48A continuous, and DCFC typically have a maximum of 60-200A.

Charging Ports

Single port EVSE units provide access for only one vehicle to charge at a time. Multiple port EVSE units (commonly 2, 3, or 4 ports) are available to allow multiple vehicles to charge simultaneously or sequentially. DCFC connectors (the part of the EVSE that is inserted into the vehicle inlet) can meet either an SAE standard or CHAdeMO (most common connector with Chevrolet, Honda, Mazda EV models) standard. A dual port DCFC may offer multiple EVSE connector standards at one unit, but only allow one vehicle to charge at a time. Careful consideration should be given to these options so that the EVSE is compatible with the PEVs that will be using it as well as potential future estimated usage. Multiple port units are more expensive than single port units but both the unit costs and the installation cost are less expensive on a per-port basis. The following photo illustrates a dual port EV charging station.

Energy Requirements

EVSE units are available in different amperage ratings which correlate to charging power. The vehicle charging time depends on the state of charge of the battery, the power coming from the EVSE, the cable length and maximum current rating, and the rate a vehicle can accept power, which may be lower than the supply power. The EVSE unit's dedicated circuit must be rated for a larger current than the EVSE continuous load rating (at least 125% larger) to conform to the National Electric Code (NEC). Please refer to Appendix J for more information on these variables.

Mounting

Units are typically available as either wall-mounted (shown in Figure 11.2.1) or pedestal mounted (shown in Figure 11.2.2). Ceiling-mounted units are also available but more common for residential use. A pedestal-mounted unit costs more than a wall mounted unit due to the material and manufacturing costs of the pedestal. There is also additional construction costs for installing a pedestal mounted unit (e.g., pouring a concrete pad at the base). Typically, site owners choose a wall mounted unit if the parking spots to be used for charging are close to a wall; however, pedestal mounted units provide more design flexibility. They can also hold multiple EVSE units.

Figure 11.2.1

Additional Features

The most basic EVSE unit will be UL (Underwriters Laboratories) approved to safely supply electricity to the vehicle and provide lights to show when it has started and stopped charging. Some additional features are listed below:

- ***Communication*** capabilities enable different levels of data communication with the user, site host, utility grid, and the Internet. For instance, a user may be able to use a mobile application to remotely find an EVSE and check if it is available for use of out of service. Also, site hosts may be able to remotely update pricing, push messages out to users, and control other charging parameters.
- ***Access control*** restricts the use of EVSE to specific users. Systems range from a simple keypad of padlock to more complex such as granting access through radio-frequency identification (RFID) cards or mobile phone applications.
- ***Point of sale*** (POS) functionality allows units to recover costs/fees associated with charging events. They could include a credit card reader, RFID reader, or mobile phone application.
- ***Energy monitoring*** tracks the EVSE unit's energy consumption and provides reports on greenhouse gas emissions reductions. This can help site hosts show how the EVSE is contributing to their sustainability goals.
- ***Energy management*** and demand response optimizes load management to maximize charging during low rate periods and minimize charging during high-rate periods. For instance, an EVSE can be programmed to only charge a vehicle during predetermined times.
- ***Advanced display screen*** provides user communication, advertising, and brand promotion.
- ***Retractable cords*** protect the cords and connector from damage, as well as reduces the risk of tripping on the cords.
- ***Automated diagnostics*** are used to troubleshoot issues or malfunctions that occur with the EVSE.

Networked or Non-Networked

EVSE units can be networked or non-networked. Networked units are connected to the Internet via a cable or wireless technology and send data to a network host's computer server. They provided the ability to remotely access availability of EVSE in real-time. Non-networked units are not connected to the Internet. They provide basic charging functionality without advanced communications or monitoring capabilities, so the equipment is priced lower than networked EVSE. Secondary systems can be purchased to incorporate additional features such as access control, payment systems, and data collection into a non-networked unit. These secondary systems can be useful if a grant or incentive requires data collection, but the site host wants to purchase a non-networked EVSE.

Networked EVSE are typically part of a charging network, which is a group of EVSE units with access control and payment systems that are managed by a single organization. A sampling of the major networks includes Webasto Charging Systems Inc. (Formerly known as AeroVironment), Blink, ChargePoint, GE WattStation Connect, Greenlots SKY, NRG eVgo, SemaConnect, and Tesla. Each charging network has its own PEV driver payment model, the most common being monthly subscriptions, pay-as-you-go (pay per charge), and free (free to charge; no subscription fee required). Benefits of a site host paying for a charging network can include charging station visibility and availability for drivers, energy monitoring, station usage analysis, automated payments, automated diagnostics, access control, and customer support. A site host may set pricing policies using a networked EVSE (e.g., employees consume electricity for free and visitors pay a fee).

Site Selection

CFX has 13 total parking lots between 12 toll plazas and 1 Headquarters. To maximize utilization, ENGINEER recommends the Headquarters be the only location considered for the EVSE units.

Conceptual Design

ENGINEER compiled a list of three of the top EVSE manufacturers. They were compared side-by-side based on many factors. The system proposed in this report is a dual port, ground-mounted pedestal unit that comes with 6’ retractable connector cables. A dedicated two-pole 240V, 40A breaker will need to be installed, as well as any electrical upgrades needed to accommodate the new loading demands. Coordination with the local utility may be required. CFX is also advised to size the electrical upgrade to accommodate for future addition of up to four more charging stations. In addition, a trench or bore is to be dug for an underground conduit layout sized to accommodate future additions. Data sheets and detailed specifications can be found in Appendix H.

Figure 11.2.2

Assuming maximum utilization for five days throughout the work week, the monthly consumption costs for one dual charging station would be around $92. Because of these relatively low costs, it is not recommended to charge employees a usage fee. It is also not recommended to offset usage costs with the installation of solar panels above the unit. This is because the PV installation costs will far outweigh the realized costs savings from the generated PV output.

Cost Analysis

Cost estimates listed in this report are based on benchmark costs. True costs will vary greatly depending on several factors discussed below.

Connecting the EVSE to the Electrical Service

The EVSE unit is connected to the electrical service by wiring enclosed in an electrical conduit. Per the location, trenching will be required for the underground conduit layout. Before digging, a contractor will need to have any existing buried utilities marked by contacting a state’s utility marking service. Costs per foot to trench through soil could range from $10-$20, and $100-$150 per foot to trench through asphalt or concrete.

Electrical Upgrades

The site must have sufficient electrical capacity at the appropriate voltage flowing from the utility to the site's electrical panel to meet the EVSE power needs. If the supply from the utility doesn't meet this demand then costly transformer upgrades may be necessary. If the site's electrical panel has insufficient capacity, an electrician will need to create additional capacity by replacing or upgrading the panel, re-working the panel to provide more breaker positions, or adding a sub-panel for the EVSE units. If there is sufficient capacity on the panel, then additional breakers can be simply added to the panel to create the necessary dedicated circuits. To minimize costs, it is encouraged to choose an EVSE design that doesn't require more power than the available electrical capacity.

