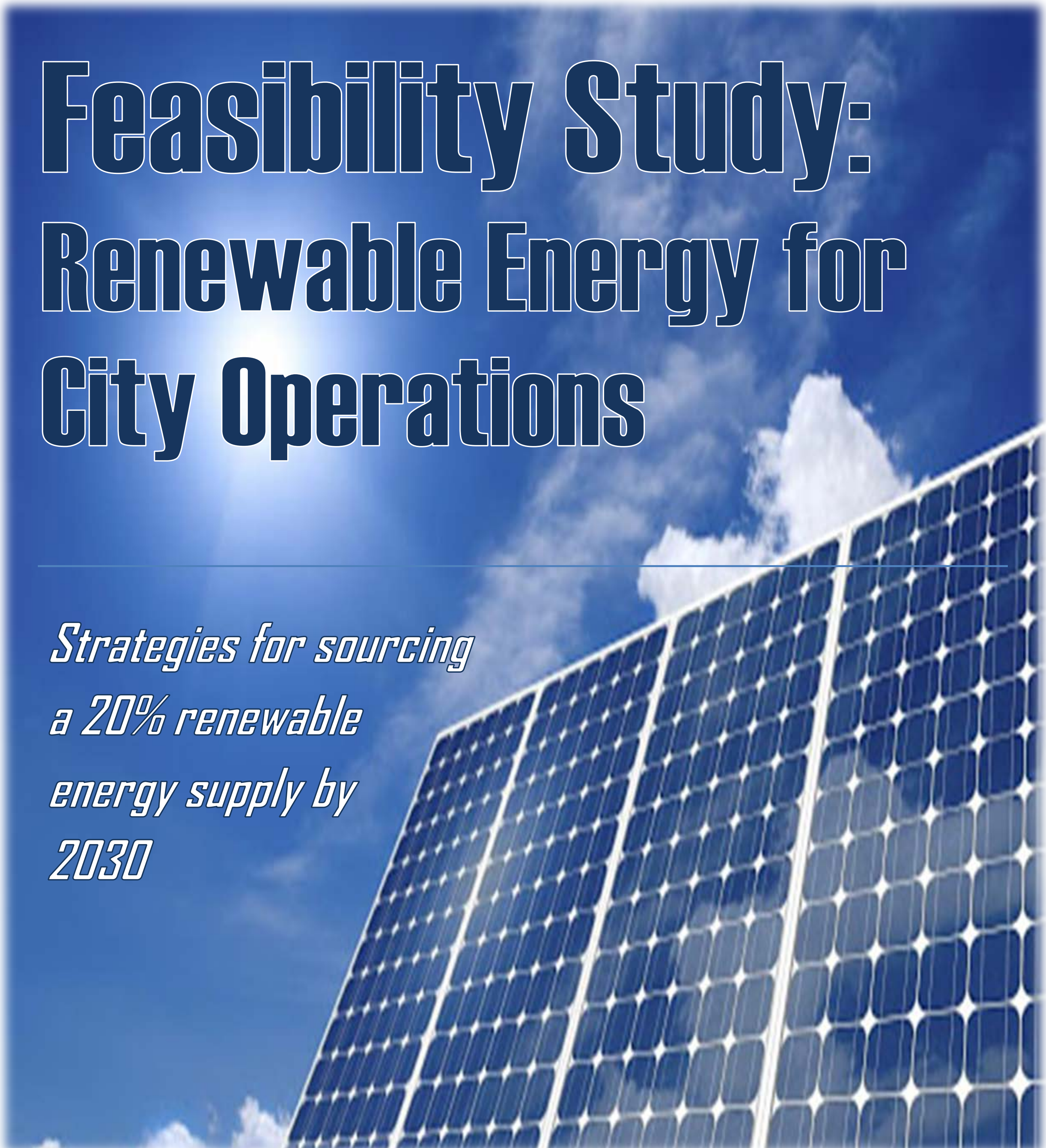
Feasibility Study: Renewable Energy for City Operations

Strategies for sourcing a 20% renewable energy supply by 2030



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Public Works Department
Sustainability & Climate Resiliency Program
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CITY OF FORT LAUDERDALE

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Definitions

Certain industry terminology will be utilized and are noted below to provide clarity. Visit the United States Department of Energy (DOE) website at www.energy.gov for more information.

BATTERY TECHNOLOGY: The utilization of chemical processes and reactions in order to transfer electrons to store energy for later use.

CARBON FOOTPRINT: The aggregation of all pollution emittance that contributes to global "greenhouse" effect, the leading cause for climate change.

CLIMATE CHANGE: The result of anthropogenic activities that have contributed to accelerated deviations from historical norms regarding global average temperatures, leading to negative environmental impacts.

EMISSIONS: Byproducts released into the atmosphere of human-led processes such as industry, energy generation, transportation, etcetera.

ENERGY CONSUMPTION: The amount of energy a facility or system utilizes to operate, generally expressed in kilowatt hours (kWh).

EXPORT CAPACITY: The amount of excess energy generated onsite that exceeds the building's needs and can be sent to the electrical grid for use elsewhere. This excess energy is credited to the customer (see net metering).

GREENHOUSE GAS: Emissions released into the atmosphere that prevent natural cooling thereby contributing to the planet retaining more solar radiation.

KW: Kilowatt. Unit of power required by a load to perform its electrical work.

KWH: Kilowatt-hour. Unit of energy of electrical work completed over time.

LOAD: The amount of energy a facility (or system) required to complete the work of its subsystems.

MT: Metric-ton. Unit commonly utilized to measure the amount of emissions a system/process emits indirectly or directly while conducting work.

NAMEPLATE: Provides an equipment's rated performance and other specifications.

NET ZERO: The total amount of energy used by a building on an annual basis is equal to the amount of renewable energy created on the site, thereby reducing its effective energy-based emissions to zero.

NET METERING: Process by which a renewable energy generating asset can send its unneeded energy to the local utility electrical grid (credit) and during times of needed energy can then pull energy from the grid (deficit).

PHOTOVOLTAICS: The conversion of light into electricity using semiconducting materials.

RENEWABLE ENERGY: Energy generation using fuel sources that are naturally replenished on a human time scale, however, may or may not be carbon neutral (i.e. biomass)

RESILIENCY: In relation to energy, the ability for a facility or asset to maintain continuity of operations should disruption to normal operating parameters occur.

Executive Summary

Located on the frontlines of climate change, the City of Fort Lauderdale has long prioritized efforts to increase its sustainability and resiliency. Since the development of its first Sustainability Action Plan in 2010, the City has focused on addressing the challenges of climate change by strategies that include establishing aggressive goals for mitigation of greenhouse gases while incorporating sustainability into its planning efforts, its operations, and its programs. The City has made significant progress towards these goals, but much work remains to further reduce the City's carbon footprint and its resulting contribution to the global problem of climate change.

To date, the City has achieved success in emissions reductions by pursuing strategic investment into energy efficiency, either in the form of new construction utilizing industry best practices or retrofitting existing assets. It has also tested different types of renewable energy technologies such as geothermal, wind and solar PV accounting for a total of approximately fifty (50) kilowatts of annual city operations energy production, a fraction of a percent of its total needs. However, without substantial investment by energy utilities to transition away from their currently dominant fossil fuel combustion generation processes to provide 100% emissions-free energy for customers such as the City, the planet will continue to increase in temperature. The year 2020 has shown what this trend will result in with record-breaking tropical storm activity and rainfall, continued sea-level rise outpacing existing and planned infrastructure, and economic disruption.

In 2013, the City of Fort Lauderdale published *Press Play Fort Lauderdale: Our City, Our Strategic Plan 2018* and set a strategic goal of becoming a leading government organization that manages all resources wisely and sustainably. Further, the City's recent Comprehensive Plan calls for even more aggressive action such as an 80% reduction to City operations' emissions by 2050 and a 20% renewable energy composition for City operations by 2030 (19.6M kWh annually as per 2019 utility data). Accomplishing this will require both continuing and expanding energy efficiency strategies currently in place but also to begin investment into renewable energy generating systems and services for its portfolio. The purpose of this study is to provide the actionable information needed to initiate such a program.

In the sections that follow, this study outlines a strategy to transition its portfolio either from retrofits or utility-derived solutions to achieve a total of twenty percent renewable energy supply. **Section 1: City Operations at a Glance** reviews the existing conditions of municipal sector energy usage and where investment into solar technology installations should target first based on the respective complexity of implementation. In **Section 2: Introduction to Photovoltaics,** the science and technical characteristics of solar and energy storage technologies are examined to provide insight of their capabilities and remove potential misconceptions. This section will also explore the myriad of contract structures currently within the energy marketplace and how regulation plays a role in availability. **Section 3: Roadmap to 20% Solar Energy** provides the investigatory preliminary analyses across City buildings to install solar energy systems. It also includes an examination of the available utility-derived options from the City's electricity provider that will be needed, and a general discussion of the study's results. **Section 4: Recommendations** summarizes immediate actions the City could pursue to implement aspects of this study.

Table ES1: Potential Solar Photovoltaic Energy Retrofit Contributions to the 20% Goal

The following estimates are based on industry assumptions, do not incorporate utilization of energy storage (batteries), and assume no future reductions from other strategies such as energy efficiency, changes to facility usage (decommissioning), demand response, or new construction.

Building Name	Size* (kW)	Est Project Cost**	Est Cost Savings	Payoff (years)	% to Goal	% Bldg Offset	GhG Offset (mt)
RIVERWALK CENTER GARAGE	322.1	$805,188	$58,408	13.4	0.54	83.5	375.42
LAS OLAS GARAGE AND PIERS	224.6	$561,438	$39,746	13.7	0.37	35.3	255.4
RIVERLAND PARK REC***	224.3	$560,625	$38,137	14.3	0.35	101.4	245.12
CNTRL MAINTENANCE SHOP	210	$524,875	$32,493	15.6	0.30	87.6	208.85
SOUTHSIDE SCHOOL***	137.2	$342,875	$24,417	13.6	0.23	106.6	157
CROISSANT PARK REC CENTER	132.6	$331,500	$21,953	14.6	0.20	75.4	141.12
BUILDING SERVICES CENTER	128.1	$320,125	$22,943	13.6	0.21	25.8	147.48
FLOYD HULL PARK***	98.5	$246,188	$15,524	15.4	0.14	106.1	99.76
HOLIDAY PARK - ACTIVITY CTR	83.5	$208,813	$14,935	13.6	0.14	48.6	96.01
EXECUTIVE AIRPORT ADMIN	76.4	$190,938	$11,988	15.4	0.11	77.7	77.06
SUNSET MEMRL GARDENS***	72.2	$180,375	$11,784	14.8	0.11	108	75.2
OSSWALD PARK REC CNTR***	59.8	$149,500	$10,697	13.6	0.10	107.1	68.72
HOLIDAY PARK – GYM	58.5	$146,250	$10,374	13.7	0.10	30.9	66.67
CARTER PARK - GYM	56.6	$141,375	$10,144	13.5	0.09	26.8	65.19
FIRE STATION NO. 3	55.9	$139,750	$9,145	14.8	0.08	31.5	58.75
GEORGE ENGLISH REC***	55.3	$138,125	$8,757	15.3	0.08	109.9	56.28
ARTS & SCIENCE PARKING***	53.6	$134,063	$9,853	13.2	0.09	109.3	63.5
EXECUTIVE AIRPORT AES	46.8	$117,000	$7,314	15.5	0.07	87.7	47.02
PARKING ADMIN.	43.6	$108,875	$7,765	13.6	0.07	55.8	49.91
CARTER PARK REC CENTER***	40.3	$100,750	$7,193	13.6	0.07	104.7	46.24
BEACH COMMUNITY CENTER	37.7	$94,250	$6,336	14.4	0.06	28.8	40.72
FIRE STATION NO. 53	32.5	$81,250	$5,093	15.4	0.05	6.2	30.82
LAUDERDALE MANORS REC	29.3	$73,125	$5,203	13.7	0.05	22.1	33.44
FIRE STATION NO. 13	22.8	$56,875	$4,065	13.6	0.04	18.4	26.16
FIRE STATION NO. 29	21.8	$54,438	$3,864	13.7	0.04	11.8	24.82
FIRE STATION / ADMIN/NO 2	21.5	$53,625	$3,837	13.6	0.04	3.5	24.67
CITY HALL	20.5	$51,200	$3,650	13.6	0.03	1.38	23.24
FIRE STATION NO. 47	17.9	$44,688	$3,196	13.6	0.03	9.6	20.57
FIRE STATION NO. 49	16.3	$40,625	$2,885	13.7	0.03	10.1	18.52
FIRE STATION NO. 35	15.6	$39,000	$2,433	15.5	0.02	8.6	15.62
FIRE STATION NO. 46	15.6	$39,000	$2,789	13.6	0.03	11.2	17.96
WARFIELD PARK REC CENTER	15	$37,375	$2,677	13.6	0.02	18	17.18
SNYDER PARK ADMIN OFC***	14.6	$36,563	$2,528	14	0.02	107.5	16.26
CARTER PARK ANNEX***	14.3	$35,750	$2,577	13.5	0.02	106.8	16.54
COAST GUARD STATION***	10.4	$26,000	$1,853	13.6	0.02	103.1	11.88
Totals:	**2485.70**	**$6,212,392**	**$426,556**	**N/A**	**4%**	**N/A**	**2739.10**

**System sizes are estimates based on easiest to implement areas at each building. Comprehensive field audits with qualified installers will be required to refine estimated production.*
***Project cost are estimates based on industry assumptions and should only be used as starting point for cost/benefit accounting.*
**** Denotes a "net zero" building if solar installation is pursued as designed.*

Table ES2: Renewable Energy Sourcing Composition Strategies based on this Study

The following composition has been determined from this study. Further investigation will be required to ascertain final source contribution percentages and their respective costs.

Source	Annual Energy (kWh)	Percent Contribution to 20% Goal	Estimated Cost
Retrofits	3,877,800	25%	$6,212,392*
Utility-Derived	15,722,200	75%	$261,382**
Total:	**19,600,000**	**100%**	**TBD**

**Cost estimates based on capital construction option. Pursuit of alternative strategies such as leasing or energy services contracting will require further investigation and RFP solicitation to determine labor and soft costs.*
***Florida Power and Light's renewable energy SolarTogether program charges fixed fees based on size of power required. This strategy will require further discussion with the utility to determine final cost and feasibility. Also note this is a recurring cost versus a capital expenditure via retrofit.*

Table ES3: Potential Future Contributors to a 20% Renewable Energy Composition Additional to this Study

Source	Description of Mechanism	Potential contribution to the 20% goal in 2030
Retrofits on City Buildings	Solar Photovoltaics	4% (based on this study)
Renewables on New Construction	Public Safety Building (design to include potential for 700kW PV)	0.3%
	Joint City/County Facility (design to include potential for 1MW PV)	0.4%
	New Parks Facilities Achieve no net increase in power use overall + Renewables to address 10% of building need	TBD
	New Water Treatment Plant; Renewables used to offset net increase in power demand	TBD
City Energy Efficiency Retrofits	Reduction to existing energy load, thus lowers kW/kWh value to achieve 20%	1.5% (estimated)
Utility-Derived (New Generation)	Continued investment in renewables-based on FPL forecast for 2030	TBD (FPL energy supply composition potentially 44% renewables by 2030[1]
Utility-Derived (City Purchase)	FPL renewable energy program to deliver needed remaining percentage	14% (TBD)
	Total Renewable Energy Composition:	20%

[1] Figure derived from the Florida Power and Light Ten-Year Power Plant Site Plan 2020-2029

Recommendations:

The following summarizes this study's action items on how the City can pursue a two-prong strategy for achieving its renewable energy target:

Determine the balance of retrofit versus utility options to support the City's goal

- Once determined, secure required funding to initiate implementation (general budget; municipal bond; third-party grant funding)

Engage FPL

- The City Procurement Department and those tasked with monitoring energy consumption should establish a working group with Florida Power and Light to learn more of their *SolarTogether* program, its estimated costs and capacity to offset approximately 15 million kilowatt-hours per year.

- Should the *SolarTogether* program prove viable, the City should next identify which facilities it can pilot this program for performance and cost. Additional facilities can then be enrolled to the program until either the 15M kWh target is met or the City exceeds potential FPL program allocation.

Finalize Project Siting

- Identify which buildings from the list should be pursued for retrofits first based on existing conditions, potential load offset, contribution to the 20% goal, and visibility to the community

- Conduct in-depth audits at selected buildings to refine system designs and ensure criteria are met (roof condition, potential for building replacement, distribution system condition, etc.)

Qualify Market Providers

- Draft and issue a 'Request for Proposals' for local solar developers. Evaluate and select a developer based on both cost per watt and experience with public entities.

Outreach and Optics Campaign

- Upon completion of project(s), coordinate outreach initiatives with Strategic Communications, City Manager's Office, and City Commission to announce to the community. Demonstration of the City's commitment to renewable energy will spur private sector interest and may accelerate community-level emissions reductions.

About the Study

Purpose

The purpose of this study is to provide key decisionmakers and stakeholders within the City of Fort Lauderdale's government with relevant, accurate, and balanced strategies in order to achieve its Comprehensive Plan goal of transitioning to a twenty percent (20%) renewable energy supply for municipal operations by the year 2030. This study examines the available possibilities to pursue this goal using solar photovoltaic technology, including preliminary feasibility analyses of municipal properties for energy system retrofits, availability of renewable energy via the local utility Florida Power and Light (FPL), as well potential financial mechanisms for procurement.

It should be noted this study is the first of its kind for the City of Fort Lauderdale and will incorporate future updates as the initiative to obtain renewable energy proceeds in the coming years.

Approach

The City's Sustainability and Climate Resiliency Program within the Public Works Department is tasked with identifying and advocating for actionable strategies to assist other departments with achieving greater environmental sustainability. Due to Florida's consistent abundance of solar irradiance, this study focused on providing a comprehensive examination of achieving the 20% goal via the utilization of solar photovoltaic (PV) technology only. There does exist potential for other renewable energy technologies to supplement PV, however they will not be thoroughly examined as part of this study's scope of work.

This study strived to answer the following:

1.) What is the City's current energy consumption for all municipal operations and what does 20% renewable energy truly represent should this trend remain largely consistent?

2.) What are solar photovoltaic energy systems, how do they provide renewable energy, and what are their benefits? Further, how does energy storage play a role with solar PV?

3.) What and where are the places that PV renewable energy systems can be easily incorporated?

4.) What options, if any, exist from the marketplace and from the City's electricity utility to purchase renewable energy?

5.) What are the preliminary actions an interested party should pursue?

Actions Included

To answer these questions, this study examined all available datasets to better understand the municipal portfolio of properties, including their existing conditions applicable to solar photovoltaic (PV) energy installations. From this, feasibility analyses for solar PV retrofits were conducted for dozens of properties to determine:

1.) Energy system siting, design, specifications, and estimated cost
2.) Potential energy production, energy cost savings, and other financial metrics
3.) Contribution to greenhouse gas emissions reductions
4.) Contribution to overall 20% renewable energy goal

Upon completion of these analyses, the City could potentially only install retrofits to supply approximately four percent (4%) of the needed 20% renewable energy composition and does not factor in that some of the identified facilities may be replaced in the coming years. This is largely due to the limited availability of City-owned assets that could host enough renewable energy systems to generate the targeted 20% and excludes any actions taken to reduce overall energy consumption from investment in efficiency. As such, an analysis was undertaken to better understand what available renewable energy purchase options were possible for the City to pursue, including the expected budgetary impact.

Finally, an examination of private marketplace options to incorporate renewable energy was undertaken, including explanation of the State of Florida's energy regulatory environment and what implementation models are legally allowable under each classification.

Actions Excluded

This study aimed to provide a level of comprehensive analysis never before completed for the City to date, however resources available to execute were limited. As a result, all feasibility analyses are limited to solar PV retrofits, do not include field assessments nor energy storage feasibility, and are reliant on a combination of modeling software and industry assumptions to provide their estimations. Interested parties should conduct facility audits to ensure the site can support such an investment without other major capital upgrades.

Additionally, the scope of this study excluded any advocacy for policy change at the State's legislature due largely to the complexity such efforts would require across Florida's many municipalities. It should be noted however that continued pressure to deregulate Florida's electricity sector should be pursued in order to open more options for renewable energy implementation, including lowering barriers to entry such as cost.

I. City Operations at a Glance

The City of Fort Lauderdale's building portfolio is comprised of approximately 140 different facilities, represented by a variety of building types, ranging from community centers, fire stations, water and wastewater treatment facilities, administration office buildings to maintenance buildings. Each space use requires a unique approach to maximize cost-effective reductions in energy usage or implementation of renewable energy technology. In fact, each facility will ideally be looked at individually to apply appropriate operational adjustments and/or upgrades in order to achieve greenhouse gas emissions reductions.

To power its operations to serve the constituency, the City of Fort Lauderdale is served by the primary electrical utility in the region, Florida Power and Light (FPL). For the entirety of their serviced territory, FPL's fuel mix supplied for power generation is estimated to be comprised from natural gas (74.5%) and nuclear (23%). The remaining fuel sources consist currently of coal (2%), renewable energy (1.5%), and market-purchased power[2]. Due to this varied approach and the uncertainty of where precisely the City receives its current energy generation from, the current 1.5% of renewables FPL operates should not be attributable to the City's 20% goal. Should the City pursue a new agreement with FPL to participate in one of their dedicated renewable energy programs, then that percentage of utility-derived energy can be attributed to the overall 20% goal. The City can also begin investment of its own installations to ensure without any doubt that the energy that powers its operations is derived from renewable energy.