Installation

These costs will vary based on the contractor's hourly rate and the time it takes to perform the work. The costs are affected by the contractor's experience and the geographic location. Although there is no way to accurately estimate these costs without a formal site evaluation, ballpark installation cost estimates per unit have been provided by the U.S. Department of Energy. Please refer to the cost analysis chart below.

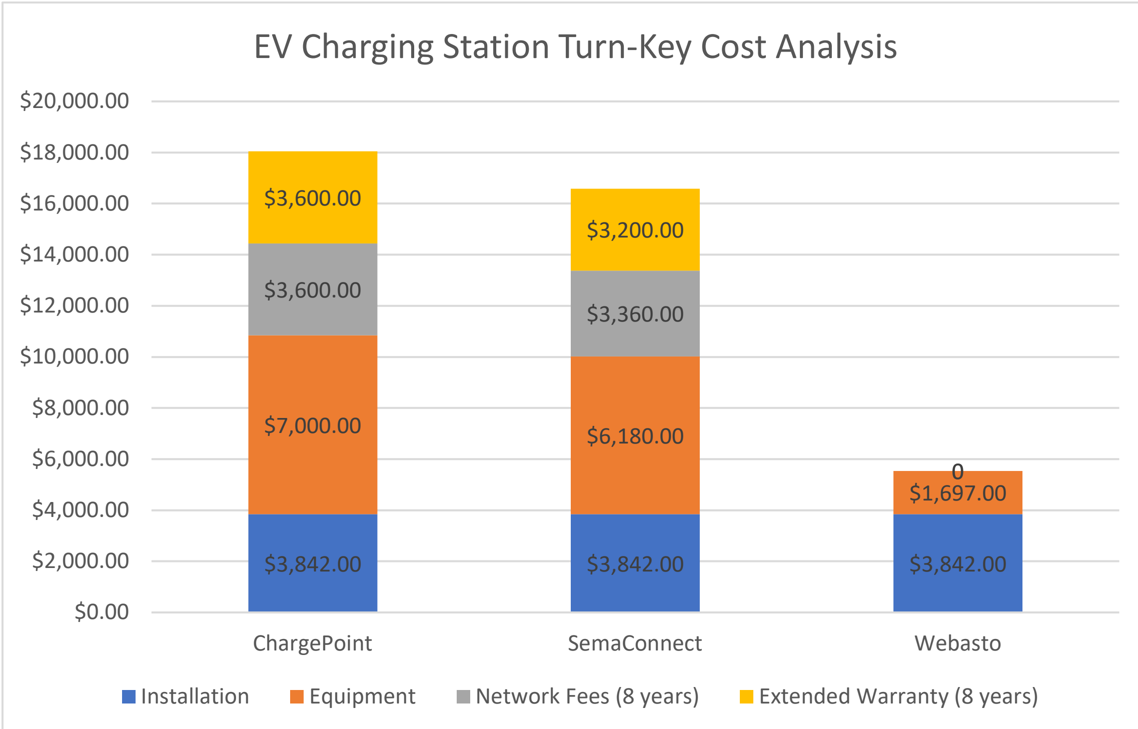
Network Fees

Networked EVSE units are connected to a network for monitoring and data collection. These fees are set costs that are billed monthly throughout the life of the unit.

Planning for Growth

It is a good practice to consider long term EVSE needs when installing an EVSE unit. If CFX anticipates installing more EVSE units in the future, it is cost effective to install conduit from the electrical panel to future EVSE locations while the ground is already trenched for the initial EVSE installation. Future EVSE installations would simply require running wire through the existing conduit and putting the EVSE unit in place.

Upgrading the electrical service for the anticipated long term EVSE electrical load is also recommended. These steps may result in an increased initial installation costs but will result in significant cost savings.



Financing

Based on the above chart, turn key costs can get high so additional financing options have been made available. Orlando Utility Cooperative (OUC) offers a seven-year billed cost plan to its' commercial customers. In this option, OUC will handle all install, equipment, and maintenance costs while billing the customer over a span of seven years. The monthly bill will of course include any usual energy consumption along with the calculated costs of the charging station.

Conclusion

Year by year, more and more electric vehicles are being introduced to the market. Consumer EV adoption is increasing with it, which in turn, so does the demand for EV Charging Stations. With workplace charging stations, PEV drivers can nearly double their vehicles' all-electric daily commuting range and feel confident to be able to get where they need to go before and after work. A study was shown and it was stated that 90% of employees reported satisfaction with their worksite's charging program. This lead to higher employee retention, as well as EV adoption. Considering this data, the need for charging stations at the workplace is evident. ENGINEER recommends CFX to install the Chargepoint, CT4021, AC Level 2 charging station

Section 12

Fleet Replacement

Description

The fleet vehicle replacement analysis is a study of the existing CFX vehicle inventory and recommend replacement vehicles as part of a strategy for increased sustainability. The objective of this analysis was to evaluate the implementation and cost effectiveness of electric vehicles (EV) used in fleet operations. The study focuses on Battery-Electric Vehicles (BEV) and Plug-In Hybrid Electric Vehicles (PHEV); collectively known as Plug-In Electric Vehicles (PEV).

CFX Fleet Assessment

According to the U.S. Department of Transportation, there are more than 11 million fleet cars and trucks in the United States. Fleet vehicles regularly cover predictable routes and often return to central depots at night; having a centralized recharging location which makes them excellent candidates for conversion to electric. PEVs are particularly attractive for light-duty fleet use because of their reduced fueling expense and lower overall maintenance cost. The transition and use of electric mode transportation in U.S. fleet operations will have significant positive economic, environmental, and public welfare benefits. PEV and alternative fuel technology continues to progress at a rapid pace and there is ever increasing participation in all areas by business, government, vehicle manufacturers and others.

Fleet Data Analysis

Currently, CFX has 16 vehicles in their fleet. The usage purposes are maintenance, construction, toll operations, traffic operations, executive, and carpooling. The fleet vehicles used for maintenance, construction, and traffic operations mainly consist of light-duty trucks and SUVs, while just a couple fleet vehicles are cars. The average yearly mileage for each usage category is shown below:

Usage Category	Average Yearly Mileage
Maintenance	21,000
Construction	7,100
Toll Operations	13,600
Traffic Operations	19,000
Pool	5,850

According to this chart, maintenance vehicles are utilized most averaging about 80 miles per day. This equates to a yearly gas consumption of about 1,170 gallons. Coming in closely at number 2, fleet vehicles used for traffic operations average about 73 miles per day; equating to a yearly gas consumption of about 1,090 gallons. That's estimated to produce around 22,923 & 21,301 lbs of CO_2 emissions respectively.

Fleet Management Analysis

Fleet vehicle management is a critical component. Typically, fleet maintenance and repairs are outsourced or covered through leasing agreements. Outsourcing these tasks minimizes costs. Based on available data, CFX currently outsources all maintenance and repair to a variety of repair shops. Upon reviewing the maintenance expense report, it is estimated that CFX spends on average about $236 per year per vehicle. This is well below the national average which sits at about $1,186.

Technical Assessment

While electric vehicle (EV) adoption in fleet applications have been low due to cost and uncertainty, EV technology has developed significantly in the past few years. EVs can be a great choice for fleet managers that are looking to save on costs while greening their fleet.