The first step to investigating potential renewable energy implementation for its facilities is to understand where current energy consumption is taking place and what are the long-term trends to control for variability such as weather or changes in building use. Figure 1 below provides a trend analysis of the most recent two years of annual energy data compared to baseline year 2010. Figure 2 further examines where the usage is estimated to occur as a percentage of the portfolio:

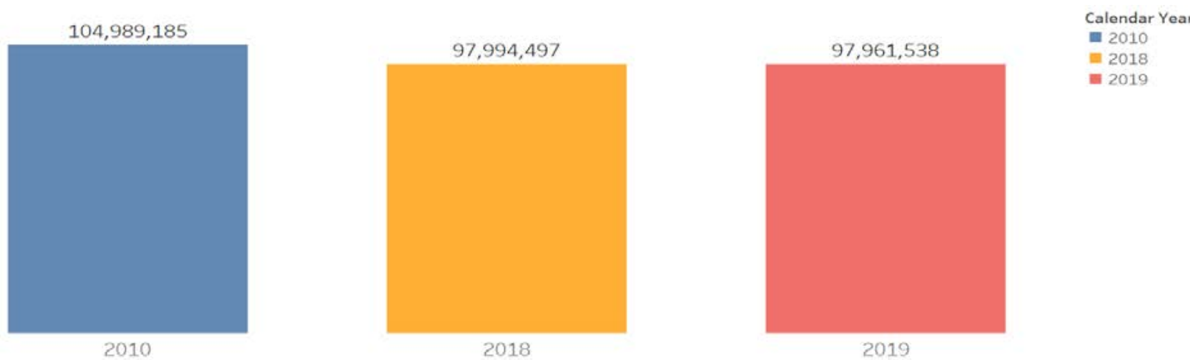


Figure 1: City operations annual kWh usage, baseline versus recent two years. Reductions can be partially attributed to energy efficiency investments over the past decade.

[2] As per Florida Power and Light's Ten-Year Power Plant Site Plan (2020-2029)

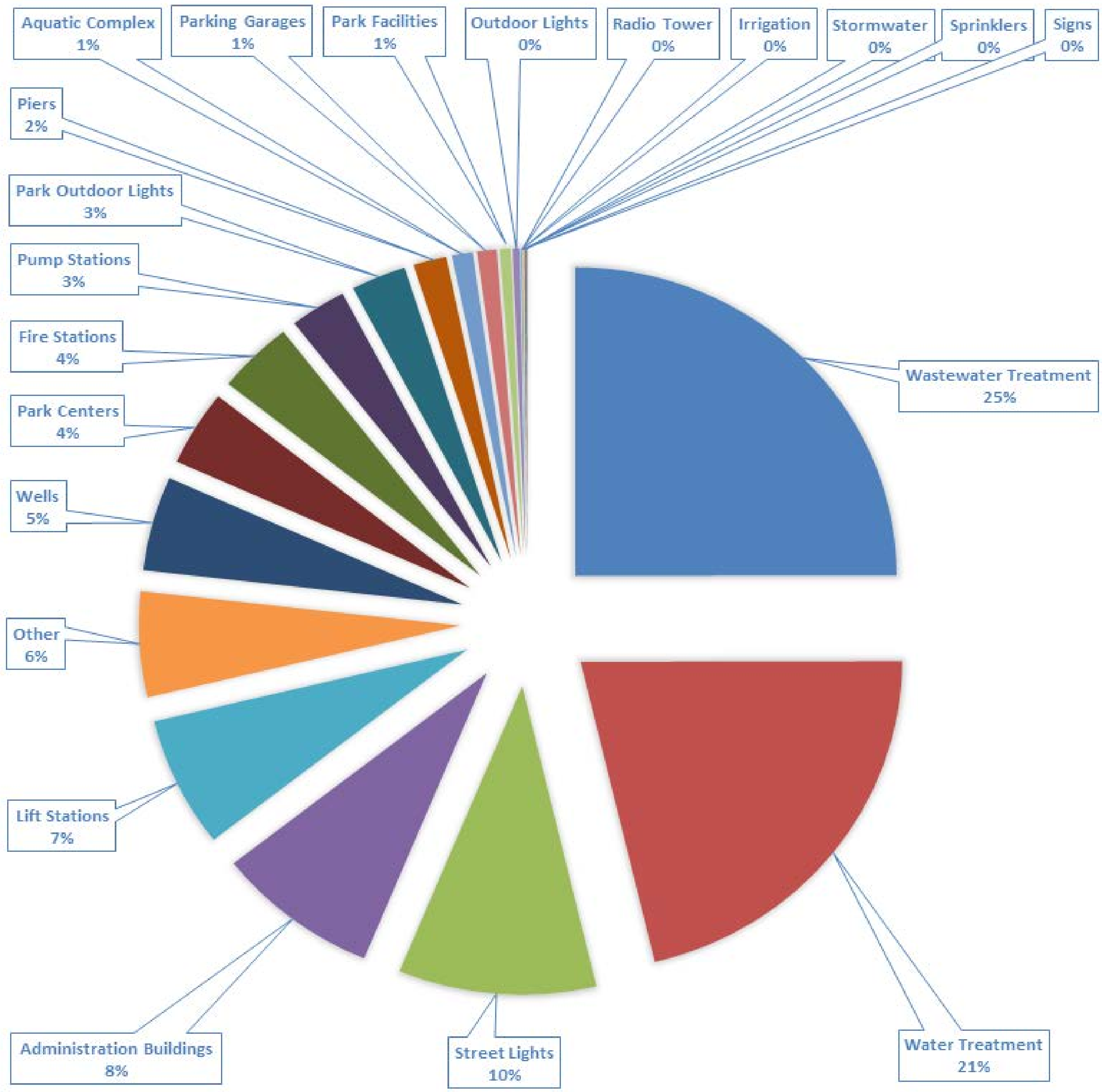


Figure 2: CY 2019 kWh City operations usage by estimated use type

Upon examination, it is apparent that the City's operational total annual usage hovers at approximately 100 million kWh, though with signs of marginal reduction, and that over 60% of this energy consumption is dedicated to the distribution, collection, and treatment of its water and wastewater. These use types require a substantial and consistent power supply to maintain their critical operations and would be exceptionally difficult to take on as a first target for solar PV retrofits. It is therefore the other 40% of operations where the City may find simpler installations that can serve as the test bed for scalability as the processes for renewable energy systems integration become better understood.

II. Introduction to Renewable Energy

There exists a variety of mature renewable energy technologies that can eliminate the usage of traditional utility-derived energy, and some have already been piloted throughout the City such as vertical-axis wind turbines, geothermal temperature controlling, and small-scale solar photovoltaics. With each technology there also exists unique parameters that must be considered for widescale adoption including siting, efficacy, environmental conditions, and production efficiency. For example, the wind turbine pilot project located at Mills Pond Park demonstrated that though the City may have the necessary space to site such equipment, the environmental conditions were less than favorable resulting in limited energy generation.

In comparison, solar photovoltaic energy systems have been successfully deployed at a targeted scale throughout the City, ranging from an array to supplement the Beach Community Center to tiny systems to power parking meters. Standard photovoltaics such as those commonly seen on rooftops or parking canopies can achieve remarkable efficacy for the City's needs due to the amount of consistent solar irradiance received in South Florida also while requiring little maintenance. Further, the market has shown consistent growth in adoption thusly spurring advances in efficiency while driving down costs.

Due to these factors, this study focused on the utilization of solar photovoltaic energy retrofits located at City facilities to achieve a portion of its 20% renewable energy goal.

Science and Applicability of Photovoltaic Energy

First developed in the 1860's as an alternative energy generator due to a fear that coal reserves were rapidly dwindling, solar energy systems have been refined and improved upon to the point of being a cost-effective solution. Over the past twenty years, their integration into the larger energy market has allowed for substantial greenhouse gas emissions reductions, resiliency against unforeseen interruptions of the grid (when tied with a battery), and the ideal choice to expand power generating capacity without expensive and complex new transmission feeders. Barriers to entry such as the cost per watt generated continue to decrease and is expected more so as efficiency of the technology requires less modules to produce the power needed. Recent advances in battery technology will serve this trend even further and may allow solar to transition from a supplemental role to a base line grid power option in the coming decades.

Fundamentally, these systems absorb the sun's radiant energy to generate electricity. This process' eventual energy generation can then either be stored in an onsite battery system for future use, sent to meet a building's load, or exported to the utility's electrical grid for usage elsewhere.

Solar PV has wide applicability due to its ability to scale, whether it be for powering a remote weather station or a massive, utility-scale PV farm that can provide power for an entire community. The most important component of either is adequate exposure to the sun's irradiance to ensure power is consistently generated. Figures 3 below provides a basic visualization of how these systems operate:

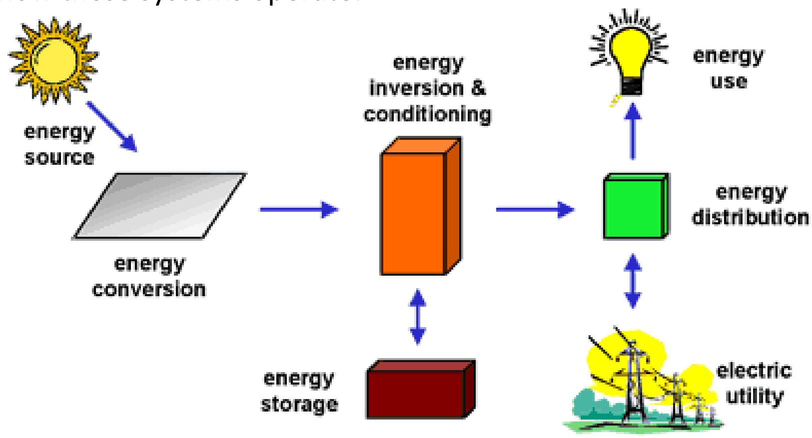


Figure 3: Photovoltaic process (source: fsec.ucf.edu)

For the City to achieve its goal of 20% by 2030, photovoltaic technology is the obvious choice for its unique portfolio of buildings. The principal process of this technology is that PV power generation occurs at the molecular level when a photon emitted from the sun shifts an electron from the outer valence ring of a material's atomic composition used in a solar cell, typically silicon. This shifted electron will be captured by a nearby semi-conductor and through induced voltage be sent on and aggregated with other shifted electrons from other cells. To scale this up to appreciable amounts of usable power, cells are structured and aggregated into standardized modules and then these are aggregated into customizable arrays. Figure 4 below provides a more detailed schematic of this process:

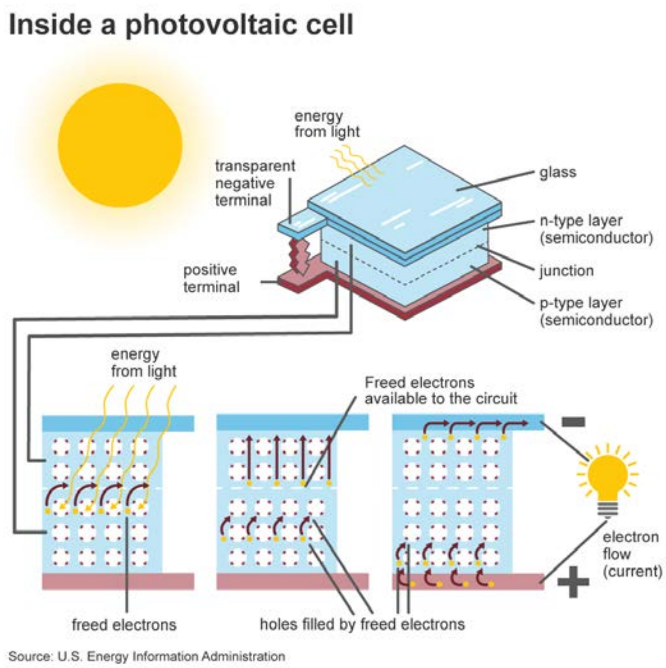


Figure 4: Photovoltaic cell energy transfer process (source: USEIA)

The array’s main conductor transfers this power into a connected controller/optimizer (which smooths out electron flow from the varying modules), then to a battery storage system (if desired), then an inverter (to transform direct current to alternating current) and finally into either the building’s main distribution system or exported to the utility grid. It should be noted that each step within this process, some power is lost due to variables such as conductor resistance, current conversion, and suboptimal ambient temperature for example.

What allows PV systems their advantage over other technologies are their simplistic designs. Utilizing very few mechanical moving parts, PV usually requires little in terms of maintenance thus saving on costly labor versus traditional power generation systems. Cleaning the modules periodically and inspecting for any damage including the ancillary equipment generally is all that is required. By implementing a preventative maintenance schedule upon installation, the design performance and lifecycle of solar can last upwards of twenty-five years before replacement to newer technology should be considered.

Figure 5: Basic maintenance routine of an array (source: energymatters.com). Removing dust improves efficiency by 1%.

Often, there is a misunderstanding that installing a solar PV system will protect a facility against failures stemming from the utility grid. While true that they provide a level of resiliency hard to match when considering the abundance of available sunshine in Florida, it must be stated that such systems are required to be paired with an onsite battery storage system if continuity of operations is desired during a grid disruption. This is because in the event of a grid outage, regulations dictate that a PV system must be de-energized to ensure the safety of utility personnel performing repairs on the grid distribution system. The PV system will automatically shut down if there is not a battery to absorb any potential export of excess energy, even if the system itself is sized smaller than the energy required to power the entire facility.

It should be noted that PV systems do not necessarily require being installed on a building’s rooftop nor do they need to be large. While certified as a ‘Solsmart Community’, constrained environments such as in Fort Lauderdale can be addressed with more unique solutions such as parking canopies that collectively can offset a building’s load or act as an off-grid method for recharging electric vehicles. Other solutions can be even more compact such as for streetlighting, parking meters, traffic safety devices, local irrigation pumping, and for the greater public benefit such as in local parks/green spaces to reduce the “heat island” effect.

Battery Energy Storage Systems (BESS)

While a solar PV system can operate without any energy storage (provided no grid disruption), the supplementation of battery energy storage systems is becoming more commonplace as their costs decrease. The available technology to store energy via battery are numerous, with recent trends towards lithium-ion becoming the favored solution due to its chemistry's energy density. Often, residential and commercial stakeholders will incorporate battery storage with their PV system to leverage the available tax incentives provided by the Federal and State governments to lower the significant cost batteries represent. The City of Fort Lauderdale by nature of a municipality is exempt from such incentives, however, can achieve additional savings by using batteries to avoid expensive peak demand utility rates.

The critical advantage a BESS provides is operational resiliency in the event of grid disruption. While traditional emergency electricity generators fueled by gasoline/kerosene/diesel/etc. do serve this exact purpose, their drawback is maintaining a supply chain with distributors. This can prove to be of high risk should a major catastrophe occur that severely limits accessibility to consistent fuel delivery. Pursuit of a pilot project consisting of a solar PV and BESS should be considered and tested to understand how such systems operate, their longevity with respect to load, and other factors before committing to widespread implementation for the City.

As mentioned, BESS also provide a financial incentive as they can be utilized to offset potentially costly 'time of use (TOU)' electricity rates charged by utilities. A BESS is charged during the day when ample solar irradiance provides excessive PV production, thereby storing the additional energy to the battery. As the sun sets and the electricity grid's "peak" begins to occur, a facility can switch to its battery to maintain operations until the peak concludes a few hours later. This avoided energy usage is more valuable and can assist with the project's payback.

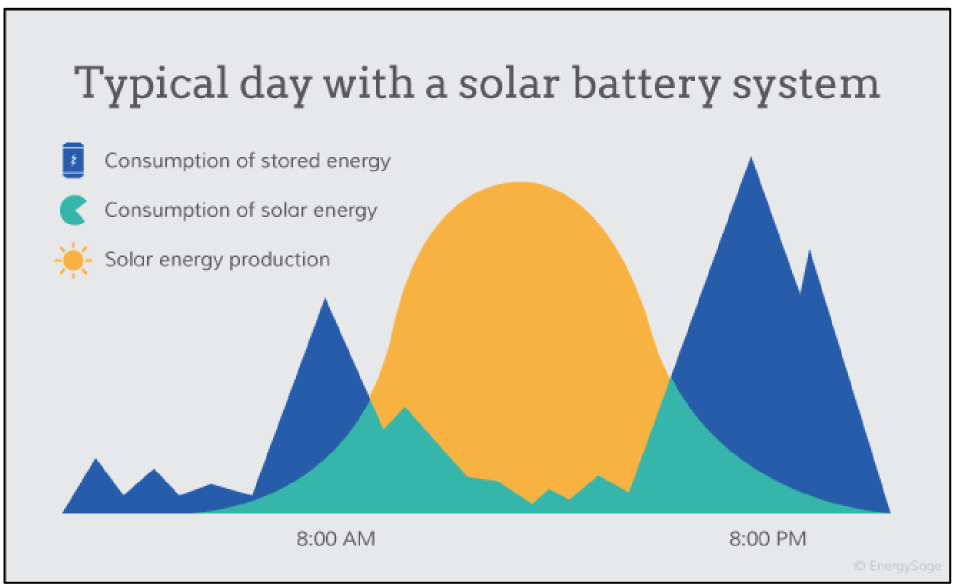


Figure 6: How a battery can offset expensive time of use electricity rates by discharging during peak demand hours in the evening (Source: energysage.com)

Mechanisms to Secure Renewable Energy

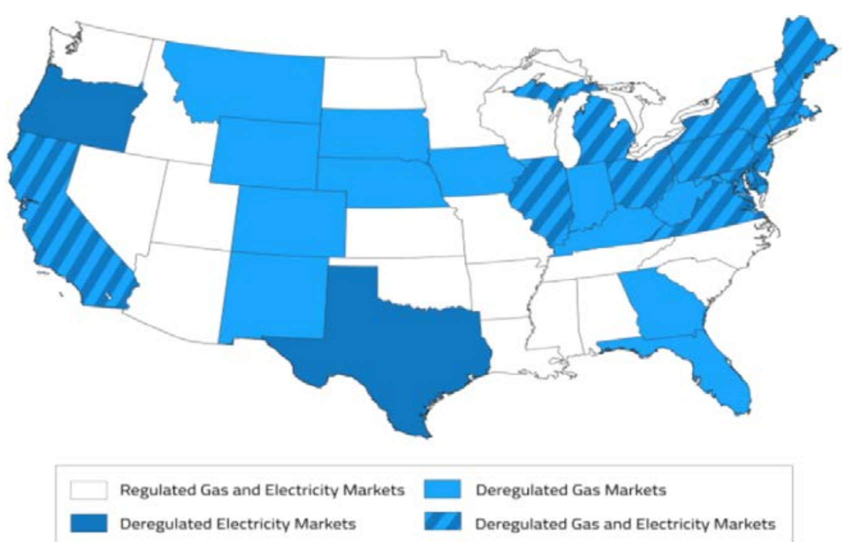
The renewable energy marketplace provides unique finance options customized for interested parties to leverage based on their respective regulatory environment. Not every option may be available for a prospective renewable energy project largely due to how energy markets are regulated. Traditionally, these markets were heavily regulated and restricted customer choice for procuring an energy supply, however in the 1970s this began to change. The passage of the Public Utilities Regulatory Policies Act initiated the restructuring of the energy industry and was further supplemented in the 1990s with the Energy Policy Act. The following will provide a cursory review of these two types commonly found within the United States to provide insight into options available to the City.

Regulated vs Deregulated Markets

In the traditional regulated model, a utility company completely owns and operates the vertical value chain of energy generation, transmission, distribution and sale to the consumer. Further, consumers are required by law to utilize the utility company assigned to their respective geographic area. Oversight of the utility is handled by a public regulatory commission to ensure among other things, that energy rates are priced effectively. Florida is a regulated electricity market, but deregulated natural gas market.

Deregulation allows for the entrance of competitors to buy and sell wholesale electricity/fuel to third party retail suppliers via ownership of the value chain whether it be the generating asset or the transmission system. This model often benefits consumers by allowing them to compare rates and services of different third-party supply companies (ESCOs) versus a regulated market of only one option. The utility still plays a role ensuring the distribution system is working correctly as well as continues to participate in the marketplace themselves. This carries over to renewable energy sourcing as well, including flexibility and availability of non-traditional contract structures provided by third party participants.

Figure 7: Regulated vs Deregulated States (source: electricchoice.com)



The following will examine the common types of mechanisms renewable energy systems are procured and where they are permissible.

Table 1: Procurement Options Matrix

Option	System Costs	Maintenance	Payment	Incentives	Permissibility
Capital Purchase	Owner	Owner	Cash or Financing	Owner	Regulated & Deregulated
Operating Lease	Developer	Owner	Recurring Fee	Developer	Regulated & Deregulated
Power Purchase Agreement (PPA)	Developer	Developer	Energy Usage	Developer	Deregulated Only
Energy Services Agreement (ESA)	Developer	Developer	Recurring Fee	Developer	Regulated & Deregulated
Property Assessed Clean Energy (PACE)	Owner	Owner	Property Tax Assessment	Owner	Regulated & Deregulated
Utility-Derived	Utility	Utility	Premium on Rate	Utility	Regulated & Deregulated

Option 1: Capital Purchase

This option is considered the most traditional method of procurement whereby an interested party engages a contractor to develop and implement a renewable energy system. It is purchased either with allocated funds or financing and ownership including the energy generated, maintenance, and all applicable incentives are retained by the customer. As a result, this option requires the greatest amount of capital availability at the onset however provides the quickest return on the investment. Capital purchases are allowable in both regulated and deregulated energy marketplaces.

Option 2: Operating Lease

This option is often used when there is insufficient capital for purchase or that the customer cannot leverage the incentives or depreciation provided by local, State or Federal tax authorities. In this model, a customer's facility will host a renewable energy system and make lease payments to a 3rd party calculated based on anticipated energy production for the right of use ("renting" the system").

Operating leases are permissible in both regulated and deregulated marketplaces. They are attractive due to the customer not incurring any upfront costs, the fixed fee is lower than a traditional capital purchase found in option 1, and the expense is off balance sheet. At the end of the lease term, a customer can take ownership via payoff of remaining principal value, engage in a new lease, or return the asset to the developer.

Option 3: Power Purchase Agreement (PPA)

Under this option, a customer will again pay no upfront costs for installation but also does not incur any maintenance responsibilities to host a system at their facility. In exchange, the customer will again forfeit any rights to applicable tax incentives and must purchase all energy produced at a rate equal to or less than current grid rates for a fixed term from the developer. The developer will be responsible to ensure the system's maintenance for the term of the agreement

PPA's are permissible only in deregulated marketplaces, thusly Florida is unable to leverage this model. Their attractiveness and risk are similar to that of an operating lease but with the key difference that a customer is making payments for energy generated, not for rental of the equipment itself. At the end of the agreement term, a customer can take ownership via payoff of remaining principal value, engage in a new agreement, or return the asset to the developer.