PHEV vs. BEV vs. Hybrid

Conventional hybrids combine both a gasoline engine with an electric motor. While these vehicles have an electric motor and battery, they can't be plugged in and recharged. Instead their batteries are charged from capturing energy when braking, using regenerative braking that converts kinetic energy into electricity. This energy is normally wasted in conventional vehicles. Depending on the type of hybrid, the electric motor will work with the gasoline-powered engine to reduce gasoline use or even allow the gasoline engine to turn off altogether. Hybrid fuel-saving technologies can dramatically increase fuel economy. For example, the 2014 Honda Accord hybrid achieves a combined 47 miles per gallon (mpg) compared to a combined 30 mpg for the non-hybrid version.

Plug-in hybrid electric vehicles (PHEV) are like conventional hybrids in that they have both an electric motor and internal combustion engine, except PHEV batteries can be charged by plugging into an outlet. So why opt for a PHEV instead of a conventional hybrid? Well, unlike conventional hybrids, PHEVs can substitute electricity from the grid for gasoline. The 2019 Chevy Volt, for example, can go around 53 miles on electricity before the gasoline motor kicks in.

Battery electric vehicles (BEV) run exclusively on electricity via on-board batteries that are charged by plugging into an outlet or charging station. The Nissan LEAF, Fiat 500e, and Tesla Model S fall into this category, though there are many other BEVs on the market. These vehicles have no gasoline engine, longer electric driving ranges compared to PHEV, and never produce tailpipe emissions.

Electric Vehicle Market

Electric cars have continued their steady development over the years. With the advancements in battery life and efficiency, their travel distances are now becoming viable for a broad range of business and personal uses. Take the Chevy Bolt for instance, offering 238 miles on a fully charged battery. All without a drastic price jump.

Car industries are buying in on the hype and are making a push to release their own EV models. The market is going strong and only growing stronger. It is forecasted that EVs will make up 14% of the overall car market by the year 2025. Here is a short list of the EVs on the market today.

- Hyundai Kona EV
- Chevrolet Bolt EV
- Jaguar I-PACE
- Audi e-tron
- Nissan LEAF
- Kia Soul EV
- Hyundai Ioniq EV
- Volkswagen e-Golf

Mechanics

Another advantage to electric vehicles when compared to internal combustion engines (ICE) is the number of moving parts. The EV has one moving part, the shaft, whereas the ICE has hundreds of moving parts. Fewer moving parts in the electric vehicle leads to another important difference. The electric vehicle requires less periodic maintenance and is more reliable. The internal combustion engine requires a wide range of maintenance, from frequent oil changes, filter replacements, periodic tune ups, and exhaust system repairs, to the less frequent component replacement, such as the water pump, fuel pump, alternator, etc. The EV's maintenance requirements are fewer and therefore the maintenance costs are lower.

Safety

All passenger vehicles are required to pass the same safety and crash tests, electric cars, however, have a few extra features which may make them safer to ride in. For example, statistics on real-world crash events show that electric vehicles are far less likely to catch fire when compared to fuel vehicles. Compare gas cars – 1 fire to every 20 million miles – to electric vehicles – 1 fire to every 120 million miles driven. It's virtually impossible for a battery-powered car to explode on impact, and because heavy battery packs significantly lower an EV's center of mass, the car is less likely to roll over. Manufacturers of electric vehicles don't spare any expense on built-in safety systems, which is why EVs regularly exceed all safety standards. In fact, many EVs score higher in crash test safety ratings, Tesla Model X, for example, has a perfect score.

Noise Reduction

At 65 mph, the average interior noise of a car with an internal combustion engine is around 70 dB. Electric vehicles, on the other hand, are almost whisper-quiet. According to a study published by the National Institute of Environmental Health ENGINEERences (NIEHS), “Tens of millions of Americans suffer from a range of adverse health outcomes due to noise exposure, including heart disease and hearing loss.” The same study claims that “nearly 100 million people in the United States (about 50% of the population) had annual exposures to traffic noise that was high enough to be harmful to health.”

Environmental Benefits

The most significant environmental benefit is in the reduction of the use of petroleum based fuels, to include consumption while idling. U.S. passenger vehicles and trucks consume more than 6 billion gallons of diesel fuel and gasoline while idling. Electric vehicles do not idle.

Gas Prices vs. Electricity Prices

While gas prices fluctuate often, the cost of electricity has been stable and predictable for decades. This presents a huge advantage for electric vehicles. Energy costs can be calculated and therefore budgeted accurately, unlike fuel costs.

Charging Infrastructure

Charging equipment for plug-in electric vehicles (PEV) is classified by the rate at which the batteries are charged. Charging times vary based on how depleted the battery is, how much energy it holds, the type of battery, and the type of charging equipment. The charging time can range from less than 20 minutes to 20 hours or more, depending on these factors.

There are 3 levels of PEV charging. AC level 1 provides charging through a 120-volt AC plug. This level of charging is ideal for households as overnight charging typically replenishes the battery for roughly about 40 miles of electric range. AC level 2 charging, ideal for commercial applications, provides charging through a 240-volt AC plug. For level 2 electric vehicle supply equipment (EVSE), a dedicated 40A breaker is typically required. This, along with the installation and operation of the EVSE unit, will increase costs.

Direct Current (DC) Fast Charging equipment enables rapid charging along heavy traffic corridors at installed stations. This EVSE unit provides impressive charging times but come with a hefty price tag. Not to mention, if used too often, the negative effects it can have on an EV’s battery life. The figure below outlines the three different charging levels.

Charging Level	Vehicle Charging Rates	Supply Power	Connector
AC Level 1	2 to 5 miles of range per 1 hour of charging	120VAC/20A *(12-16A continuous)*	 J1772 charge port
AC Level 2	10 to 20 miles of range per 1 hour of charging	208/240VAC/20-100A *(16-80A continuous)*	 J1772 charge port
DC Fast Charging	60 to 80 miles of range per 20 minutes of charging	208/480VAC 3-phase (input current proportional to output power; ~ 20-400A AC)	 J1772 combo

Fleet and Federal Government Regulatory Assessment

ENGINEER reviewed all potentially applicable federal, state, and local environmental regulations for the permitting and construction.

Corporate Average Fuel Economy (CAFÉ) Standards

CAFE standards are the NHTSA fuel efficiency goals that auto manufacturers have agreed to meet. The standards are established to reduce petroleum use, lower GHGs and save the public money. Petroleum imports in 2025 from OPEC countries are expected to be approximately half of the 2012 levels, and the average driver can expect about $8000 in lifetime fuel savings with a 2025 vehicle when compared to a 2012 model 8. The goals are reviewed and revised periodically, the current compliance period for passenger and light trucks ends with model year 2016 and new goals have been adopted for model years 2017-2021. The compliance goal for 2016 is 35.5 mpg, rising to 41 mpg in model year 2021. NHTSA and EPA established the first standards for medium and heavy-duty vehicles in 2011, new standards for model years 2021-2027 are currently being formulated. An excellent source for more information on federal fuel efficiency standards is available from the Center for Climate and Energy Solutions website at: http://www.c2es.org/federal/executive/vehicle-standards#more_info.

Clean Air Act

Smog and other pollution prompted Congress to establish the Clean Air Act in 1970. The Act, which was last amended in 1990, requires the EPA establish and enforce air quality standards. The EPA monitors the concentration of six common air pollutants, four of which are among the six major pollutants from vehicles.

The EPA enforces its mandate using several mechanisms, including, reducing pollution from vehicle exhaust and refueling evaporation, and requiring the seasonal reformulation of gasoline to maintain air quality. EPA also promotes the use of alternative fuels such as electricity. Policy goals are also established that require that federally funded transportation projects conform to air quality standards. There are also requirements for on board vehicle diagnostics to monitor performance, and vehicle inspection and maintenance programs are required for areas that do not meet air quality attainment standards. Obviously, there is a significant amount of effort and expense associated with the mitigation of the detrimental environmental effects of CFVs, the integration of electric vehicles into fleets has the potential to significantly reduce much of this effort and expense. More information on the role of the EPA can be found at: https://www.epa.gov/clean-air-act-overview/plain-english-guide-clean-air-act.

Conceptual EV Fleet

In recent years many foreign nations have been acquiring EVs to modernize their fleets. This forward thinking has caught the attention of the U.S. and now many companies are doing their part and considering the same. Like all major business decisions, careful planning and considerations must be made. Throughout this process, several strategies have been formed and developed. This section will outline the most critical strategies for EV fleet acquisition, replacement, and operation and management.

The primary criterion used for vehicle replacement ideally is the economically viable age of the vehicle. This is determined by calculating the optimum replacement point that results in the lowest total cost over the vehicle’s life. The primary criterion used for vehicle acquisition is the cost of acquisition. Both the acquisition and replacement strategies listed below will ensure an efficient, cost effective, and sustainable fleet. These should also be considered for use as best practices moving forward for future vehicle acquisitions.

Acquisition Strategies

- Reduce Operational Costs
- Improve Operations
- Improve Safety
- Improve Sustainability

Replacement Strategies

- Cost of Maintenance
- Vehicle Age
- Vehicle Acquisition Cost

Fleet Management Strategies

In fleet management, a centralized approach should be taken. Centralized management allows for standardized fleet operation. For instance, with charging stations at the centralized fleet location, operation costs are minimalized and ensure adequate charging of the EV fleet is done on a routine basis. This will also help prolong an EV's battery life.

In addition, it is common to outsource maintenance and repairs which CFX is already doing based on the data provided. Outsourcing maintenance and repairs is a very cost effective cutting driver. These efforts should continue; however, moving forward it is recommended that CFX also take a centralized approach by creating service level agreements with manufacturers that cover maintenance at the time of acquisition. Doing so creates certainty and minimizes the impact of rapidly increasing maintenance costs over a specified period.

EVSE Infrastructure

The distinction needs to be made between workplace and fleet charging as they are two distinctly different applications that can be easily confused. Workplace charging is an installation of charging facilities that provide the opportunity for employees to charge their personal EVs at their place of employment. Fleet charging is an installation that provides charging for EVs that are owned and operated by a company or organization. Both types of installations vary in size, ranging from very large campus style workplace charging installations to a much smaller installation designed to service a small municipal EV fleet.

As stated earlier in the report, AC level 2 charging is recommended for EV fleets. Installing a level 2 EVSE unit per EV at a centralized location will allow fleet vehicles to charge overnight and ensure optimal charge throughout the operation period.

Cost Analysis

A wide range of electric vehicles are available for every conceivable free market segment. As a result, the purchase price of a new electric vehicle varies widely based upon the vehicle make, model, type, package, and accessories. As the number of EV models for sale grows, the comparative cost to conventional vehicles continues to fall. Several factors are considered when purchasing an EV, including the initial purchase price, cost to operate the vehicle, utility or charging rebates, and repair costs. When the total lifetime costs of an EV are lower compared to its comparable conventional vehicle counterpart, EV purchase is justified.

Total Cost of Ownership

Total cost of ownership (TCO) is the sum of all realized costs for a vehicle over its span of ownership. These realized costs consist of the purchase price or depreciation if vehicle is sold, fuel or charging costs, maintenance and repairs, insurance, and cost of money if financed. In general, EVs have lower TCOs when compared to their conventional vehicle counterparts due to less required maintenance and low electricity costs.