Option 4: Energy Service Agreement (ESA)

This option is an amalgamation of aspects from both the Operating Lease and PPA models, although legally distinct. A customer enters into an agreement with a developer who will install and maintain a renewable energy system at the customer's facility at no cost. In exchange, the customer pays a recurring fee for this service derived from anticipated utility grid rates and energy system production for predetermined amount of time. The customer again loses any rights to applicable tax incentives.

ESA's are permissible in both regulated and deregulated marketplaces. Their attractiveness can be ascribed to that of a PPA but with the added flexibility of an operating lease and bypasses regulatory restrictions of 3rd party energy sales. As with both an operating lease and a PPA, a customer who pursues an ESA can at the end of the agreement term purchase the system, engage in a new agreement or return the asset to the developer.

Option 5: Property Assessed Clean Energy (PACE)

Under this option, a private property owner can finance the upfront costs to install a renewable energy system on their property and then leverage a property tax assessment to collect the payment needed for payback to the developer. Similar to Option 1, a customer is responsible for maintenance of their equipment and gets to utilize any applicable tax incentives to lower the overall cost of purchase.

PACE is permissible in both regulated and deregulated marketplaces. A customer's eligibility is based on the property's equity ("debt on property") rather than that of a customer's creditworthiness. PACE loans are often lower interest compared to capital lease rates as property tax repayment rates generally default less than other lines of credit. Further eligibility includes a customer to be current on all property taxes and if applicable, mortgage payments. Should a property owner sell, their remaining PACE assessment may be carried over onto the next owner until repayment is completed. This model is currently available to residents of the Fort Lauderdale.

Option 6: Utility-Derived Renewable Energy

Under this option an existing or new rate payer would engage with their local utility and request that their existing electricity service is composed of available renewable energy. This may not be available in all jurisdictions however many large utilities have been investing in replacing their obsolete coal/petroleum generating assets with large-scale solar photovoltaic and wind farms. FPL currently offers a program for residential/commercial to pay a fixed fee to “own” a portion of production derived from a new or soon to be commissioned renewable energy plant, similar to the ‘Community Solar’ model listed below.

Utility derived is permissible in both regulated and deregulated marketplaces and logistically is the easiest for a customer such as the City to pursue (provided their utility has renewable energy capacity to buy into). Cost of service would continue to be administered by the utility company and would include either a premium on the customer’s cost/per kilowatt-hour rate or a fixed-fee contract structure based on need. This option is often utilized when a customer lacks the available space to host enough renewable energy systems to meet their needs.

Other Advances in the Market

Exclusive to deregulated markets as of this time, there are new mechanisms underway to further adoption of renewable energy usage to sectors that historically could not leverage one of the aforementioned options.

Community Choice Aggregation (CCA):

Under the CCA model of procurement, local agencies aggregate the buying power of individual interested customers within a defined jurisdiction in order to secure alternative energy supply contracts and/or systems. By aggregating purchasing power, these agencies are able to create large contracts with volumetric pricing discounts, something individual buyers may be unable to do. This energy is delivered via the local utility’s grid distribution system but is sourced from renewable market sources (or onsite if possible). This mechanism allows low/mid income households, renters, and other overlooked but potentially interested customers access to renewable energy with more affordable pricing.

Community Solar

Under this model, customers interested in renewable energy but cannot/ do not want to host a renewable energy system can pool resources with other customers for development of an offsite solar farm whereby their contribution will be attributed as an offset. The utility’s transmission system will continue to handle energy distribution and through the use of virtual net-metering the customer’s monthly invoices will be credited for using renewable energy. The developer of the farm aggregates all interested customers and handles obtaining the necessary subscriptions or owners needed for economic viability. This structure is similar to FPL’s current *SolarTogether* program offering and is available to all of their account holders.

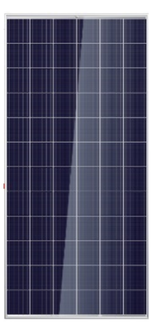
III. Roadmap to 20% Solar Energy

Methodology for Calculations

This study's primary goal was to find solutions to achieve a 20% renewable energy supply sourced strictly from solar photovoltaics for the City of Fort Lauderdale independent of any efforts by FPL to incorporate more renewables into their grid composition. As such, capital investment into various iterations of onsite systems were investigated and sized to accommodate physical limitations and total facility energy usage, with some instances demonstrating the possibility of becoming "net-zero". Utilizing utility-derived energy consumption data and the *Helioscope* photovoltaic systems design and cost modeling software, building profiles were developed for thirty-five (35) properties to explore the implementation of solar energy generating assets. Note that this software is limited to financial calculation estimations of solar PV materials only (excludes battery storage systems, any existing tax incentive due to the City's inapplicability). The final cost of each project will require a developer to provide quotes based on City stakeholders' desired scope of work for each facility, incorporating cost of labor and materials selected.

Certain assumptions were utilized in order to provide a logical first step when considering different buildings for renewable energy systems, such as technology, cost factors, and rate of return. For example, this study calculated a 20% goal on the calendar year 2019 FPL utility consumption data and that this percentage would not diminish from outside factors such as energy efficiency, changes in property usage, or downscaling of operations due to decreased demand. Additionally, analyses used one type of component across all investigated buildings such as modules, inverters and wiring. When further investigation is pursued through field audits and ultimately preliminary development, different brands of equipment may inevitably be utilized that provide different energy production and/or costs. All system designs, and their associated power and cost performance calculations have utilized the following with a projected system design life of twenty-five years:

- Trina Solar Modules, TSM-PD14 320 watt



MECHANICAL DATA

Solar Cells	Multicrystalline 156 × 156 mm (6 inches), 4BBMulticrystalline
Cell Orientation	156.75 × 156.75 mm (6 inches), 72 cells (6 × 12)
Module Dimensions	1960 × 992 × 40 mm (77.2 × 39.1 × 1.57 inches)
Weight	22.5 kg (49.6 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Tempered Glass
Backsheet	White
Frame	Silver Anodized Aluminium Alloy
J-Box	IP 67 or IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), 1200 mm (47.2 inches)
Connector	Trina TS4
Fire Type	Type1 or Type 2

- Sunny Tripower Inverters, 24000TL-US

Electrical Data	
Max. Usable DC Power:	24500 Watts
Max. DC Voltage:	1000 Volts
Rated MPP Voltage Range:	450V - 800 Volts
MPPT Operating Voltage Range:	150 V - 1000 Volts
Min. DC Voltage/Start Voltage:	150 V/188 Volts
Number of MPP Tracker Inputs:	2
Max. Input Current/Per MPP Tracker Input:	66 A/33 Amps
Output (AC)	
AC Nominal Power:	24000 Watts
Max. AC Apparent Power:	24000 VA
Output Phases/Line Connections:	3/3-N-PE
Nominal AC Voltage:	480/277 V WYE
AC Voltage Range:	244 V - 305 Volts
Rated AC Grid Frequency:	60 Hz
AC Grid Frequency/Range:	50 Hz, 60 Hz/-6 Hz +5 Hz
Max. Output Current:	29 Amps
Harmonics:	< 3%

With regards to field inspections, a previously conducted roof audit dataset was utilized to ascertain whether a facility identified for potential solar PV may require a roof replacement (if the design calls for roof-mounted). This dataset was limited so all feasibility analyses within this study should undergo a comprehensive investigation should a project receive funding to determine roof condition.

To account for anticipated cost variances from the City's electricity utility provider and the cost of money to pursue such projects versus debt service, a 1% annual escalation rate and a 3% discount rate have been factored to conservatively account for each project's lifetime value (NPV) at a blended cost structure of $0.11/kWh. Additionally, all environmental factors such as weather and seasonality that would impact a building and its system's performance have been derived from the Fort Lauderdale-Hollywood International Airport's (FLL) National Oceanic and Atmospheric Administration (NOAA) station.

Finally, to establish an energy performance trend for each selected building an annual average kWh value was calculated based on data from calendar years 2018 and 2019 (CY2020 was not fully available at time of analysis). Data exclusively from calendar year 2019 was utilized for consumption offset analyses as well as establishing the 20% citywide operations target of 19.6M kWh annual renewable electricity production.

It should be noted that achieving the 20% goal may not be feasible due to physical limitations of the municipal portfolio that prevents enough renewable energy systems to be installed. This study determined that only 4% of the 20% goal could be realistically installed based on available datasets of the 35 facilities selected at this time. It is advised to conduct additional analyses based on request to determine feasibility of additional contribution to the goal. The commissioning of new City facilities in the coming decade should also seek out integration of solar photovoltaics to further contribute to accomplishing the 20% goal.

Feasibility Analyses

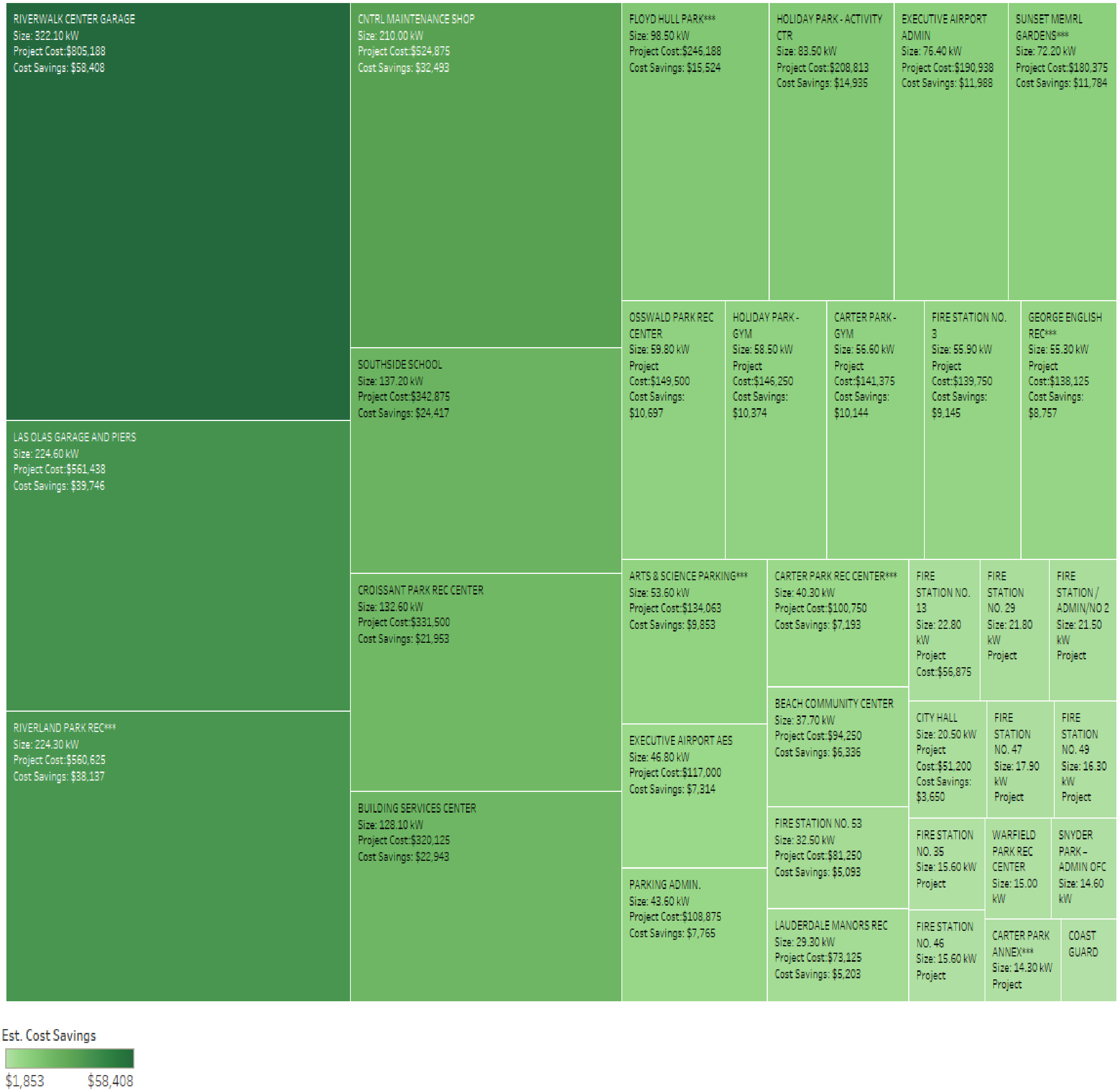
The following will provide renewable energy profiles on 35 of the likeliest municipal properties within the portfolio to pursue retrofit installations, based on available footprint for system sizing. Where roof siting was identified, facilities with estimated roof useful life of ten years or less are noted as candidates for potential replacement prior to installation.

Table 2: Potential Solar Energy Retrofit Contributions to the 20% Goal

Building Name	System Size* (kW)	Estimated Project Cost**	Est. Cost Savings	Est. Payoff (years)	% Goal	% Facility Offset	GhG Offset (mt)
RIVERWALK CENTER GARAGE	322.1	$805,188	$58,408	13.4	0.54	83.5	375.42
LAS OLAS GARAGE AND PIERS	224.6	$561,438	$39,746	13.7	0.37	35.3	255.4
RIVERLAND PARK REC***	224.3	$560,625	$38,137	14.3	0.35	101.4	245.12
CNTRL MAINTENANCE SHOP	210	$524,875	$32,493	15.6	0.30	87.6	208.85
SOUTHSIDE SCHOOL***	137.2	$342,875	$24,417	13.6	0.23	106.6	157
CROISSANT PARK REC CENTER	132.6	$331,500	$21,953	14.6	0.20	75.4	141.12
BUILDING SERVICES CENTER	128.1	$320,125	$22,943	13.6	0.21	25.8	147.48
FLOYD HULL PARK***	98.5	$246,188	$15,524	15.4	0.14	106.1	99.76
HOLIDAY PARK - ACTIVITY CTR	83.5	$208,813	$14,935	13.6	0.14	48.6	96.01
EXECUTIVE AIRPORT ADMIN	76.4	$190,938	$11,988	15.4	0.11	77.7	77.06
SUNSET MEMRL GARDENS***	72.2	$180,375	$11,784	14.8	0.11	108	75.2
OSSWALD PARK REC CNTR***	59.8	$149,500	$10,697	13.6	0.10	107.1	68.72
HOLIDAY PARK – GYM	58.5	$146,250	$10,374	13.7	0.10	30.9	66.67
CARTER PARK - GYM	56.6	$141,375	$10,144	13.5	0.09	26.8	65.19
FIRE STATION NO. 3	55.9	$139,750	$9,145	14.8	0.08	31.5	58.75
GEORGE ENGLISH REC***	55.3	$138,125	$8,757	15.3	0.08	109.9	56.28
ARTS & SCIENCE PARKING***	53.6	$134,063	$9,853	13.2	0.09	109.3	63.5
EXECUTIVE AIRPORT AES	46.8	$117,000	$7,314	15.5	0.07	87.7	47.02
PARKING ADMIN.	43.6	$108,875	$7,765	13.6	0.07	55.8	49.91
CARTER PARK REC CENTER***	40.3	$100,750	$7,193	13.6	0.07	104.7	46.24
BEACH COMMUNITY CENTER	37.7	$94,250	$6,336	14.4	0.06	28.8	40.72
FIRE STATION NO. 53	32.5	$81,250	$5,093	15.4	0.05	6.2	30.82
LAUDERDALE MANORS REC	29.3	$73,125	$5,203	13.7	0.05	22.1	33.44
FIRE STATION NO. 13	22.8	$56,875	$4,065	13.6	0.04	18.4	26.16
FIRE STATION NO. 29	21.8	$54,438	$3,864	13.7	0.04	11.8	24.82
FIRE STATION / ADMIN/NO 2	21.5	$53,625	$3,837	13.6	0.04	3.5	24.67
CITY HALL	20.5	$51,200	$3,650	13.6	0.03	1.38	23.24
FIRE STATION NO. 47	17.9	$44,688	$3,196	13.6	0.03	9.6	20.57
FIRE STATION NO. 49	16.3	$40,625	$2,885	13.7	0.03	10.1	18.52
FIRE STATION NO. 35	15.6	$39,000	$2,433	15.5	0.02	8.6	15.62
FIRE STATION NO. 46	15.6	$39,000	$2,789	13.6	0.03	11.2	17.96
WARFIELD PARK REC CENTER	15	$37,375	$2,677	13.6	0.02	18	17.18
SNYDER PARK ADMIN OFC***	14.6	$36,563	$2,528	14	0.02	107.5	16.26
CARTER PARK ANNEX***	14.3	$35,750	$2,577	13.5	0.02	106.8	16.54
COAST GUARD STATION***	10.4	$26,000	$1,853	13.6	0.02	103.1	11.88
Totals:	2485.70	$6,212,392	$426,556	N/A	4%	N/A	2739.10

** System sizes are estimated based on easiest to implement areas at each building. Comprehensive field audits with qualified developers will be required to refine estimated production.*
***Project costs are estimated based on industry assumptions and should only be used as starting points for cost/benefit accounting.*
**** Denotes a "net zero" building if solar installation is pursued.*

Figure 8: Solar Project Size, Cost and Savings Tree Map. Size of square indicates pv power, shade of green indicates cost savings.



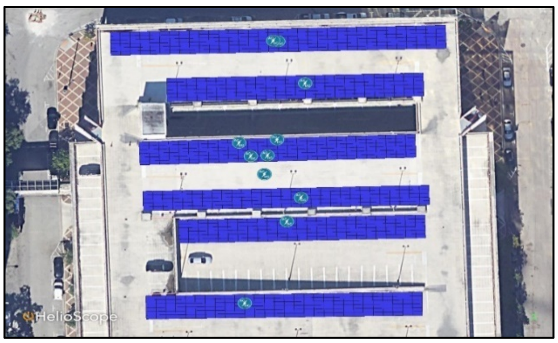
How to Interpret a Feasibility Analysis

Riverwalk Center Garage

[Facility name]

Meter Address: 150 SE 2nd Street
Location: 26.121277, -80.141972
Estimated Gross Square Footage: 1,000,000
Average Annual Consumption: 591,255 kWh

[Address listed by FPL]
[GPS coordinates of facility]
[Facility size]
[Electricity utilized per year]



[Potential design of photovoltaic array(s)]

System Design	
Production Estimate:	**531,000 kWh (annual) @ 322.1 kW (nameplate)**
Project Cost Estimate:	**$805,188**
Energy Cost Savings Estimate:	**$58,408 (annual)**
Reduction to Facility's Energy Load:	**83.5%**
Contribution to City Operations 20% Goal:	**0.54%**
Greenhouse Gas Emissions Reduction:	**375.42 metric tons (annual)**
Notes:	**Helipad at site (glare); shading on south side**

[Anticipated electricity production per year based on site design and wattage of modules selected]

[Conservative cost of materials only]

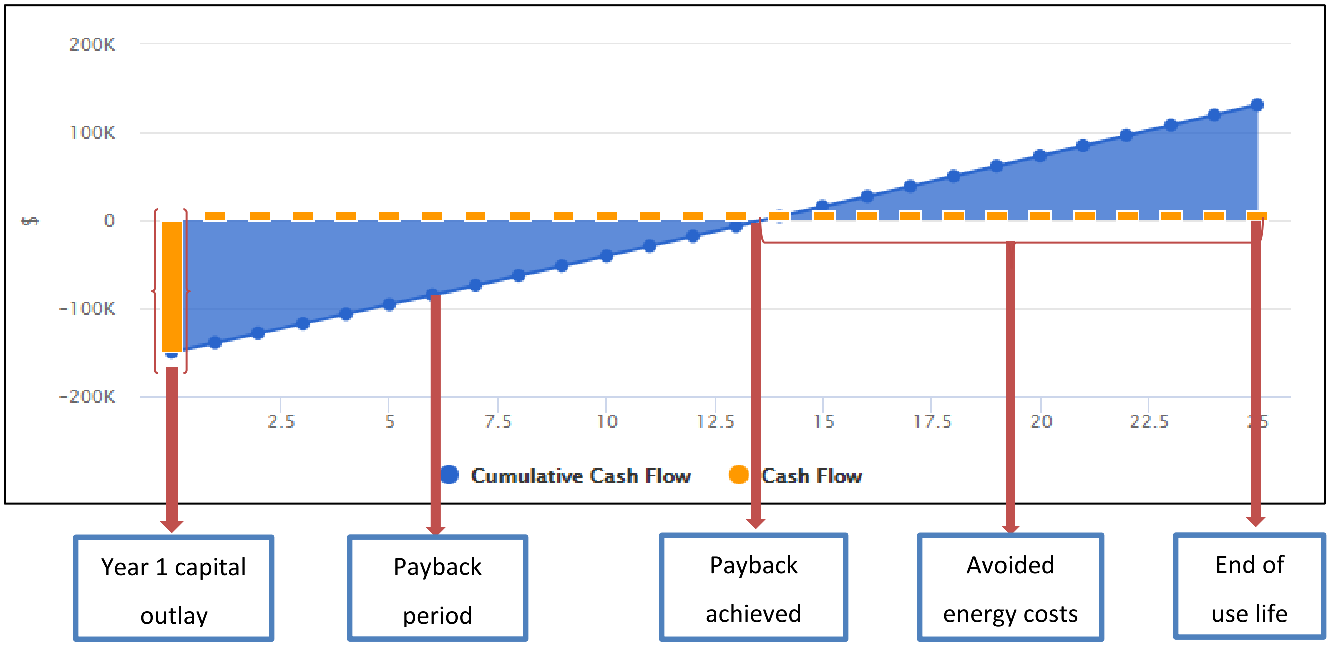
[Conservative annual savings from avoided electricity costs]

[Percent of electricity usage to be served by solar]

[Percentage this project contributes to 20% Goal]

[Emissions reduced from avoided usage of utility electricity]

[Facility-specific notes and considerations]



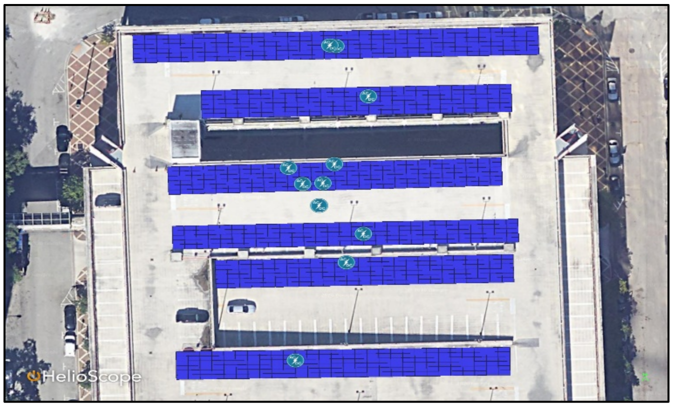
System Start	[Date system energizes]
Total Value of Energy	[Value of electricity generated based on current + annual escalation rate]
Lifetime Value (NPV)	[Net present value of the investment]
Internal Rate of Return (IRR)	[Estimated annual rate of return of the investment]
Return on Investment (ROI)	[Percent return of the investment. 100% = payback achieved]
Payback Period	[Time required to payback investment via avoided energy costs]
Levelized Cost of Energy	[Average cost of unit of energy factoring all project externalities]

**Note 1: All financial/production calculations are performed within the Helioscope modeling software and their respective methodologies are not provided to users for examination.*

**Note 2: All cost estimates are for standard materials only; hurricane-rated racking for rooftop and parking canopies will be required and may result in an additional cost premium.*

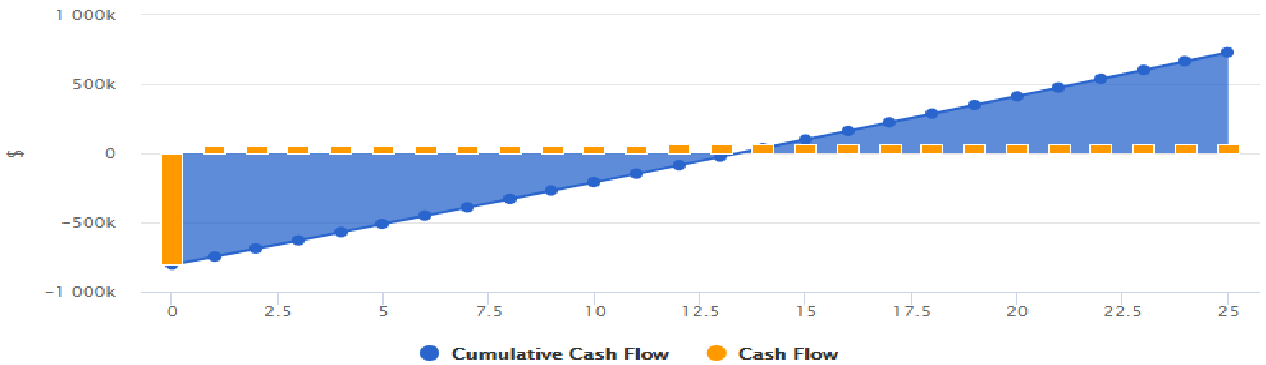
Riverwalk Center Garage

Meter Address: 150 SE 2nd Street
Location: 26.121277, -80.141972
Estimated Gross Square Footage: 1,000,000
Average Annual Consumption: 591,255 kWh



System Design	
Production Estimate:	**531,000 kWh (annual) @ 322.1 kW (nameplate)**
Project Cost Estimate:	**$805,188 (materials only)**
Energy Cost Savings Estimate:	**$58,408 (annual)**
Reduction to Facility's Energy Load:	**83.5%**
Contribution to City Operations 20% Goal:	**0.54%**
Greenhouse Gas Emissions Reduction:	**375.42 metric tons (annual)**
Notes:	**Parking Canopy Arrays; Helipad at site (glare); shading on south side; Minor loss to available parking**

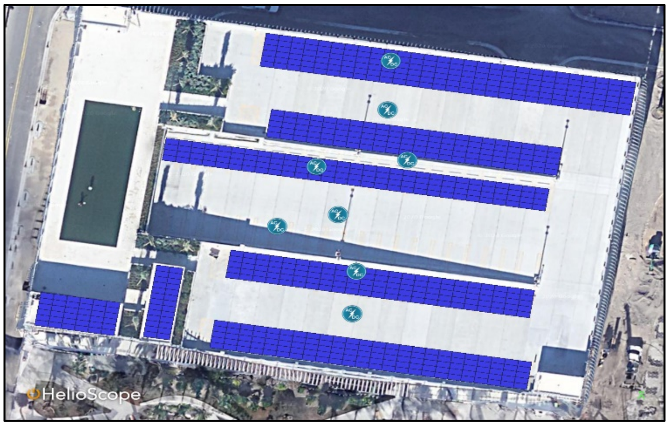
Financial Metrics



System Start	February 2021
Total Value of Energy	$1,534,368.70
Lifetime Value (NPV)	$257,584.02
Internal Rate of Return (IRR)	5.62%
Return on Investment (ROI)	190.56%
Payback Period	13.4 years
Levelized Cost of Energy	$0.09 / KWh

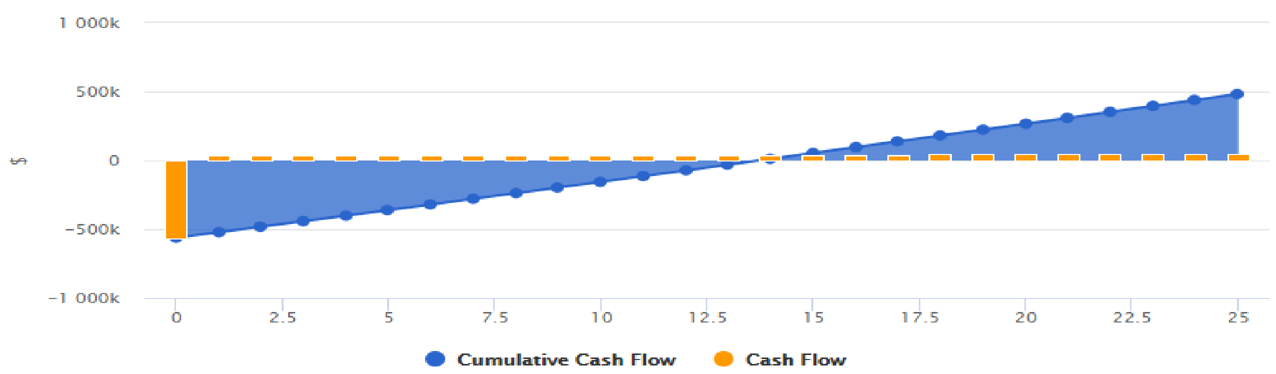
Las Olas Garage and Piers

Meter Address: 200-240 East Las Olas Circle
Location: 26.12005, -80.10741
Estimated Gross Square Footage: 251,100
Average Annual Consumption: 1,022,728kWh



System Design	
Production Estimate:	**361,300 kWh (annual) @ 224.6 kW (nameplate)**
Project Cost Estimate:	**$561,438 (materials only)**
Energy Cost Savings Estimate:	**$39,746 (annual)**
Reduction to Facility's Energy Load:	**35.3%**
Contribution to City Operations 20 % Goal:	**0.37%**
Greenhouse Gas Emissions Reduction:	**255.44 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays. Minor shading potential along garage boundaries; Minor loss to available parking**

Financial Metrics



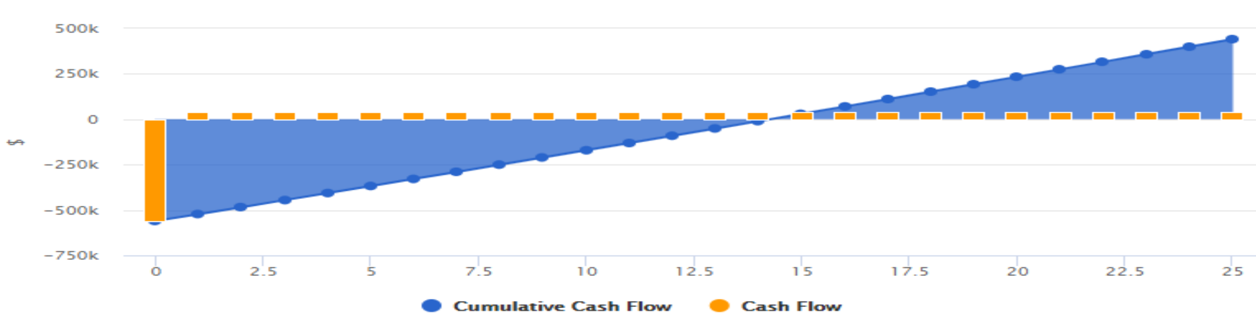
System Start	February 2021
Total Value of Energy	$1,044,121.29
Lifetime Value (NPV)	$161,766.98
Internal Rate of Return (IRR)	5.38%
Return on Investment (ROI)	185.97%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

Riverland Park Recreation Center

Meter Address: 950 SW 27th Avenue
Location: 26.110234, -80.17748
Estimated Gross Square Footage: 3,380
Average Annual Consumption: 331,272 kWh

System Design	
Production Estimate:	**346,700 kWh (annual) @ 224.3 kW (nameplate)**
Project Cost Estimate:	**$560,625 (materials only)**
Energy Cost Savings Estimate:	**$38,137 (annual)**
Reduction to Facility's Energy Load:	**101.4%**
Contribution to City Operations 20% Goal:	**0.35%**
Greenhouse Gas Emissions Reduction:	**245.12 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays. Potential shading impacts from tree canopy; Potential roof replacement required; Minor loss to available parking; Net-zero (all accounts on site); ~1% grid export capacity**

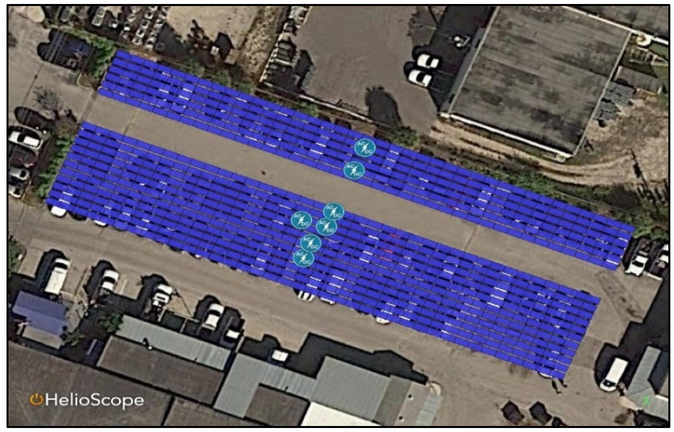
Financial Metrics



System Start	February 2021
Total Value of Energy	$1,001,842.28
Lifetime Value (NPV)	$133,295.30
Internal Rate of Return (IRR)	4.98%
Return on Investment (ROI)	178.70%
Payback Period	14.3 years
Levelized Cost of Energy	$0.10 / KWh

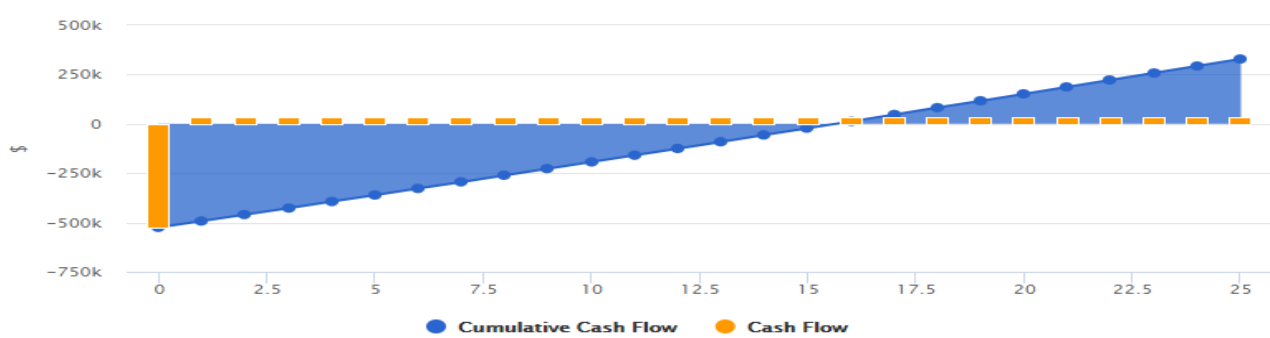
Central Maintenance Shop

Meter Address: 4250 NW 10th Avenue
Location: 26.17876, -80.15747
Estimated Gross Square Footage: 13,100
Average Annual Consumption: 335,030 kWh



System Design	
Production Estimate:	**295,400 kWh (annual) @ 210 kW (nameplate)**
Project Cost Estimate:	**$524,875 (materials only)**
Energy Cost Savings Estimate:	**$32,493 (annual)**
Reduction to Facility's Energy Load:	**87.6%**
Contribution to City Operations 20% Goal:	**0.30%**
Greenhouse Gas Emissions Reduction:	**208.85 metric tons (annual)**
Notes:	**Parking Canopies. Calculations include auxiliary building on site; Minor loss to available parking; Overhead clearance for work vehicles may be required**

Financial Metrics



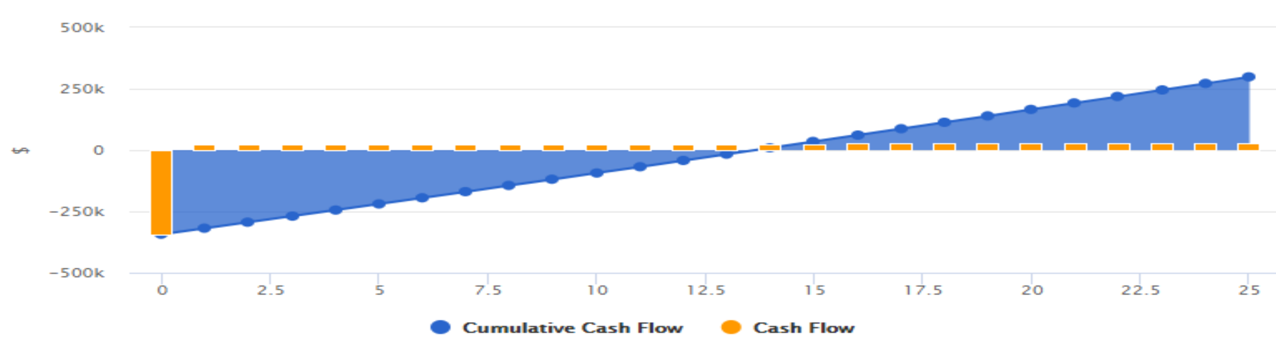
System Start	January 2021
Total Value of Energy	$853,644.70
Lifetime Value (NPV)	$66,395.69
Internal Rate of Return (IRR)	4.08%
Return on Investment (ROI)	162.64%
Payback Period	15.6 years
Levelized Cost of Energy	$0.11 / KWh

South Side School

Meter Address: 701 South Andrews Avenue
Location: 26.11261, -80.14353
Estimated Gross Square Footage: 11,805
Average Annual Consumption: 208,320 kWh

System Design	
Production Estimate:	**222,000 kWh (annual) @ 137.2 kW (nameplate)**
Project Cost Estimate:	**$342,875 (materials only)**
Energy Cost Savings Estimate:	**$24,417 (annual)**
Reduction to Facility's Energy Load:	**106.6%**
Contribution to City Operations 20% Goal:	**0.23%**
Greenhouse Gas Emissions Reduction:	**157 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays; Potential shading impacts from tree canopy; Net-zero; ~7% export capacity; Minor loss to available parking**

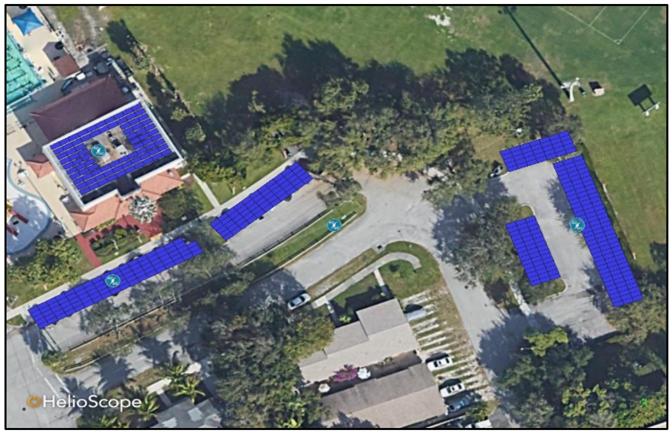
Financial Metrics



System Start	February 2021
Total Value of Energy	$641,441.41
Lifetime Value (NPV)	$101,415.67
Internal Rate of Return (IRR)	5.44%
Return on Investment (ROI)	187.08%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

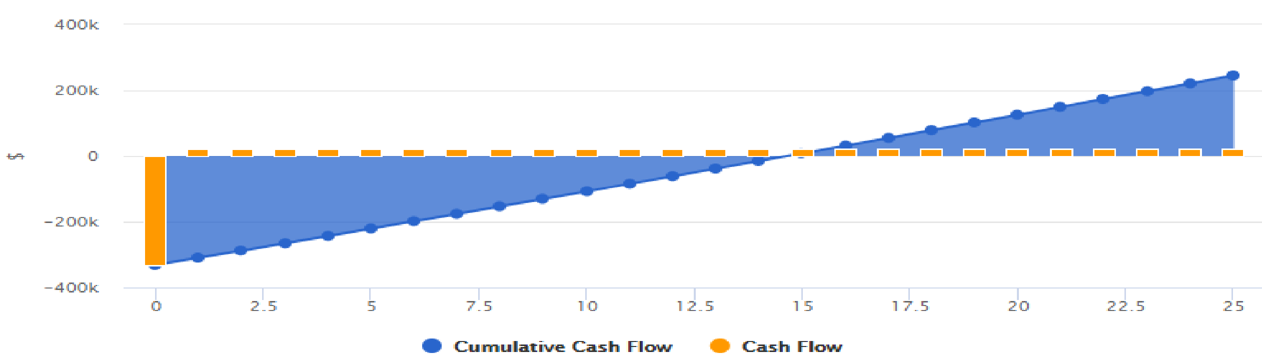
Croissant Park Community Center

Meter Address: 1800 SW 4th Avenue
Location: 26.098643, -80.14502
Estimated Gross Square Footage: 5,354
Average Annual Consumption: 260,557 kWh



System Design	
Production Estimate:	**199,600 kWh (annual) @ 132.6 kW (nameplate)**
Project Cost Estimate:	**$331,500 (materials only)**
Energy Cost Savings Estimate:	**$21,953 (annual)**
Reduction to Facility's Energy Load:	**75.4%**
Contribution to City Operations 20% Goal:	**0.20%**
Greenhouse Gas Emissions Reduction:	**141.12 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays; Shading impacts from tree canopies near parking; Minor loss to available parking**

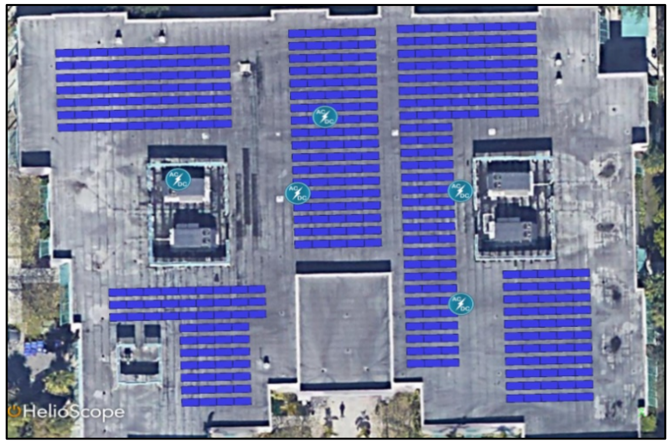
Financial Metrics



System Start	February 2021
Total Value of Energy	$576,520.13
Lifetime Value (NPV)	$67,827.01
Internal Rate of Return (IRR)	4.72%
Return on Investment (ROI)	173.91%
Payback Period	14.6 years
Levelized Cost of Energy	$0.10 / KWh

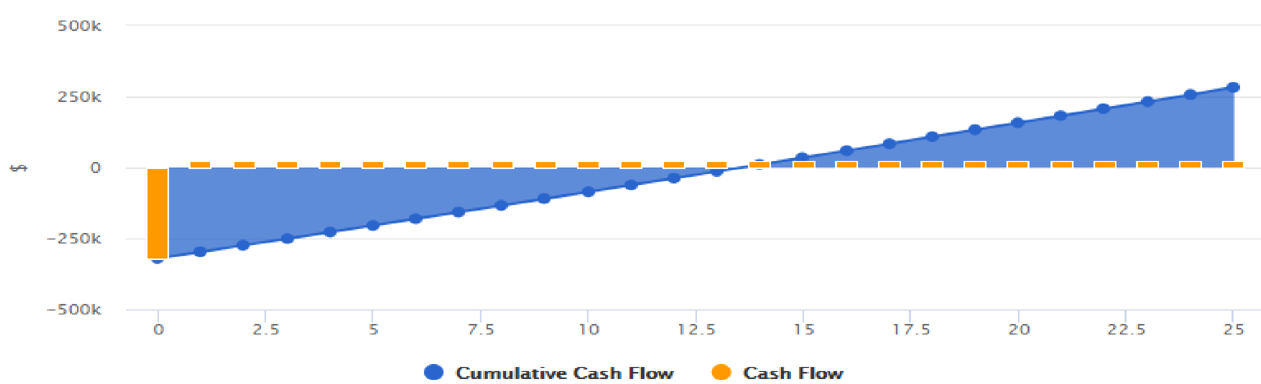
Buildings Service Center (DSD)

Meter Address: 700 NW 19th Avenue
Location: 26.130992, -80.166643
Estimated Gross Square Footage: 43,000
Average Annual Consumption: 866,430 kWh