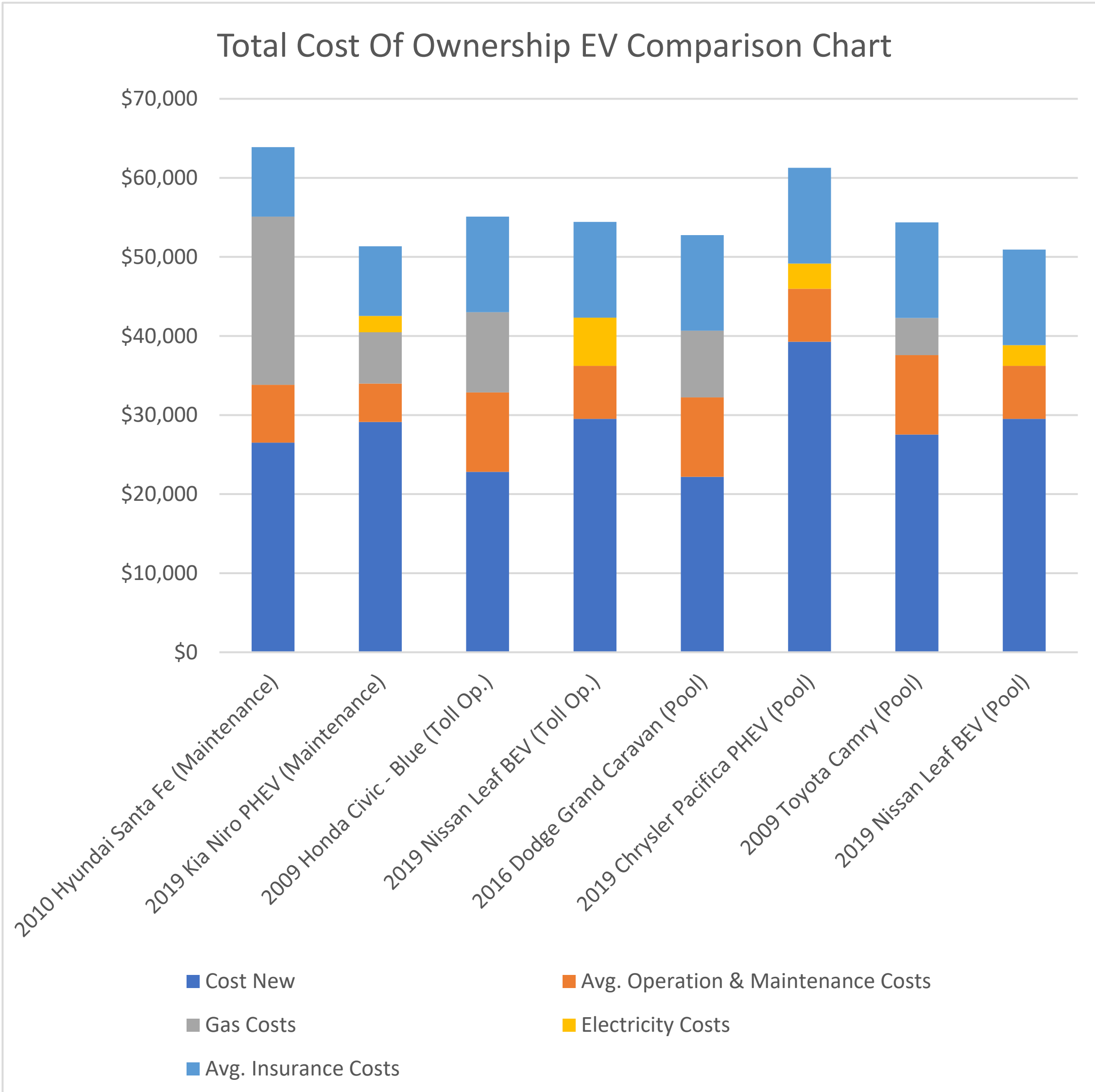
Optimum Replacement Cycles

To ensure the TCO of an EV is kept at a minimum, structured replacement cycles need to be determined. The replacement cycle recommended for CFX is to replace its fleet vehicles at their optimum replacement points. The optimum replacement point occurs during a window where a vehicles' TCO per year is virtually stagnant. As the age of the vehicle gets higher, so does the severity of repairs resulting in an increased TCO. According to many studies, it was found that this optimum replacement window occurs between 9 and 12 years. Of course, this varies greatly depending on driving habits and vehicle performance among other things.

Because CFX has different fleet operation requirements, ENGINEER recommends that the optimum replacement point must be determined for each vehicle based on total mileage, age, and use of best judgement. The chart below illustrates a TCO model based on the provided data.

The data was calculated based off the following assumptions:

- Average Orlando Gas Prices = $2.62 per gallon
- Average Electricity Prices = $0.12 per kwh
- Average Insurance Costs = $1,100 per year
- Average ICE Vehicles Maintenance and Repair Costs = $913.50 per year
- Average EV Maintenance and Repair Costs = $609 per year



**Sources - https://www.fueleconomy.gov/feg/findacar.shtml, https://newsroom.aaa.com/2015/04/annual-cost-operate-vehicle-falls-8698-finds-aaa-archive/, https://www.greencarreports.com/news/1080925_electric-car-maintenance-a-third-cheaper-than-combustion-vehicles*

The data in the chart represents side by side TCO projections of CFX's current conventional vehicle fleet vs. comparable EV fleet replacements. Please note that CFX has light-duty trucks that weren't modeled due to no comparable EVs currently on the market. According to this chart, with exception of the Minivan, the EVs have a lower TCO than their conventional vehicle counterparts. Although initial purchase costs for EVs are higher, the realized cost savings on fuel and maintenance make up for it. After reviewing this data, it is safe to conclude that an

EV will generally have a lower TCO as compared to its comparable counterpart. As technology continues to advance, this generalization will become even more evident.

Sustainability Assessment

EV adoption can significantly reduce Green House Gas (GHG) contributions, noise produced by ICE vehicles, and urban heating. In addition, the environment benefits from a reduction in the use and disposal of lubricants, coolants, and other petroleum based automotive additives. The negative health effects from GHG emissions include asthma, cardiovascular disease, and impaired lung function. Like environmental impact benefits, the numerical scale of benefits afforded to public health by EV adoption could be truly impressive. Below is a table illustrating the potential environmental benefits by transitioning to an EV fleet.

Model Year	Make	Model	Mileage (Yearly)	Average MPG	Gas Consumption (gal. Yearly)	Estimated Reduction in CO2 Emissions (lbs. Yearly)
2010	Hyundai	Santa Fe	21,000	20.7	1,014	19,876
2012	Nissan	Frontier	21,000	17	1,235	24,202
2016	Nissan	Frontier	21,000	17.9	1,173	22,986
2016	Nissan	Frontier	21,000	17.9	1,173	22,986
2016	Nissan	Frontier	24,817	17.9	1,386	27,163
2016	Ford	Explorer	21,000	19	1,105	21,655
2018	Ford	F-150 SuperCab	9,966	17	586	11,486
2019	Ford	F-150 SuperCrew	9,111	17	536	10,501
2008	Honda	Ridgeline	7,070	17.3	409	8,007
2018	Ford	F-150 SuperCrew	7,069	17	416	8,147
2009	Honda	Civic	13,655	38.8	352	6,895
2010	Nissan	Frontier	20,783	17.3	1,201	23,537
2018	Nissan	Frontier	17,108	17.5	978	19,153

2016	Dodge	Grand Caravan	6,135	21	292	5,724
2009	Toyota	Camry	5,538	34	163	3,192
2017	Ford	Explorer	12,000	19	632	12,374
Total Potential Green House Gas Reduction			=	112 Metric Tons Per Year		

**Source* https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Based on the collected data, CFX would potentially reduce 112 metric tons of Green House Gas Emissions (GHGe) per year if they transitioned to an all EV fleet. To look at this from a different perspective, that's roughly equivalent to 39.2 Tons of waste recycled instead of landfilled.

Conclusion

Based on overall TCO and environmental benefits, ENGINEER recommends CFX to replace all ICE fleet vehicles with PEVs over a determined life cycle. The life cycle should be determined based on mileage, age, maintenance, and the availability of a comparable PEV. While it is noted in this report that there are no like for like replacements on the current market for combustion trucks, it is anticipated that they will be available in the next few years. CFX should consider re-evaluating the EV market at the time of each vehicle replacement. As of now, ENGINEER is recommending the following vehicles be replaced with an EV immediately:

Model Year	Make	Model	Usage	Replacement Window	Recommended Replacement Vehicle	Replacement Vehicle Type
2010	Hyundai	Santa Fe	Maintenance	0	2019 Kia Niro	Plug-In Hybrid
2009	Toyota	Camry	Pool	0	2019 Nissan Leaf	All Electric

Additionally, ENGINEER recommends CFX to take the following considerations:

- Consider performing an annual physical condition assessment of vehicles at least 10 years or older, or exceed 150,000 miles.
- Consider the feasibility of purchasing used vehicles one to three years old to reduce the new vehicle prestige depreciation costs.
- Consider incorporating historical vehicle reliability into the vehicle procurement process.

- Reassign older vehicles to less intensive uses where possible, which can help extend the replacement cycle.

Section 13

Tire Sensor Study

Description

A tire safety check station is a drive-over tire inspection center that utilize sensors to conduct tire condition diagnostics. CFX has shown interest in WheelRight's Tyre Management Technology.

Wheelright's system provides reports that include tire pressure, tread depth, temperature, and vehicle weight and load on each axle. ENGINEER investigated history of tire safety and each aspect of tire inspection below in order to evaluate this system.

Tire Monitoring Technology Assessment

Since the 1970s, there has been an interest in monitoring tire pressure without the need of a handheld gauge or technician. The main roadblock was lack of sufficient sensor technology.