System Design	
Production Estimate:	**208,600 kWh (annual) @ 128.1 kW (nameplate)**
Project Cost Estimate:	**$320,125 (materials only)**
Energy Cost Savings Estimate:	**$22,943 (annual)**
Reduction to Facility's Energy Load:	**25.8%**
Contribution to City Operations 20% Goal:	**0.21%**
Greenhouse Gas Emissions Reduction:	**147.48 metric tons (annual)**
Notes:	**Rooftop Array; Potential roof condition issue reported; Minor loss to available parking**

Financial Metrics



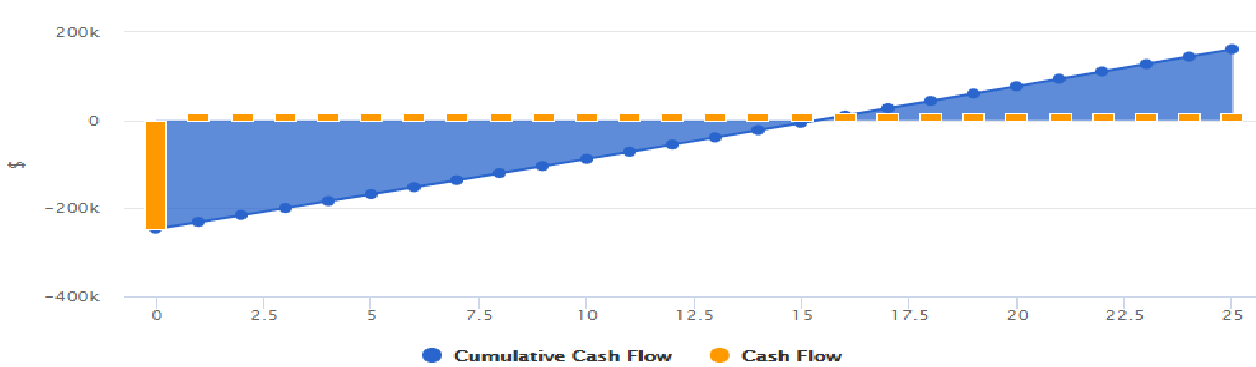
System Start	January 2021
Total Value of Energy	$602,707.99
Lifetime Value (NPV)	$97,337.17
Internal Rate of Return (IRR)	5.50%
Return on Investment (ROI)	188.27%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

Floyd Hull Park Campus

Meter Address: 2800 8th Avenue
Location: 26.087611, -80.1504
Estimated Gross Square Footage: 6,350
Average Annual Consumption: 149,936 kWh

System Design	
Production Estimate:	**141,100 kWh (annual) @ 98.5 kW (nameplate)**
Project Cost Estimate:	**$246,188 (materials only)**
Energy Cost Savings Estimate:	**$15,524 (annual)**
Reduction to Facility's Energy Load:	**106.1%**
Contribution to City Operations 20% Goal:	**0.14%**
Greenhouse Gas Emissions Reduction:	**99.76 metric tons (annual)**
Notes:	**Rooftop Arrays; Potential shading impacts from tree canopy; Net-zero (all accounts on site); ~6% grid export capacity**

Financial Metrics



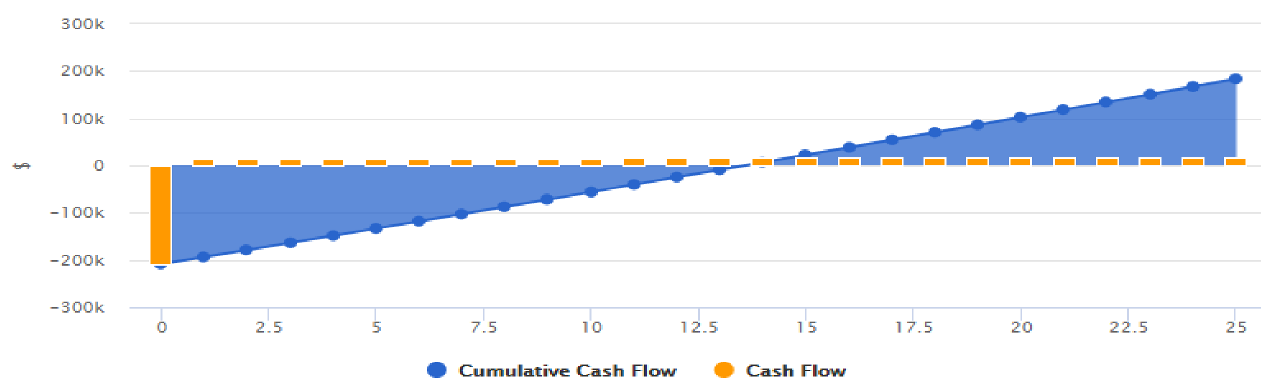
System Start	February 2021
Total Value of Energy	$407,677.86
Lifetime Value (NPV)	$36,190.84
Internal Rate of Return (IRR)	4.25%
Return on Investment (ROI)	165.60%
Payback Period	15.4 years
Levelized Cost of Energy	$0.11 / KWh

Holiday Park Activity Center

Meter Address: 736 North Federal Highway
Location: 26.132971, -80.137240
Estimated Gross Square Footage: 22,496
Average Annual Consumption: 287,880 kWh

System Design	
Production Estimate:	**135,800 kWh (annual) @ 83.5 kW (nameplate)**
Project Cost Estimate:	**$208,813 (materials only)**
Energy Cost Savings Estimate:	**$14,935 (annual)**
Reduction to Facility's Energy Load:	**48.6**
Contribution to City Operations 20% Goal:	**0.14%**
Greenhouse Gas Emissions Reduction:	**96.01 metric tons (annual)**
Notes:	**Rooftop Array; Shade impacts from the southeast corner**

Financial Metrics



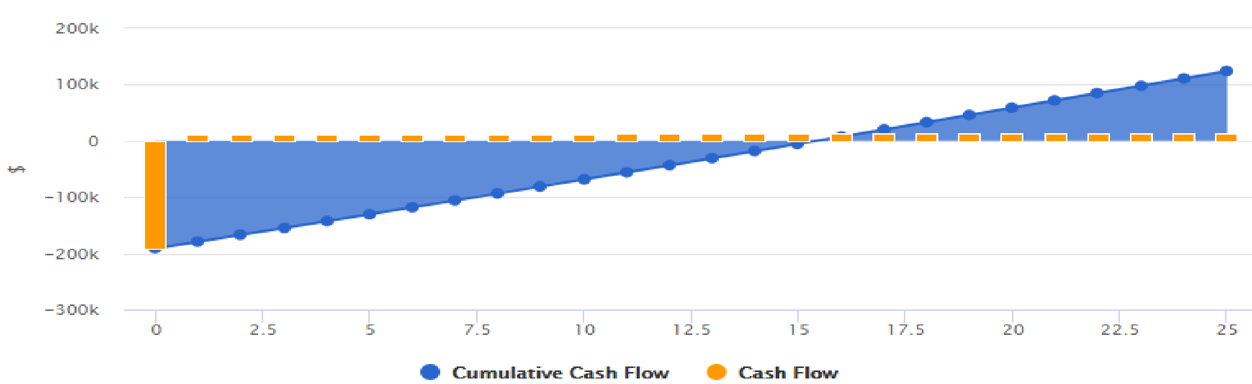
System Start	January 2021
Total Value of Energy	$392,349.95
Lifetime Value (NPV)	$62,946.39
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.90%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

Executive Airport Administration

Meter Address: 6000 NW 21st Avenue
Location: 26.200558, -80.171383
Estimated Gross Square Footage: 10,000
Average Annual Consumption: 125,765 kWh

System Design	
Production Estimate:	**108,000 kWh (annual) @ 76.4 kW (nameplate)**
Project Cost Estimate:	**$109,938 (materials only)**
Energy Cost Savings Estimate:	**$11,988 (annual)**
Reduction to Facility's Energy Load:	**77.7%**
Contribution to City Operations 20% Goal:	**0.11%**
Greenhouse Gas Emissions Reduction:	**77.06 metric tons (annual)**
Notes:	**Rooftop Array; Potential for FAA compliance for glare mitigation**

Financial Metrics



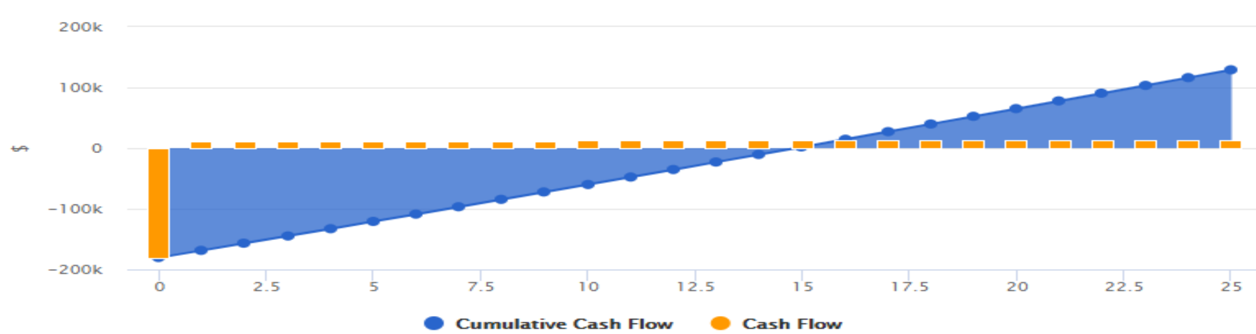
System Start	January 2021
Total Value of Energy	$314,951.14
Lifetime Value (NPV)	$27,210.93
Internal Rate of Return (IRR)	4.21%
Return on Investment (ROI)	164.95%
Payback Period	15.4 years
Levelized Cost of Energy	$0.11 / KWh

Sunset Memorial Gardens

Meter Address: 321 NW 19th Street
Location: 26.152211, -80.19235
Estimated Gross Square Footage: 2,475
Average Annual Consumption: 99,201 kWh

System Design	
Production Estimate:	**107,100 kWh (annual) @ 72.2 kW (nameplate)**
Project Cost Estimate:	**$180,375 (materials only)**
Energy Cost Savings Estimate:	**$11,784 (annual)**
Reduction to Facility's Energy Load:	**108%**
Contribution to City Operations 20% Goal:	**0.11%**
Greenhouse Gas Emissions Reduction:	**75.2 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays; Potential shading impacts from tree canopy; Net-zero (all accounts on site); ~8% grid export capacity; Minor loss to available parking**

Financial Metrics



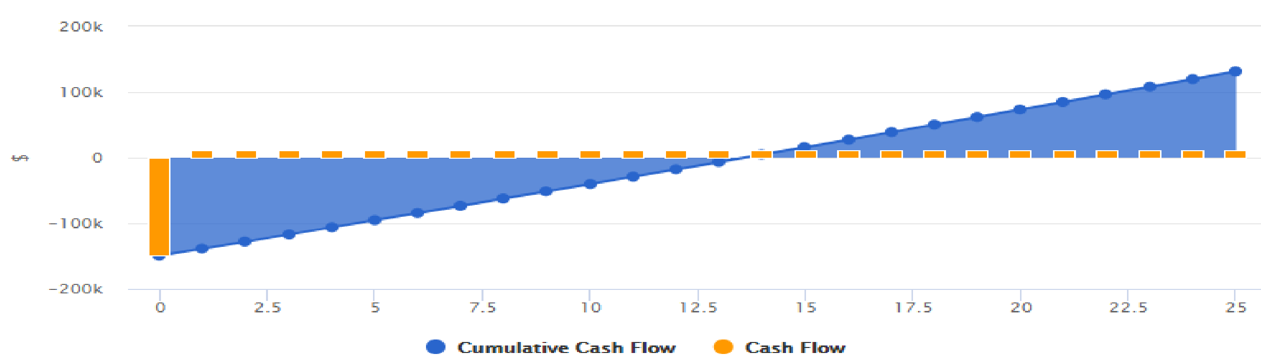
System Start	February 2021
Total Value of Energy	$309,549.48
Lifetime Value (NPV)	$34,032.70
Internal Rate of Return (IRR)	4.59%
Return on Investment (ROI)	171.61%
Payback Period	14.8 years
Levelized Cost of Energy	$0.10 / KWh

Osswald Park Recreation Center

Meter Address: 2250 NW 21st Avenue
Location: 26.156054, -80.17018
Estimated Gross Square Footage: 6,000
Average Annual Consumption: 94,661 kWh

System Design	
Production Estimate:	**97,200 kWh (annual) @ 59.8 kW (nameplate)**
Project Cost Estimate:	**$149,500 (materials only)**
Energy Cost Savings Estimate:	**$10,697 (annual)**
Reduction to Facility's Energy Load:	**107.1%**
Contribution to City Operations 20% Goal:	**0.10%**
Greenhouse Gas Emissions Reduction:	**68.72 metric tons (annual)**
Notes:	**Parking Canopy Array; Net-zero; ~7% grid export capacity; Shading impacts from tree canopies near parking; Minor loss to available parking**

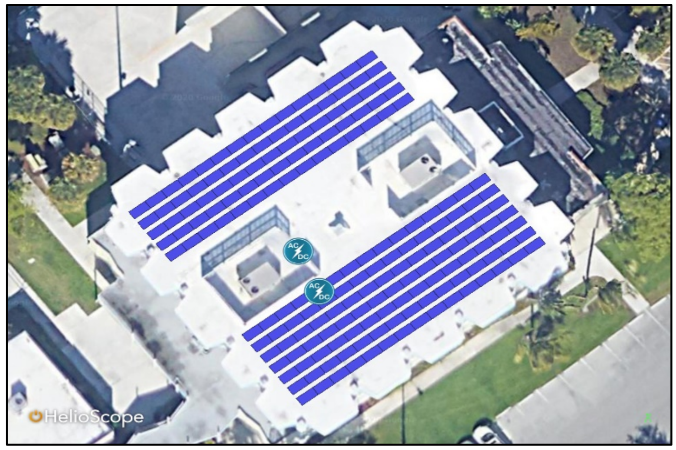
Financial Metrics



System Start	February 2021
Total Value of Energy	$281,001.29
Lifetime Value (NPV)	$45,133.91
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.96%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

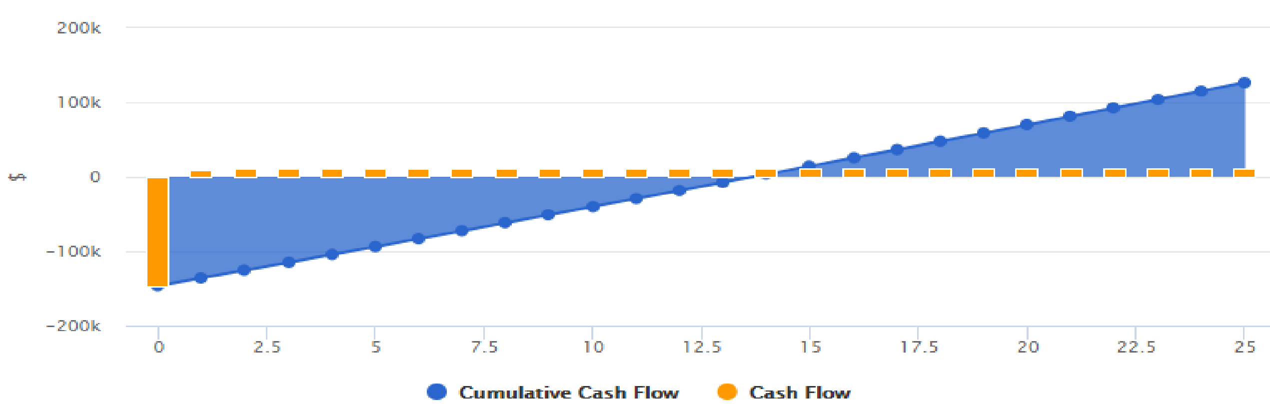
Holiday Park Gymnasium

Meter Address: 1200 G. Martin Harold Drive
Location: 26.132902, -80.1323
Estimated Gross Square Footage: 14,500
Average Annual Consumption: 282,390 kWh



System Design	
Production Estimate:	**94,300 kWh (annual) @ 58.5 kW (nameplate)**
Project Cost Estimate:	**$146,250 (materials only)**
Energy Cost Savings Estimate:	**$10,374 (annual)**
Reduction to Facility's Energy Load:	**30.9%**
Contribution to City Operations 20% Goal:	**0.10%**
Greenhouse Gas Emissions Reduction:	**66.67 metric tons (annual)**
Notes:	**Rooftop Array; Potential roof replacement required**

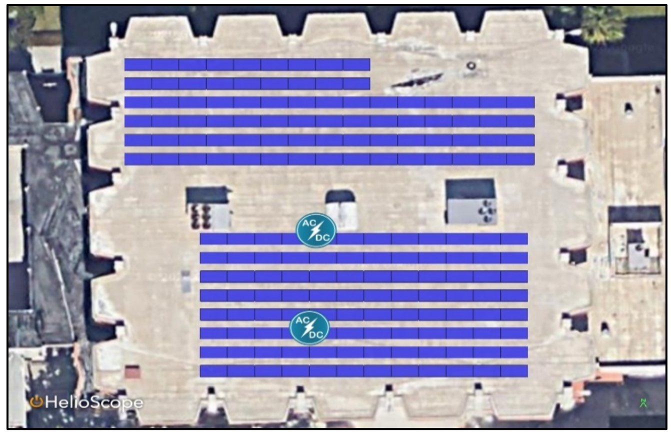
Financial Metrics



System Start	January 2021
Total Value of Energy	$272,526.89
Lifetime Value (NPV)	$42,514.19
Internal Rate of Return (IRR)	5.40%
Return on Investment (ROI)	186.34%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

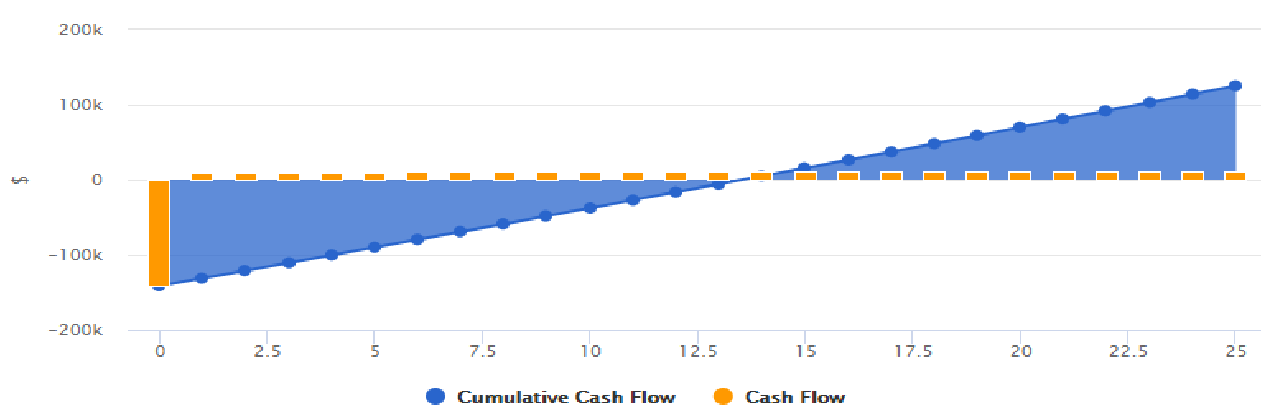
Carter Park - Gymnasium

Meter Address: 1450 West Sunrise Blvd
Location: 26.135959, -80.16137
Estimated Gross Square Footage: 13,139
Average Annual Consumption: 311,010 kWh



System Design	
Production Estimate:	**92,200 kWh (annual) @ 56.6 kW (nameplate)**
Project Cost Estimate:	**$141,375 (materials only)**
Energy Cost Savings Estimate:	**$10,144 (annual)**
Reduction to Facility's Energy Load:	**26.8%**
Contribution to City Operations 20% Goal:	**0.09%**
Greenhouse Gas Emissions Reduction:	**65.19 metric tons (annual)**
Notes:	**Rooftop Array; Potential roof replacement required**

Financial Metrics



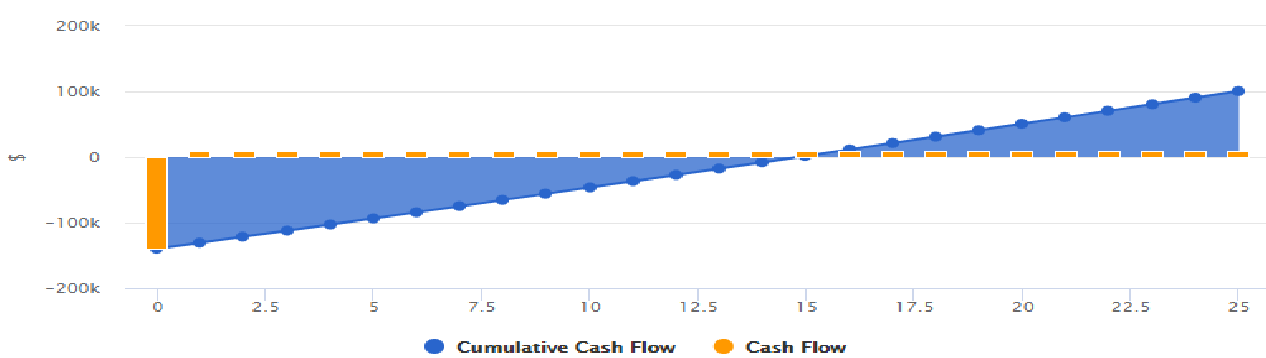
System Start	January 2021
Total Value of Energy	$266,474.15
Lifetime Value (NPV)	$43,196.75
Internal Rate of Return (IRR)	5.51%
Return on Investment (ROI)	188.49%
Payback Period	13.5 years
Levelized Cost of Energy	$0.09 / KWh

Fire Station No. 3

Meter Address: 2801 Southwest 4th Avenue
Location: 26.0887198, -80.14724
Estimated Gross Square Footage: 8,742
Average Annual Consumption: 266,940 kWh

System Design	
Production Estimate:	**83,100 kWh (annual) @ 55.9 kW (nameplate)**
Project Cost Estimate:	**$139,750 (materials only)**
Energy Cost Savings Estimate:	**$9,145 (annual)**
Reduction to Facility's Energy Load:	**31.5%**
Contribution to City Operations 20% Goal:	**0.08%**
Greenhouse Gas Emissions Reduction:	**58.75 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays; Potential shading from nearby tree canopy; Minor loss to available parking**

Financial Metrics



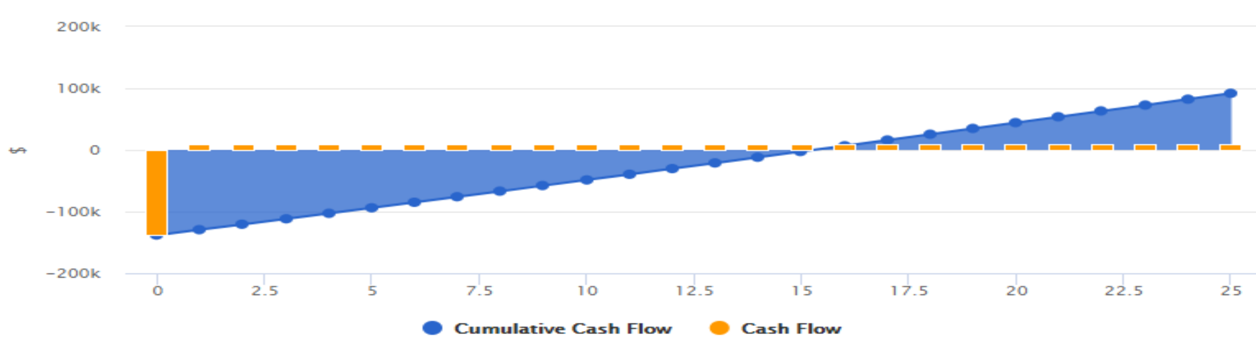
System Start	February 2021
Total Value of Energy	$240,156.00
Lifetime Value (NPV)	$26,594.22
Internal Rate of Return (IRR)	4.60%
Return on Investment (ROI)	171.85%
Payback Period	14.8 years
Levelized Cost of Energy	$0.10 / KWh

George English Park Recreation Center

Meter Address: 1101 Bayview Drive
Location: 26.1401854, -80.1159771
Estimated Gross Square Footage: 3,149
Average Annual Consumption: 69,963 kWh

System Design	
Production Estimate:	**79,600 kWh (annual) @ 55.3 kW (nameplate)**
Project Cost Estimate:	**$138,125 (materials only)**
Energy Cost Savings Estimate:	**$8,757 (annual)**
Reduction to Facility's Energy Load:	**109.9%**
Contribution to City Operations 20% Goal:	**0.08%**
Greenhouse Gas Emissions Reduction:	**56.28 metric tons (annual)**
Notes:	**Parking Canopy Arrays; Potential shading impacts from tree canopy; Net-zero (all accounts on site); ~10% grid export capacity; Minor loss to available parking**

Financial Metrics



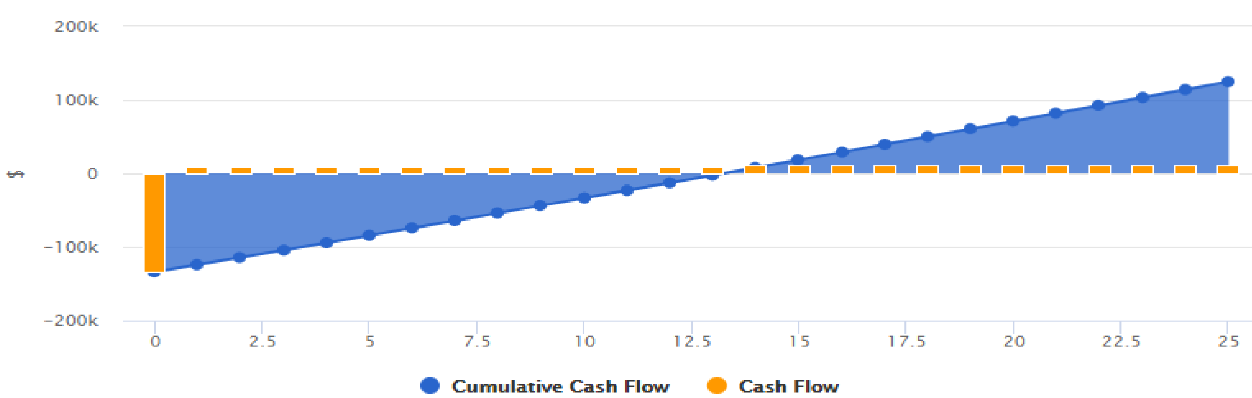
System Start	February 2021
Total Value of Energy	$230,035.53
Lifetime Value (NPV)	$21,207.81
Internal Rate of Return (IRR)	4.30%
Return on Investment (ROI)	166.54%
Payback Period	15.3 years
Levelized Cost of Energy	$0.11 / KWh

Arts and Science Parking (PACA)

Meter Address: 101 SW 5th Avenue
Location: 26.121058, -80.149052
Estimated Gross Square Footage: 295,920
Average Annual Consumption: 81,632 kWh

System Design	
Production Estimate:	**89,600 kWh (annual) @ 53.6 kW (nameplate)**
Project Cost Estimate:	**$134,063 (materials only)**
Energy Cost Savings Estimate:	**$9,853 (annual)**
Reduction to Facility's Energy Load:	**109.3%**
Contribution to City Operations 20% Goal:	**0.09%**
Greenhouse Gas Emissions Reduction:	**63.35 metric tons (annual)**
Notes:	**Parking Canopy Array; Net-zero; ~9% export capacity; Minor loss to available parking**

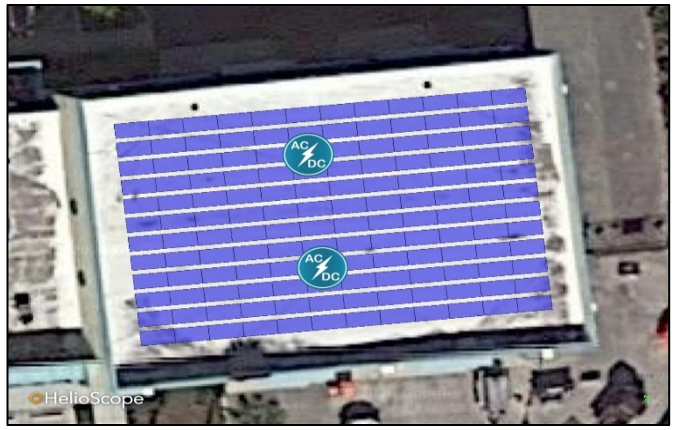
Financial Metrics



System Start	January 2021
Total Value of Energy	$258,841.45
Lifetime Value (NPV)	$45,222.47
Internal Rate of Return (IRR)	5.76%
Return on Investment (ROI)	193.08%
Payback Period	13.2 years
Levelized Cost of Energy	$0.09 / KWh

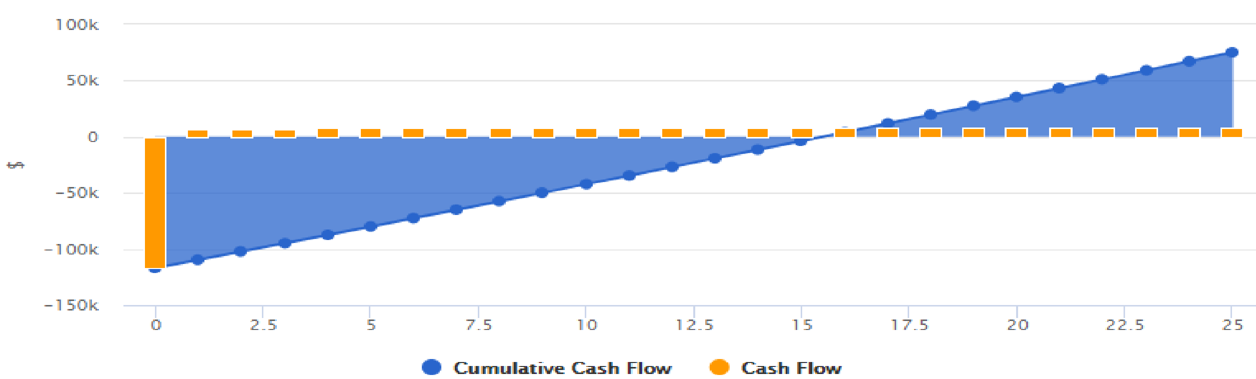
Executive Airport AES

Meter Address: 2020 Executive Airport Way
Location: 26.132751, -80.132772
Estimated Gross Square Footage: 7,745
Average Annual Consumption: 77,485 kWh



System Design	
Production Estimate:	**66,500 kWh (annual) @ 46.8 kW (nameplate)**
Project Cost Estimate:	**$117,000 (materials only)**
Energy Cost Savings Estimate:	**$7,314 (annual)**
Reduction to Facility's Energy Load:	**87.7%**
Contribution to City Operations 20% Goal:	**0.07%**
Greenhouse Gas Emissions Reduction:	**47.02 metric tons (annual)**
Notes:	**Rooftop Array; Potential for FAA compliance for glare mitigation**

Financial Metrics



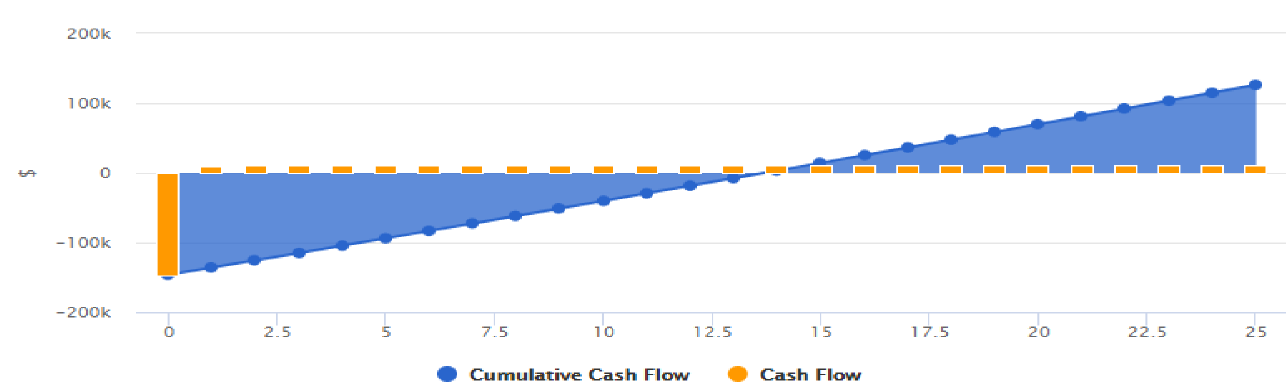
System Start	January 2021
Total Value of Energy	$192,148.35
Lifetime Value (NPV)	$16,090.04
Internal Rate of Return (IRR)	4.17%
Return on Investment (ROI)	164.23%
Payback Period	15.5 years
Levelized Cost of Energy	$0.11 / KWh

TAM Parking Administration

Meter Address: 290 NE 3rd Avenue
Location: 26.12496815, -80.140309
Estimated Gross Square Footage: 14,449
Average Annual Consumption: 125,760 kWh

System Design	
Production Estimate:	**70,600 kWh (annual) @ 43.6 kW (nameplate)**
Project Cost Estimate:	**$108,875 (materials only)**
Energy Cost Savings Estimate:	**$7,765 (annual)**
Reduction to Facility's Energy Load:	**55.8%**
Contribution to City Operations 20% Goal:	**0.07%**
Greenhouse Gas Emissions Reduction:	**49.91 metric tons (annual)**
Notes:	**Rooftop Array; Potential for shading from south east**

Financial Metrics



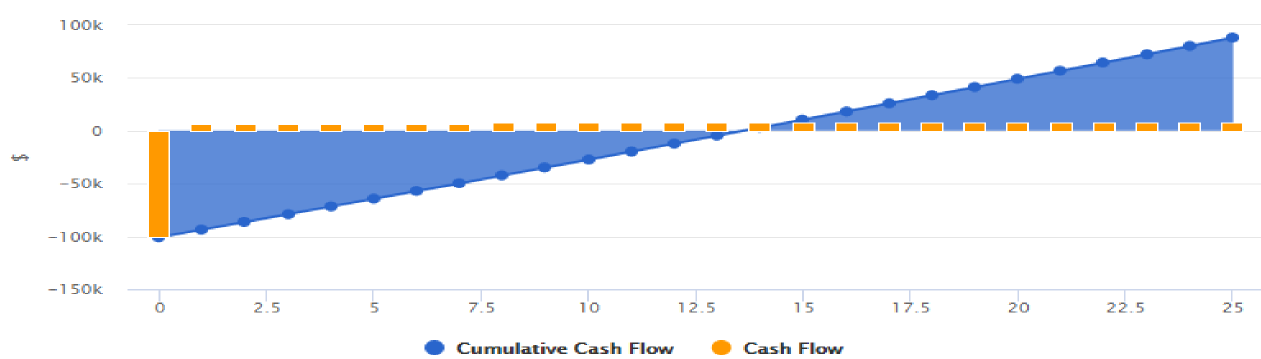
System Start	January 2021
Total Value of Energy	$272,526.89
Lifetime Value (NPV)	$42,514.19
Internal Rate of Return (IRR)	5.40%
Return on Investment (ROI)	186.34%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

Carter Park – Recreation Center

Meter Address: 1450 West Sunrise Blvd
Location: 26.1348010, -80.161917
Estimated Gross Square Footage: 2,140
Average Annual Consumption: 62,000 kWh

System Design	
Production Estimate:	**65,400 kWh (annual) @ 14.3 kW (nameplate)**
Project Cost Estimate:	**$100,750 (materials only)**
Energy Cost Savings Estimate:	**$7,193 (annual)**
Reduction to Facility's Energy Load:	**104.7%**
Contribution to City Operations 20% Goal:	**0.07%**
Greenhouse Gas Emissions Reduction:	**46.24 metric tons (annual)**
Notes:	**Rooftop and Parking Canopy Arrays; Potential roof replacement required; Net-zero; ~5% grid export capacity; Minor loss to available parking**

Financial Metrics



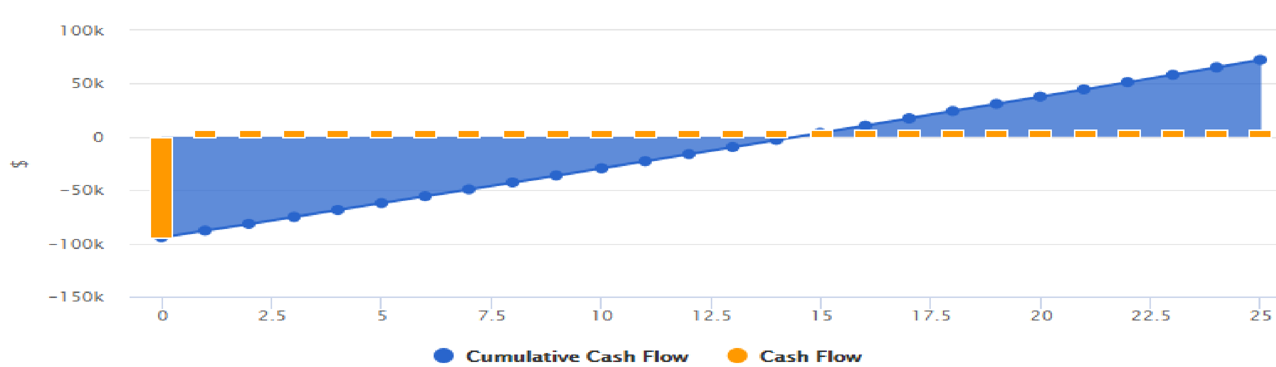
System Start	February 2021
Total Value of Energy	$188,953.78
Lifetime Value (NPV)	$30,127.72
Internal Rate of Return (IRR)	5.46%
Return on Investment (ROI)	187.55%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

Beach Community Center

Meter Address: 3351 NE 33rd Avenue
Location: 26.169696, -80.10241
Estimated Gross Square Footage: 12,573
Average Annual Consumption: 222,360 kWh

System Design	
Production Estimate:	**57,600 kWh (annual) @ 37.7 kW (nameplate)**
Project Cost Estimate:	**$94,250 (materials only)**
Energy Cost Savings Estimate:	**$6,336 (annual)**
Reduction to Facility's Energy Load:	**28.8%**
Contribution to City Operations 20% Goal:	**0.06%**
Greenhouse Gas Emissions Reduction:	**40.72 metric tons (annual)**
Notes:	**Rooftop Arrays; Site has small PV system in place that needs to be integrated with a newer installation**

Financial Metrics



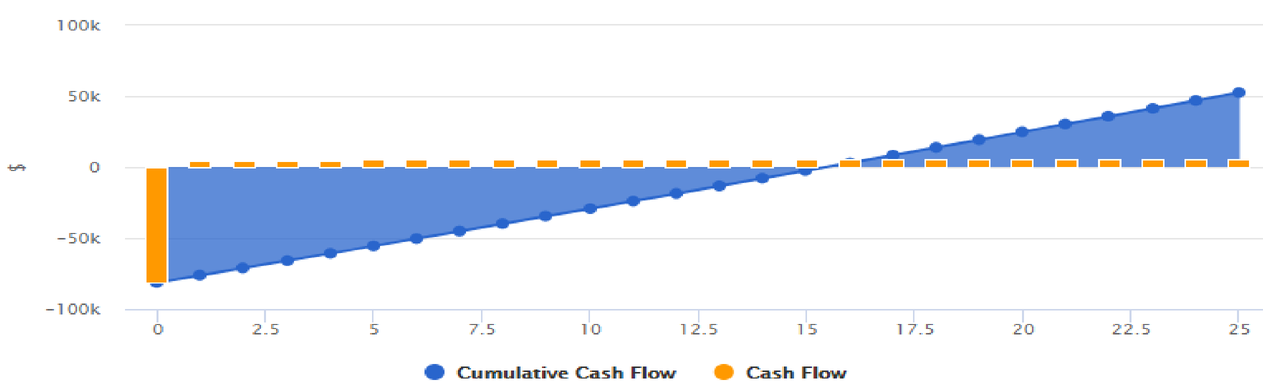
System Start	January 2021
Total Value of Energy	$166,432.21
Lifetime Value (NPV)	$21,028.32
Internal Rate of Return (IRR)	4.87%
Return on Investment (ROI)	176.59%
Payback Period	14.4 years
Levelized Cost of Energy	$0.10 / KWh

Fire Station No. 53

Meter Address: 2200 Executive Airport Way
Location: 26.200595, -80.173058
Estimated Gross Square Footage: 27,310
Average Annual Consumption: 706,800 kWh

System Design	
Production Estimate:	**46,300 kWh (annual) @ 32.5 kW (nameplate)**
Project Cost Estimate:	**$81,250 (materials only)**
Energy Cost Savings Estimate:	**$5,093 (annual)**
Reduction to Facility's Energy Load:	**6.2%**
Contribution to City Operations 20% Goal:	**0.05%**
Greenhouse Gas Emissions Reduction:	**30.82 metric tons (annual)**
Notes:	**Rooftop Arrays; Potential FAA issues due to glare requirements**

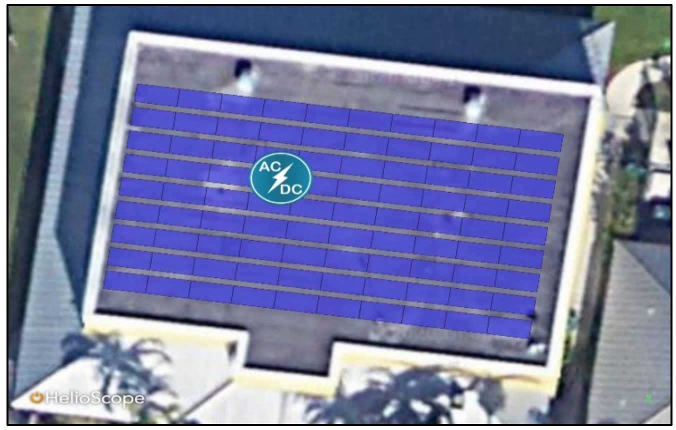
Financial Metrics



System Start	January 2021
Total Value of Energy	$133,809.87
Lifetime Value (NPV)	$11,432.35
Internal Rate of Return (IRR)	4.20%
Return on Investment (ROI)	164.69%
Payback Period	15.4 years
Levelized Cost of Energy	$0.11 / KWh

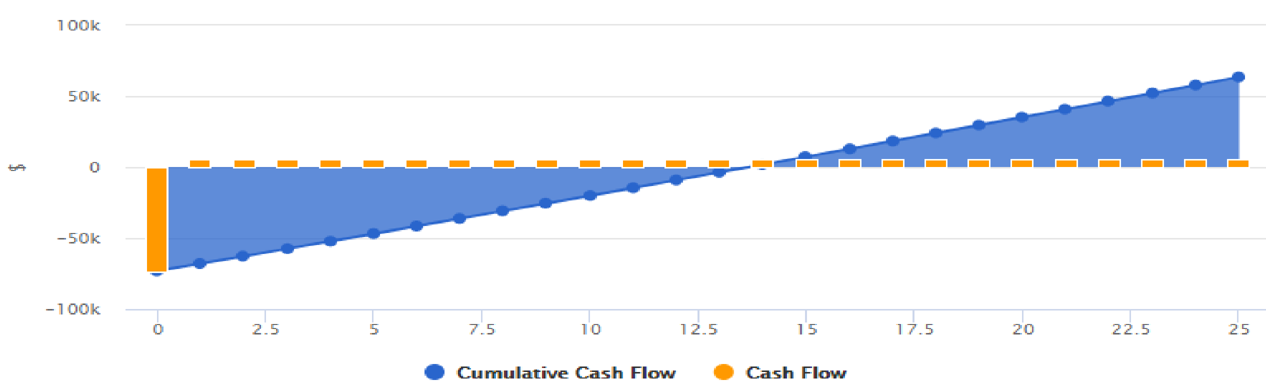
Lauderdale Manors Recreation Center

Meter Address: 1340 Chateau Park Drive
Location: 26.1428477, -80.16018
Estimated Gross Square Footage: 4,399
Average Annual Consumption: 210,840 kWh