Arrival of pressure sensing technology, electronics and battery power along with many tragic events have led to implementation of deployment of low tire pressure systems in cars.

Firestone and Ford Controversy, and Tire Regulations

A period of unusually high failures of certain Firestone tires installed in Ford explorers in the late 1990s caused U.S. lawmakers and the National Highway Traffic Safety Administration (NHTSA) to launch investigations. It was found that the two were linked to 271 fatalities and over 800 injuries in the U.S. only.

Investigation also found that tire tread separation occurred in these vehicles and the main causes were tire age, manufacturing facility, operating temperature, tire design, and labor/management problems in the Bridgestone/Firestone facility in Decatur, Illinois, factory. Additionally, low tire pressure recommendations, high center of gravity increased the likelihood of a rollover of Ford Explorers, that were sold with the problematic tires.

In 2000, United States Congress was pushed to legislate the TREAD Act, which called for better reporting practices for accidents and recalls and mandated installation of Tire Pressure Monitoring Systems (TPMS) technology in (light motor) vehicles under 10,000 pounds. Mandate obtained full adoption in 2007.

Tire Pressure Monitoring Systems

Underinflation is the main cause of tire irregular wear. Most of major tire problems could be traced back to low tire pressure. An NHTSA study shows that vehicles with tires underinflated by more than 25% of the recommended pressure five times more likely to have a tire related crash.

There are currently two types of TPMS systems today: Indirect and Direct systems. An indirect (iTPMS) system measures rotational speeds of wheels. Because underinflated tires have a higher angular velocity the difference in speed cause wheel sensors to warns the driver if underinflation is determined. This system cannot measure or display pressure values and the system must be reset by the user once all tires are adjusted correctly.

Direct TPMS (dTPMS) systems have pressure sensors to each wheel. The pressure is physically measured on each tire and reported to the driver. Some systems also measure temperature as well. Major drawbacks of these systems are exposure to hostile environments and the requirement of batteries, which limits their useful life.

Aftermarket dTPMS systems that measure both pressure and temperature of each tire are available and some of them have replaceable batteries. Because heavy motor vehicles are not required to have TPMS systems, these products have high acceptance from truck and RV owners that want to detect tire problems early and mitigate cost and safety concerns.

Tire Thread Monitoring Systems

NHTSA study found that in a sample of 5,470 crashes analyzed, 26% of tire related crash vehicles were linked to a tread depth of 2/32" or less.

Cars currently have not automatic way of measuring tire thread. Typically, a hand-held measurement device or the "penny test" is done. Lack of automated options have led to products like Hunter's Quick Tread and Nokian Tyres' Snapskan. These options utilize laser technology to find tire tread depth and have proven to be more accurate than traditional methods. These options require the car to drive-over and are more suited for indoor fleet monitoring in shops or garages.

Apart from laser systems, a company named Tyara, Inc., has started commercializing a tire depth sensor, using printed carbon nanotube device that is capable of measuring tread thickness from within a tire. The nanotube can be attached to the tire without disrupting the tire itself. This tire depth sensor would be combined with dTPMS systems to obtain complete tire diagnostics automatically. Technology is being tested by manufacturer Continental now.

Tire Temperature

Underinflation is the main cause of excess heat in a tire. Overtemperature is the telling sign that a tire is about to break. Excessive heat typically leads to hard, brittle beads, and eventual rupture of the tire. As mentioned before, only aftermarket dTPMS systems can provide high temperature warnings to drivers.

Vehicle Weight

Weight and load axle limits are typically closely monitored in trucks for tax and safety purposes. Weight stations are typically used to obtain both axle weight and gross weight. Currently weight monitoring is not available in lighter motor vehicles.

There are no commercially available vehicle integrated tire weight sensors now. Tire manufacturer Continental is developing technology to detect the weight of each axle using sensors and inform drivers of overweight or imbalances.

Conceptual Design and Specifications

WheelRight Tire Monitoring System

Unlike other systems, WheelRight provides tire pressure, tread depth, temperature and vehicle weight and load in the same system. A report is developed automatically by the system.

Fleet Management

WheelRight's system can be utilized as a daily monitor of commercial fleet tires. This system provides a web interface program that can store, analyze and report each vehicle's results. WheelRight system is typically used for fleet management of trucks, buses and other heavy class vehicles that does not have TMPS systems included.

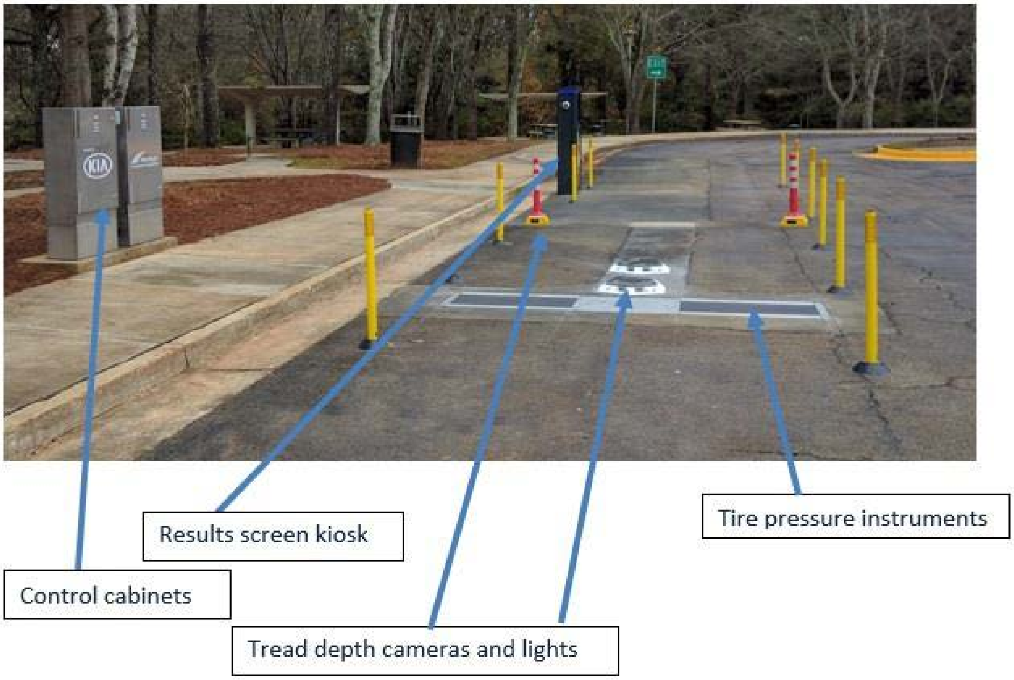
CFX fleet consist of vehicles under 10,000 lbs therefore some type of TPMS system should be included as long as the vehicles were manufactured after 2007. Additional temperature and thread monitoring systems as described in previous sections could be added if desired.