System Design	
Production Estimate:	**47,300 kWh (annual) @ 29.3 kW (nameplate)**
Project Cost Estimate:	**$73,125 (materials only)**
Energy Cost Savings Estimate:	**$5,203 (annual)**
Reduction to Facility's Energy Load:	**22.1%**
Contribution to City Operations 20% Goal:	**0.05%**
Greenhouse Gas Emissions Reduction:	**33.44 metric tons (annual)**
Notes:	**Rooftop Array; Additional periphery setback may be required**

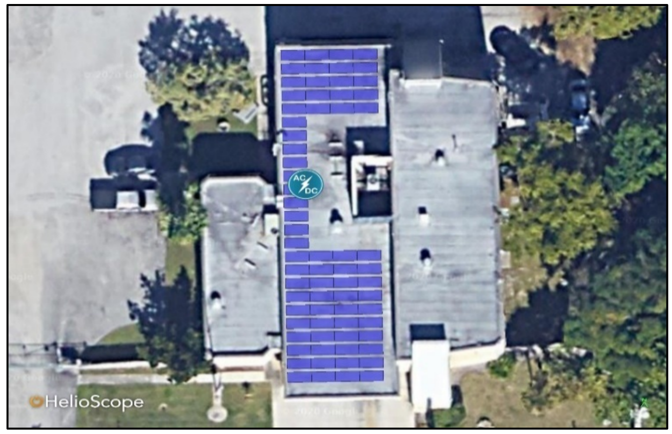
Financial Metrics



System Start	January 2021
Total Value of Energy	$136,675.69
Lifetime Value (NPV)	$21,542.62
Internal Rate of Return (IRR)	5.43%
Return on Investment (ROI)	186.91%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

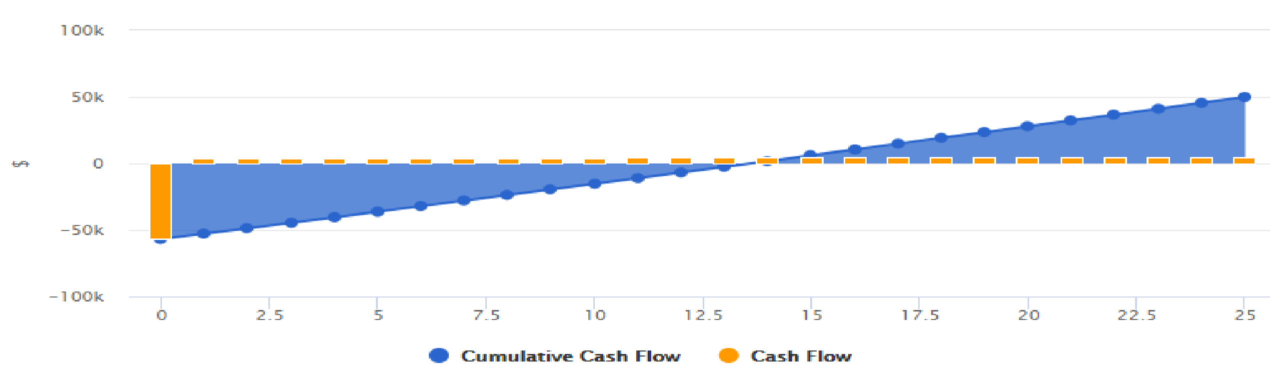
Fire Station No. 13

Meter Address: 2871 East Sunrise Blvd.
Location: 26.13837, -80.1065
Estimated Gross Square Footage: 6,100
Average Annual Consumption: 199,680 kWh



System Design	
Production Estimate:	**37,000 kWh (annual) @ 22.8 kW (nameplate)**
Project Cost Estimate:	**$56,875 (materials only)**
Energy Cost Savings Estimate:	**$4,065 (annual)**
Reduction to Facility's Energy Load:	**18.4%**
Contribution to City Operations 20% Goal:	**0.04%**
Greenhouse Gas Emissions Reduction:	**26.16 metric tons (annual)**
Notes:	**Rooftop Array; Potential early morning shading impact; Additional periphery setback may be required**

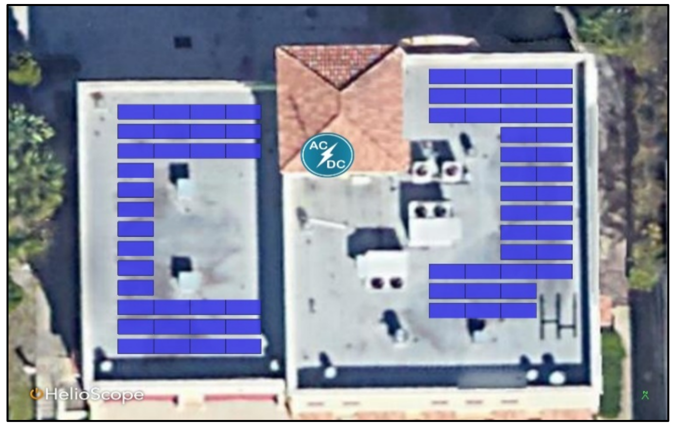
Financial Metrics



System Start	January 2021
Total Value of Energy	$106,790.83
Lifetime Value (NPV)	$17,093.04
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.76%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

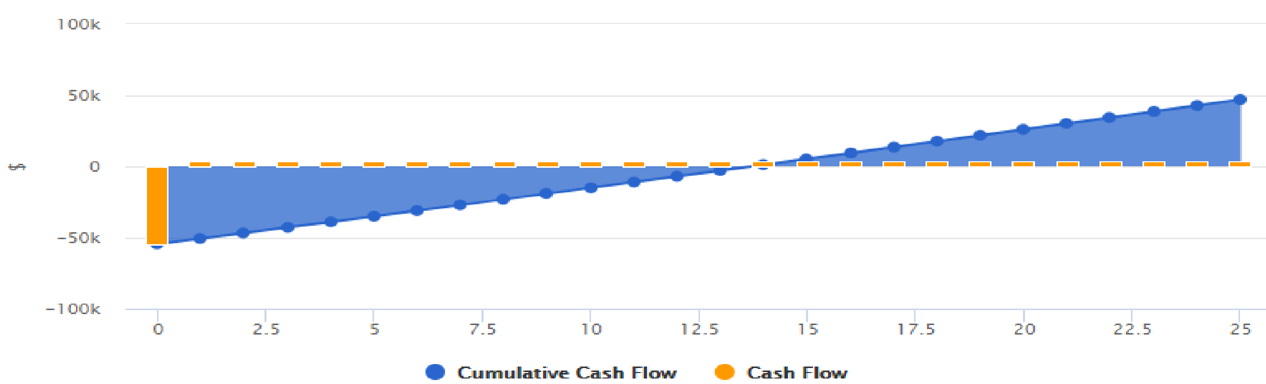
Fire Station No. 29

Meter Address: 2002 NE 16th Street
Location: 26.148458, -80.12064
Estimated Gross Square Footage: 10,291
Average Annual Consumption: 298,680 kWh



System Design	
Production Estimate:	**35,100 kWh (annual) @ 21.8 kW (nameplate)**
Project Cost Estimate:	**$54,438 (materials only)**
Energy Cost Savings Estimate:	**$3,864 (annual)**
Reduction to Facility's Energy Load:	**11.8%**
Contribution to City Operations 20% Goal:	**0.04%**
Greenhouse Gas Emissions Reduction:	**24.82 metric tons (annual)**
Notes:	**Rooftop Arrays; Additional periphery setback may be required**

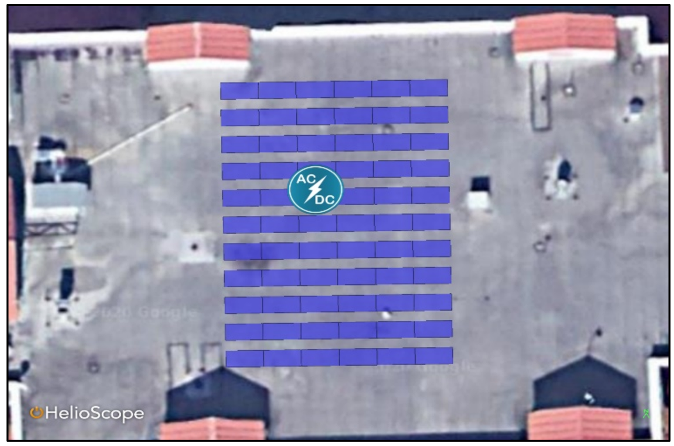
Financial Metrics



System Start	January 2021
Total Value of Energy	$101,501.43
Lifetime Value (NPV)	$15,866.88
Internal Rate of Return (IRR)	5.40%
Return on Investment (ROI)	186.45%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

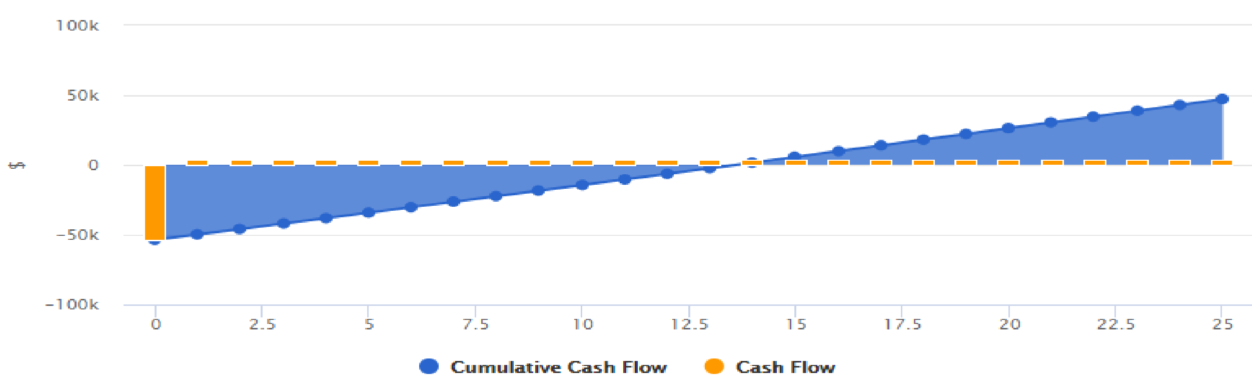
Fire Station No. 2 (Administration)

Meter Address: 528 NW 2nd Street
Location: 26.123673, -80.149317
Estimated Gross Square Footage: 30,900
Average Annual Consumption: 1.04M kWh



System Design	
Production Estimate:	**34,900 kWh (annual) @ 21.5 kW (nameplate)**
Project Cost Estimate:	**$53,625 (materials only)**
Energy Cost Savings Estimate:	**$3,837 (annual)**
Reduction to Facility's Energy Load:	**3.5%**
Contribution to City Operations 20% Goal:	**0.04%**
Greenhouse Gas Emissions Reduction:	**24.67 metric tons (annual)**
Notes:	**Rooftop Array; Potential for additional solar modules**

Financial Metrics



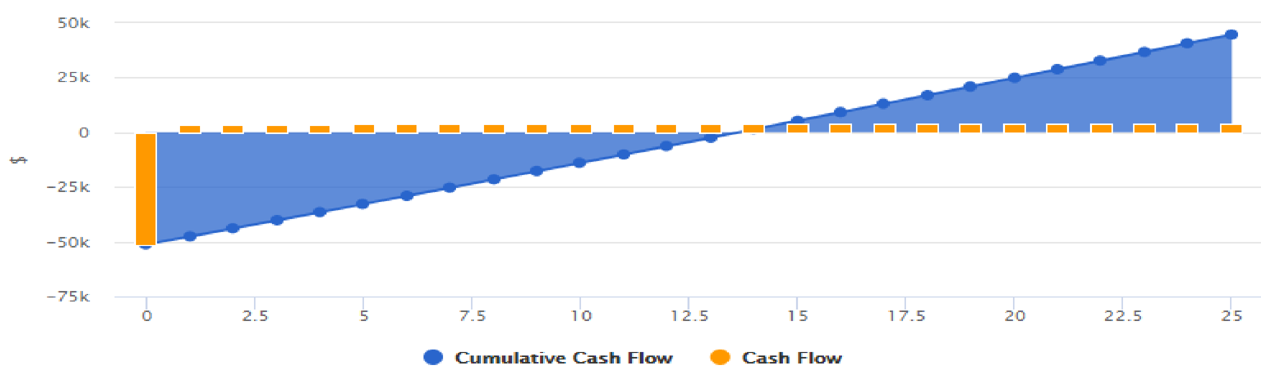
System Start	January 2021
Total Value of Energy	$100,798.83
Lifetime Value (NPV)	$16,192.72
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.97%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

City Hall

Meter Address: 100 North Andrews Avenue
Location: 26.123582, -80.143255
Estimated Gross Square Footage: 83,276
Average Annual Consumption: 2.4M kWh

System Design	
Production Estimate:	**33,200 kWh (annual) @ 20.5 kW (nameplate)**
Project Cost Estimate:	**$51,200 (materials only)**
Energy Cost Savings Estimate:	**$3,650 (annual)**
Reduction to Facility's Energy Load:	**1.38%**
Contribution to City Operations 20% Goal:	**0.03%**
Greenhouse Gas Emissions Reduction:	**23.24 metric tons (annual)**
Notes:	**Rooftop Array; Adjacent City Hall Garage can provide solar generation capacity for additional offset, if desired**

Financial Metrics



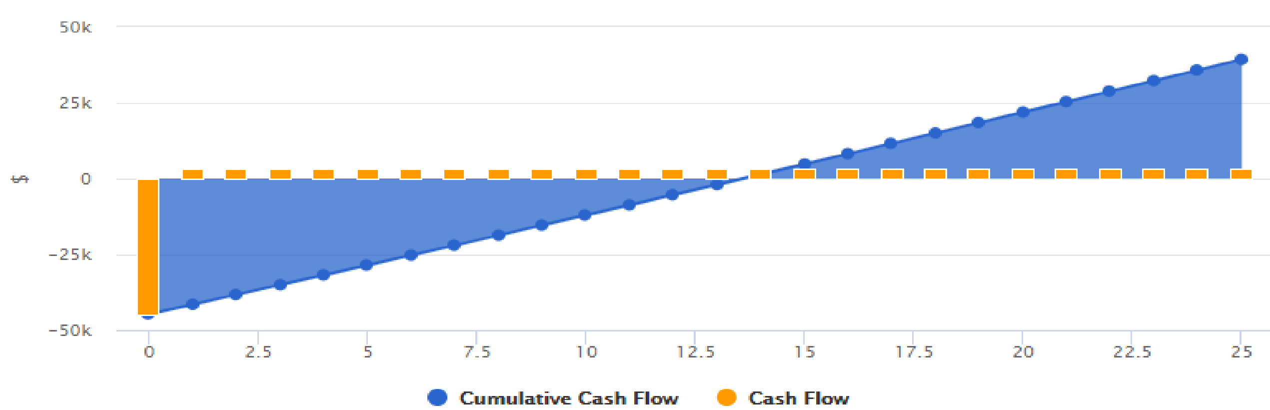
System Start	January 2021
Total Value of Energy	$95,873.76
Lifetime Value (NPV)	$15,206.40
Internal Rate of Return (IRR)	5.45%
Return on Investment (ROI)	187.25%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

Fire Station No. 47

Meter Address: 1000 SW 27th Avenue
Location: 26.109408, -80.17755
Estimated Gross Square Footage: 15,391
Average Annual Consumption: 312,3000 kWh

System Design	
Production Estimate:	**29,100 kWh (annual) @ 17.9 kW (nameplate)**
Project Cost Estimate:	**$44,688 (materials only)**
Energy Cost Savings Estimate:	**$3,196 (annual)**
Reduction to Facility's Energy Load:	**9.6%**
Contribution to City Operations 20% Goal:	**0.03%**
Greenhouse Gas Emissions Reduction:	**20.57 metric tons (annual)**
Notes:	**Rooftop Array**

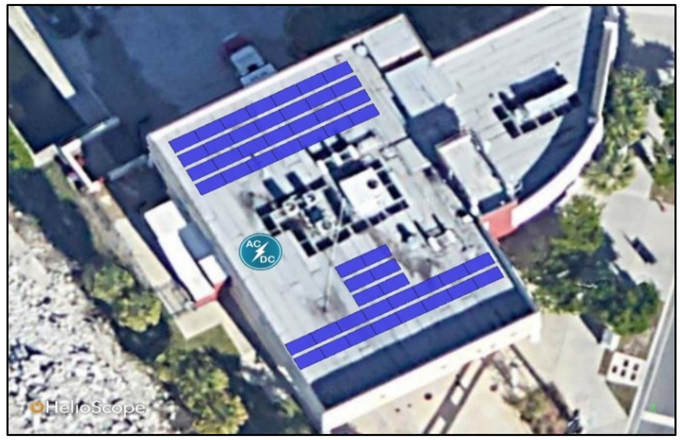
Financial Metrics



System Start	January 2021
Total Value of Energy	$83,963.31
Lifetime Value (NPV)	$13,469.19
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.89%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

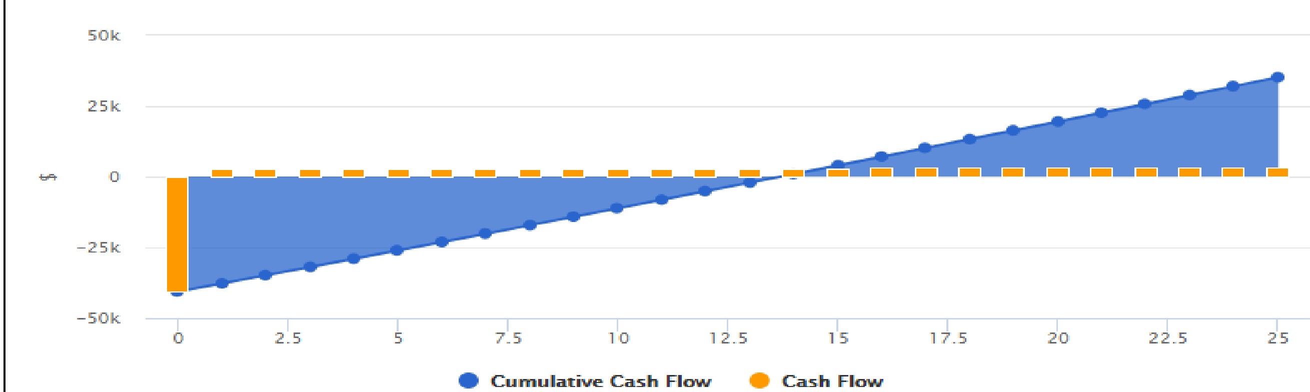
Fire Station No. 49

Meter Address: 1015 Seabreeze Blvd.
Location: 26.1104156, -80.10618
Estimated Gross Square Footage: 12,170
Average Annual Consumption: 259,620 kWh



System Design	
Production Estimate:	**26,200 kWh (annual) @ 16.3 kW (nameplate)**
Project Cost Estimate:	**$40,625 (materials only)**
Energy Cost Savings Estimate:	**$2,885 (annual)**
Reduction to Facility's Energy Load:	**10.1%**
Contribution to City Operations 20% Goal:	**0.03%**
Greenhouse Gas Emissions Reduction:	**18.52 metric tons (annual)**
Notes:	**Rooftop Array; Additional periphery setback may be required**

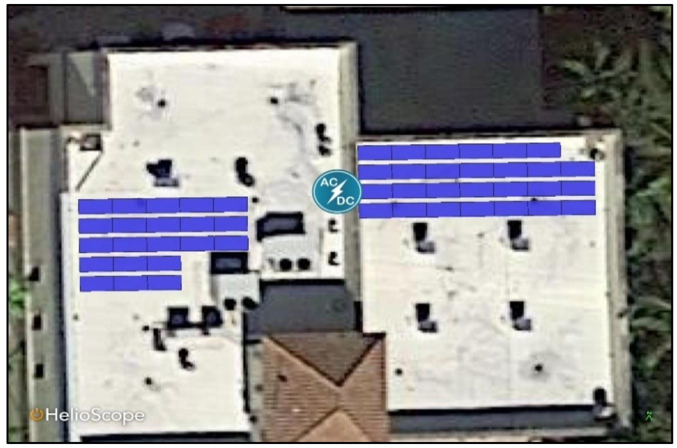
Financial Metrics



System Start	January 2021
Total Value of Energy	$75,795.25
Lifetime Value (NPV)	$11,874.16
Internal Rate of Return (IRR)	5.41%
Return on Investment (ROI)	186.57%
Payback Period	13.7 years
Levelized Cost of Energy	$0.09 / KWh

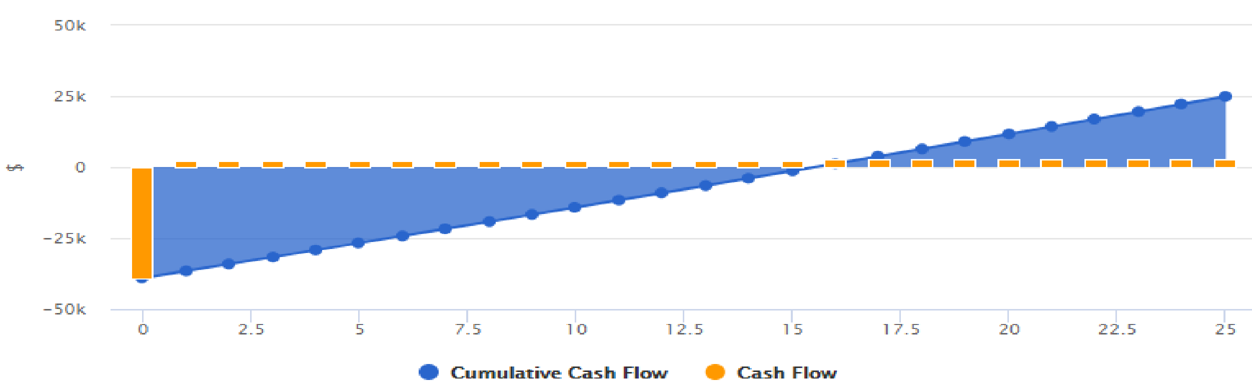
Fire Station No. 35

Meter Address: 1971 East Commercial Blvd.
Location: 26.18947, -80.11976
Estimated Gross Square Footage: 12,207
Average Annual Consumption: 272,280 kWh