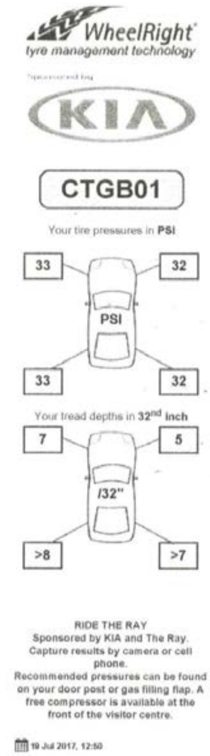
Expressway Applications

Other applications for WheelRight are visitor centers or highways and weight stations.

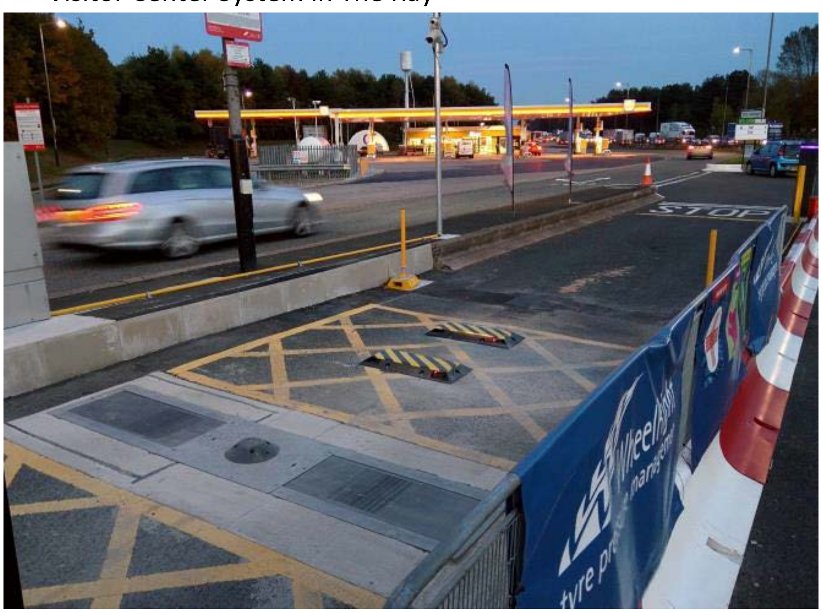
Visitor Centers/Highways: Like system installed in The Ray in Georgia. Tire temperature and weight not included in this option. System is available for public use and a report is printed for driver review. Automatic texting or e-mail could be included. A highway pilot project with Highways England was able to measure over 25,000 cars by installing the system in the highway instead of a visitor center. Questions that were raised based on the pilot programs were related to how to engage drivers and measure how much response was obtained from drivers.

Weight Stations: Includes weight in motion equipment and tire temperature can be added if desired. CFX does not own any truck weight stations.





Visitor Center System in The Ray



Highways England Pilot Project

Cost Estimates

No cost data has been provided by WheelRight.

Summary and Recommendations

As can be seen from the analysis presented in this study, a WheelRight Tire Monitoring System is viable.

The following conclusions were drawn from the evaluation of a possible Tire Monitoring Station:

- All vehicles that weight under 10,000 lbs. manufactured after September of 2007 have at least one type of Tire Pressure Monitoring System, which informs drivers when low pressure is present.
- WheelRight's Tire temperature and vehicle weight measurements are only available for truck weight stations therefore only benefit gained by installing this system for CFX would be knowing specific pressure level, tread depth and its reporting capabilities.
- WheelRight's system can be used to monitor tire pressure and tread in highways and/or visitor centers.
- Adding WheelRight's system in highways proved to engage a larger number of drivers but it was hard to measure customer response and actions afterwards.
- Apart from WheelRight's system, tread monitoring is only available using laser technology to monitor fleets in shops, but a tire depth sensor is currently being developed to be used in vehicle tires.
- Pressure monitoring system will become obsolete as older cars are retired from the road. Additionally, current thread monitoring technology might be commercialized in a few years.

Section 14

Landscape Sustainability Review

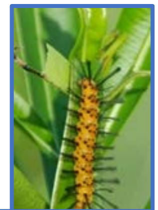
Description

The CFX Landscape Sustainability summary covers the main tenants of a successful, effective and sustainable Landscape for Central Florida. Creative plant selection, arrangement and maintenance are also evident throughout the CFX roadway system in an observable way. CFX clearly places a high priority on landscape features to provide visual beauty and environmental benefit. It is understood that this is an evolving process and sustainable implementation strategies are being discovered, added and/or modified thru the benefit of trial error.

Plant Material Selection

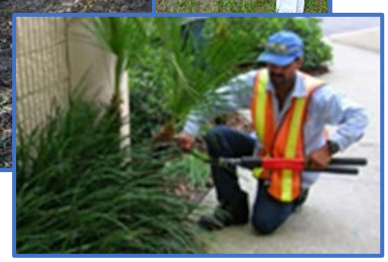
The list provided and observed in the field consists of durable, largely native, drought tolerant and disease resistant species. While somewhat limited for the vast areas covered it still provides a good pallet for aesthetic enhancement. A limited pallet is not necessary a bad thing if the material meets the above criteria in addition to giving a good variety of options in color, texture and form, this pallet does that.

Pest and Disease Control Assessment



Integrated Pest Management or IPM is a term used for the smart system of pest/disease prevention as opposed to control. IPM emphasizes the use of Cultural, Mechanical and Biological methods of management while de-emphasizing the use of chemical pesticides and only as a last resort and CFX appears to adhere to that tenant. However further examples and perhaps a manual with schedule of tasks would be helpful to better demonstrate appropriate and effective implementation. The use of 'spot treatments' and selective pesticides (ones that don't harm beneficial insects) are good examples cited. However, it should also be noted that there are certification and licenses available for those that apply these pesticides and CFX should ensure that employees are properly trained and educated accordingly.

Best Management Practices

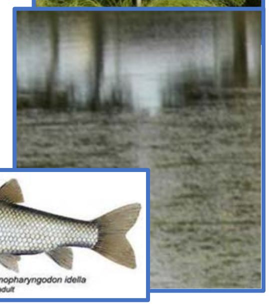


The principals and examples cited here are good and integral in a sustainable landscape but again more information and details would be helpful. For instance, fertilizers should have little to no phosphorous and organic supplements such as manure, peat moss, etc., should be utilized to lessen the effects of other more harmful elements being introduced into the ground water and surface water runoff. Also, in this section the arrangement of like plant material in terms of water, light and soil needs in keeping with xeriscape practices could be addressed along with the discussion of irrigation applications. Are fully automated underground irrigation systems used for all installations or are hand watering using water trucks the predominant method? The size of plant material at installation is also a key factor, especially regarding trees, in how much water is needed for establishment. While the importance of large and visually impactful specimens is acknowledged it is also important to consider using more practical sizes that shock less easily and require less water for establishment. The use of ground cover material to eliminate or significantly reduce the use of thirsty and 'mow needy' sod is a very important tenant that is implemented effectively by CFX.

Native Tree Buffers

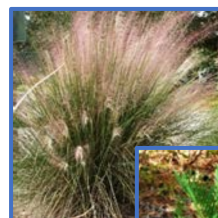
The selected species list and use of trees to provide large shaded areas do help reduce maintenance, retain soil moisture, reduce erosion and generally provides sustainable benefits such as carbon sequestration, and reduction of heat islands. Proper size selection as noted in paragraph 4 above is an important consideration as related to the reduction of resources during the establishment period. Frequent pruning of trees, especially cabbage palms in natural areas where clear sight lines are not a consideration should be limited.

Hydrilla Control



The proposed use of Grass Carp fish to control the rampant growth of hydrilla in all the wet retention ponds is a very good start on adapting more sustainable practices for this problem. CFX should continue to explore other biological and mechanical methods for hydrilla control to reduce or eliminate the need for harmful chemicals.

Native Grass/Drought Tolerant Ground Cover Species in Right-of-Way



As mentioned in Section 4 above the use of native bunch grasses wherever possible to eliminate or significantly reduce mowing of sod areas is very beneficial and effective toward sustainability goals. One observation relative the species of perennial peanut is that it has a more open growth habit and without regular irrigation and fertilization it may not be vigorous enough to choke out some noxious weeds that would require mechanical control. But overall this strategy is successful at reducing maintenance while providing visual enhancements and accenting as opposed to wide open fields of sod.

Conclusions

The efforts by CFX to provide a sustainable landscape thru the implementation of the strategies listed are generally effective and beneficial. CFX has demonstrated flexibility in their approach. As new processes and methods are discovered and implemented this successful program will only improve.

Section 15

Roadway Sustainability

Description

CFX follows the Florida Department of Transportation's (FDOT) roadway design guidelines and construction requirements. Historically, FDOT has used recycled materials for transportation projects and works nationally with the Recycled Materials Resource Center and the American Association of Highway and Transportation Officials to develop guidelines and specifications for the use of recycled materials in highway projects.

Assessment

Currently, FDOT specifications include recycled materials for asphalt, concrete, soils and aggregates. FDOT's objective is to create additional specifications for recycled resources and to remove any restrictions that may prevent the use of these materials in existing specifications. CFX's criteria that governs the use of a recycled material includes environmental conditions, economics and availability. Generally, when any of the following conditions are met, CFX implements recycled materials:

- The recycled material performs as well or better than the material it replaces.
- The use of a recycled material minimizes the impact on limited resources.
- The use of the recycled material does not exceed the cost of the material it replaces.

Conclusion

Reclaimed materials have already been used for CFX projects. Some examples include coal combustion fly ash in concrete; recycled asphalt in pavement; recycled plastic in guardrail offset blocks and flexible delineator posts. As FDOT approves new recycled materials, CFX plans to implement them.

Section 16

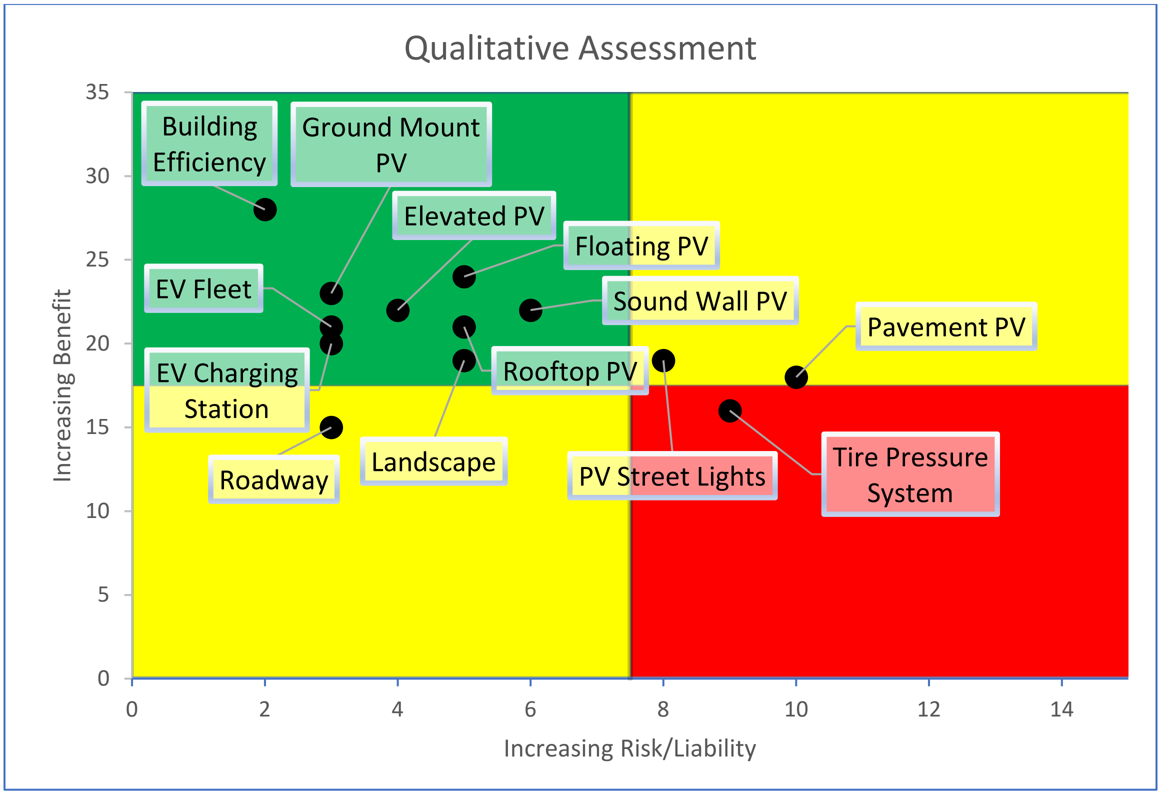
Qualitative Risk and Benefit Matrix Analysis

We generated Risk Register for each technology option that was studied. The risk register categories are defined below.

Risk Category	Definition
Utility/Grid	Risks related to operations of PV system (e.g., not meeting demand, brownouts, blackouts).
Technical/Development	Risks related to PV system development, including development schedule, changes in costs, design issues, permit issues, etc.
Permitting/Environmental	Risks related to the effect on local environment, local habitats, weather related issues, environmental opposition, etc.
Economics/Financing	Risks related financing of project
Construction	Risks associated with construction

The Risk Register is attached in the Appendix section. The result is that no deal killers were identified for any of the options. Risk control strategies are also included in the analysis in the appendix.

We also generated a Benefit/Risk/Liability Qualitative Assessment. This assessment not only identifies the benefits and risks for each option, it serves the purpose of prioritizing the various options. The results of this assessment are shown below. For this draft of the report, each of the Benefit and Risk factors were weighed equally. Varying factor weights can be adjusted as directed by CFX and AECOM.



Please refer to Appendix for Assessment Data and Specifications

The result of this analysis indicates that the best return options studied is the Building Efficiency due to low cost and high benefits associated with this option. Ground-mount Solar plant was found to have the best lower risk high benefits combination out of the large capital investment options. Dry Pond and Floating Solar options followed closely. Another factor that could be introduced is the criticality of power in certain geographic areas which could certainly change the assessment result. Additional Benefit, Risk, or Liability factors can be added to this assessment as directed by CFX.

Section 17

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