System Design	
Production Estimate:	**22,100 kWh (annual) @ 15.6 kW (nameplate)**
Project Cost Estimate:	**$39,000 (materials only)**
Energy Cost Savings Estimate:	**$2,433 (annual)**
Reduction to Facility's Energy Load:	**8.6%**
Contribution to City Operations 20% Goal:	**0.02%**
Greenhouse Gas Emissions Reduction:	**15.62 metric tons (annual)**
Notes:	**Rooftop Arrays; Additional periphery setback may be required**

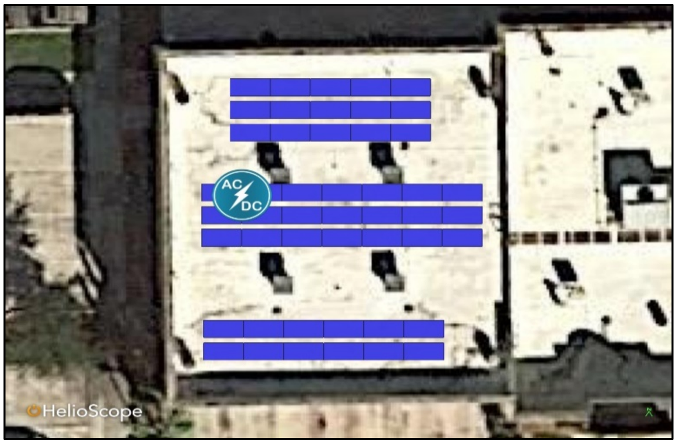
Financial Metrics



System Start	January 2021
Total Value of Energy	$63,914.33
Lifetime Value (NPV)	$5,269.76
Internal Rate of Return (IRR)	4.15%
Return on Investment (ROI)	163.88%
Payback Period	15.5 years
Levelized Cost of Energy	$0.11 / KWh

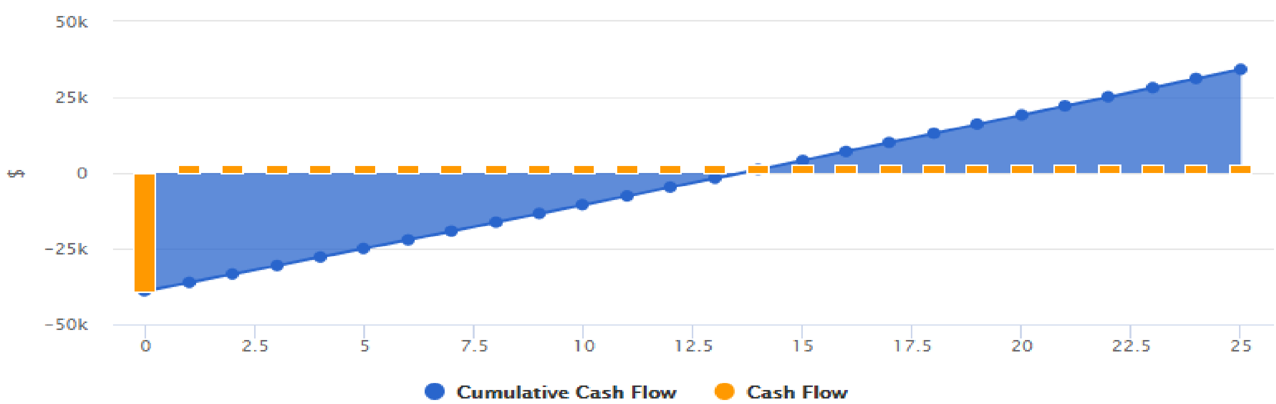
Fire Station No. 46

Meter Address: 1515 NW 19th Street
Location: 26.151822, -80.16333
Estimated Gross Square Footage: 10,817
Average Annual Consumption: 234,480 kWh



System Design	
Production Estimate:	**25,400 kWh (annual) @ 15.6 kW (nameplate)**
Project Cost Estimate:	**$39,000 (materials only)**
Energy Cost Savings Estimate:	**$2,789 (annual)**
Reduction to Facility's Energy Load:	**11.2%**
Contribution to City Operations 20% Goal:	**0.03%**
Greenhouse Gas Emissions Reduction:	**17.96 metric tons (annual)**
Notes:	**Rooftop Arrays**

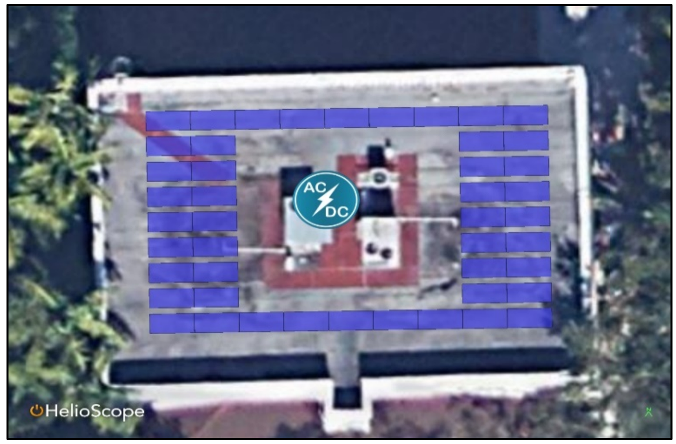
Financial Metrics



System Start	January 2021
Total Value of Energy	$73,259.73
Lifetime Value (NPV)	$11,742.92
Internal Rate of Return (IRR)	5.48%
Return on Investment (ROI)	187.85%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

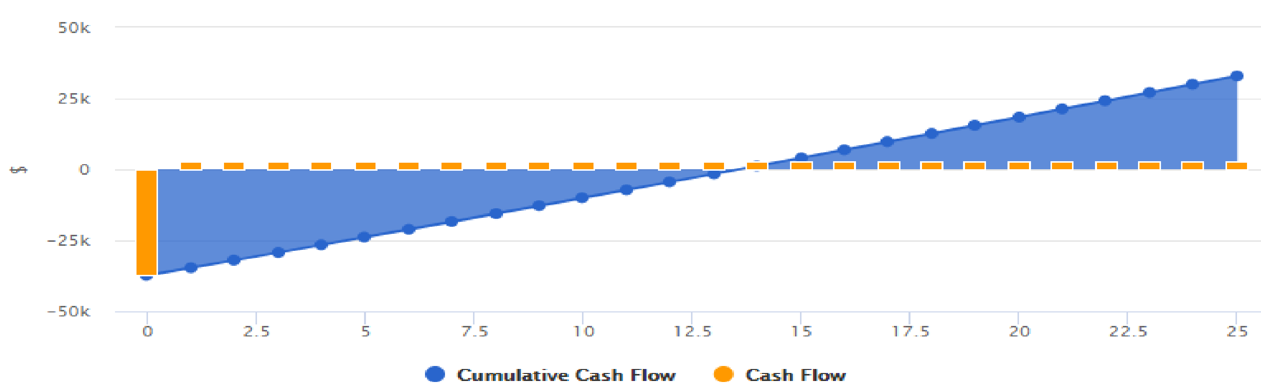
Warfield Park Recreation Center

Meter Address: 1000 North Andrews Avenue
Location: 26.137233, -80.1438
Estimated Gross Square Footage: 3,750
Average Annual Consumption: 149,312 kWh



System Design	
Production Estimate:	**24,300 kWh (annual) @ 15 kW (nameplate)**
Project Cost Estimate:	**$37,375 (materials only)**
Energy Cost Savings Estimate:	**$2,677 (annual)**
Reduction to Facility's Energy Load:	**18%**
Contribution to City Operations 20% Goal:	**0.02%**
Greenhouse Gas Emissions Reduction:	**17.18 metric tons (annual)**
Notes:	**Rooftop Array; Potential shading impacts from tree canopy**

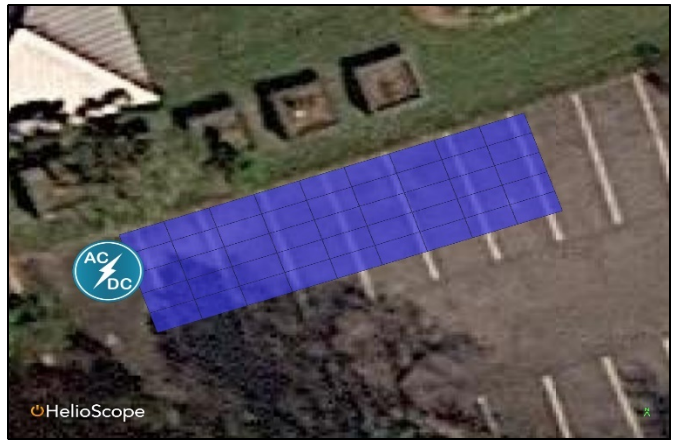
Financial Metrics



System Start	January 2021
Total Value of Energy	$70,325.88
Lifetime Value (NPV)	$11,335.81
Internal Rate of Return (IRR)	5.49%
Return on Investment (ROI)	188.16%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

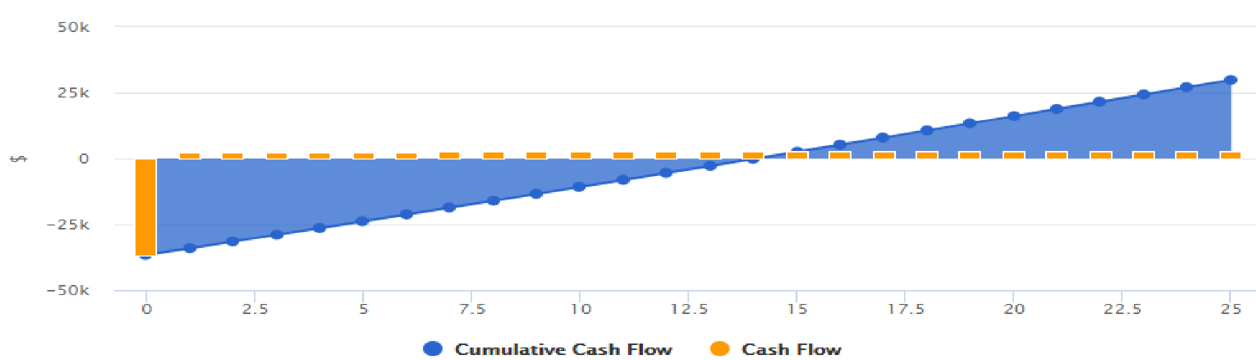
Snyder Park – Admin Office

Meter Address: 3299 SW 4th Avenue
Location: 26.0832, -80.147015
Estimated Gross Square Footage: 2,464
Average Annual Consumption: 25,003 kWh



System Design	
Production Estimate:	**23,000 kWh (annual) @ 14.6 kW (nameplate)**
Project Cost Estimate:	**$36,563 (materials only)**
Energy Cost Savings Estimate:	**$2,528 (annual)**
Reduction to Facility's Energy Load:	**107.5%**
Contribution to City Operations 20% Goal:	**0.02%**
Greenhouse Gas Emissions Reduction:	**16.26 metric tons (annual)**
Notes:	**Parking Canopy; Potential shading impacts from nearby tree canopy; Net-zero; ~8% grid export capacity; Minor loss to available parking**

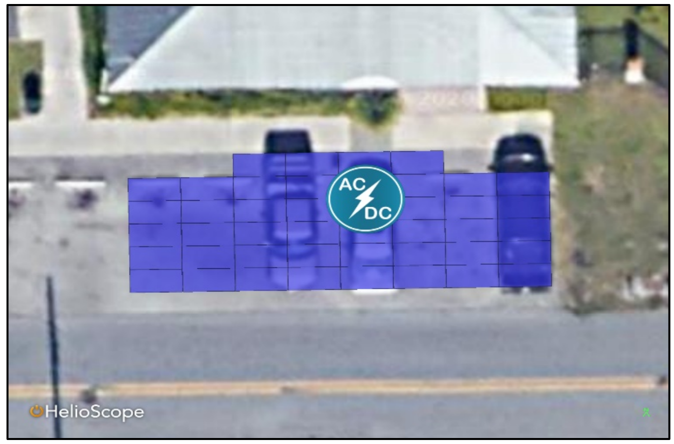
Financial Metrics



System Start	February 2021
Total Value of Energy	$66,392.34
Lifetime Value (NPV)	$9,424.20
Internal Rate of Return (IRR)	5.14%
Return on Investment (ROI)	181.59%
Payback Period	14.0 years
Levelized Cost of Energy	$0.10 / KWh

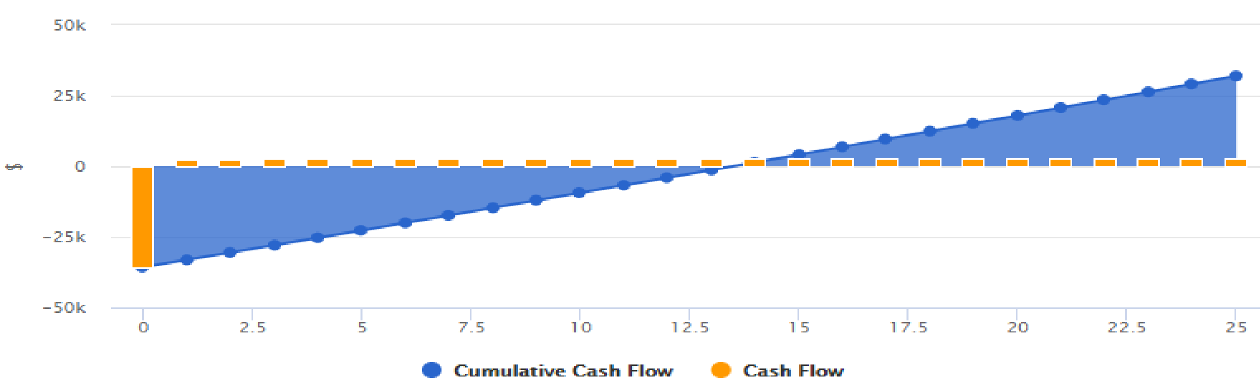
Carter Park - Annex

Meter Address: 1450 West Sunrise Blvd
Location: 26.134766, -80.1617
Estimated Gross Square Footage: 1,818
Average Annual Consumption: 22,002 kWh



System Design	
Production Estimate:	**23,400 kWh (annual) @ 14.3 kW (nameplate)**
Project Cost Estimate:	**$35,750 (materials only)**
Energy Cost Savings Estimate:	**$2,577 (annual)**
Reduction to Facility's Energy Load:	**106.8%**
Contribution to City Operations 20% Goal:	**0.02%**
Greenhouse Gas Emissions Reduction:	**16.54 metric tons (annual)**
Notes:	**Parking Canopy; Net-zero; ~7% grid export capacity; Minor loss to available parking**

Financial Metrics



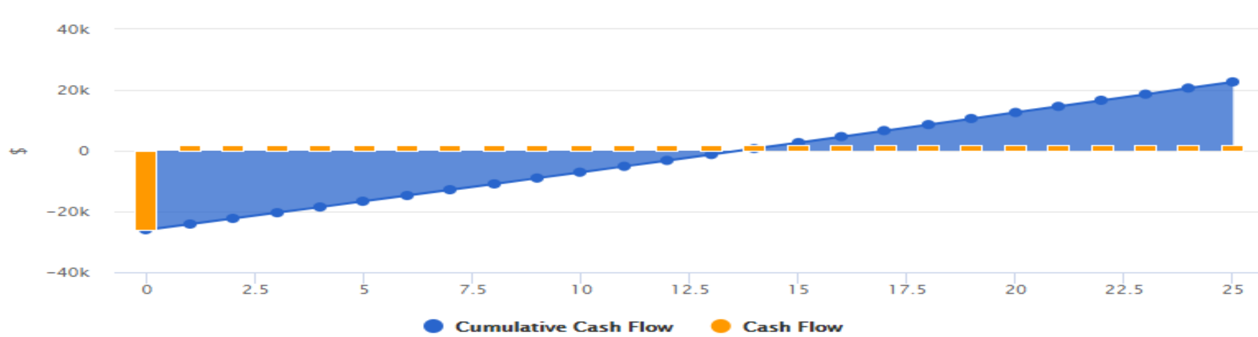
System Start	February 2021
Total Value of Energy	$67,705.02
Lifetime Value (NPV)	$11,145.49
Internal Rate of Return (IRR)	5.56%
Return on Investment (ROI)	189.38%
Payback Period	13.5 years
Levelized Cost of Energy	$0.09 / KWh

Coast Guard Auxiliary Station

Meter Address: 601 Seabreeze Blvd
Location: 26.11556, -80.10575
Estimated Gross Square Footage: 2,400
Average Annual Consumption: 16,343 kWh

System Design	
Production Estimate:	**16,800 kWh (annual) @ 10.4 kW (nameplate)**
Project Cost Estimate:	**$26,000 (materials only)**
Energy Cost Savings Estimate:	**$1,853 (annual)**
Reduction to Facility's Energy Load:	**103.1%**
Contribution to City Operations 20% Goal:	**0.02%**
Greenhouse Gas Emissions Reduction:	**11.88 metric tons (annual)**
Notes:	**Rooftop Array; Potential shading impacts from eastern high-rise; Potential roof replacement required; Net-zero; ~3% grid export capacity; Additional periphery setback may be required**

Financial Metrics



System Start	February 2021
Total Value of Energy	$48,665.41
Lifetime Value (NPV)	$7,707.80
Internal Rate of Return (IRR)	5.44%
Return on Investment (ROI)	187.17%
Payback Period	13.6 years
Levelized Cost of Energy	$0.09 / KWh

Analyses Review

The feasibility analyses conducted as part of this overall study determined that for the thirty-five City facilities chosen for preliminary design, only 4% (3.9M kWh annual) could be produced of the needed 20% Comprehensive Plan Goal (19.6M kWh annual). These thirty-five facilities were initially chosen due to their presumable simplicity of installation when compared with other facilities with unique footprints such as the energy-intensive water/wastewater treatment plants and ancillary infrastructure. Further analyses can be initiated to examine these and other excluded facilities to determine their feasibility and potential contribution to the 20% goal if requested by interested City stakeholders.

Of the 4% renewable energy determined within this study, it should be noted that this contribution results in a potential decrease of 2,739.10 metric tons of greenhouse gas emissions, a 6.37% decrease to the estimated 43,771 metric tons emitted via all of City operations in 2019 (for energy-only emissions, an 8.84% reduction) thus also contributing to the City's Comprehensive Plan goal of 80% emissions reductions by 2050.

All results are contingent on the assumption no operational changes are expected and that these results are likely to change as time progresses. For example, long term facility management planning indicates that some facilities are slated for replacement due to their respective ages and will inevitably not be candidates for a solar photovoltaic retrofit due to the payback period required to recoup the capital investment. For facilities that fall into such a scenario, City stakeholders should seek out incorporation of solar photovoltaic energy systems into the design of replacement facilities that can then be attributed to the 20% goal upon construction completion.

There also exists the potential within the thirty-five selected facilities of a subset that existing roofs will need to be replaced in the near future. Available data at the time of this study's issuance was utilized to indicate which of the thirty-five facilities may fall into this subset, however further investigation should be conducted to verify. Should a facility be identified needing an immediate roof replacement, incorporation of a solar photovoltaic retrofit at time of replacement will add to the incremental cost for the materials needed. There will also exist favorable economics in the cost of labor versus needing to retrofit at a later date and should be examined.

Finally, the preliminary feasibility analyses contained within this study are drafted utilizing software incorporating industry assumptions. As called out throughout this study, the listed project costs and savings are only a starting point for understanding what a photovoltaic energy system may entail. City stakeholders who desire to commit to initiating such projects will require securitization of the necessary funding to engage solar development providers to run more thorough, site-specific audits and designs. Advocacy may also be of value to mandate City facilities of a certain metric (i.e. size) require such retrofits and to be provided City Commission-allocated funding in order to achieve design/implementation services.

Utility-Sourced and Other Renewable Energy Strategies

Florida Power and Light Offerings

This study's underlying analyses have determined that in order for the City of Fort Lauderdale to achieve its 20% renewable energy for operations goal, it will need to work with the local utility (FPL) to source the remaining percentage not feasible through onsite construction. Further investigation may elicit additional opportunities to raise the sourcing percentage of onsite construction somewhat higher. Conservatively, it is prudent to seek a larger contribution from FPL in the short term and in later years supplement with new PV construction as new locations are identified in order to meet the City's 20% renewable energy Comprehensive Plan goal. FPL's services can be discontinued as new PV systems are commissioned at City facilities.

With regards to renewable energy, FPL's composition continues to grow annually. Currently the utility provides an option similar to that of the 'Community Solar' discussed earlier in this study whereby a customer pays a premium to obtain renewable energy sourced from an FPL solar farm. Pursuit of this option will inevitably require both the capacity of FPL to generate enough energy to supply the City's needs (14.6M kWh annually) as well the additional costs such a subscription would entail. Purportedly this program offering provides offset credits to customers insofar that over time, these credits will surpass the subscription fee thus demonstrating cost savings.

Table 3: Potential Future Contributors to a 20% Renewable Energy Composition Additional to this Study

Source	Description of Mechanism	Potential contribution to the 20% goal in 2030
Retrofits on City Buildings	Solar Photovoltaics	4% (based on this study)
Renewables on New Construction	Public Safety Building (design to include potential for 700kW PV)	0.3%
	Joint City/County Facility (design to include potential for 1MW PV)	0.4%
	New Parks Facilities Achieve no net increase in power use overall + Renewables to address 10% of building need	TBD
	New Water Treatment Plant (load increase)	TBD (potential offset of its new load)
City Energy Efficiency Retrofits	Reduction to existing energy load, thus lowers kW/kWh value to achieve 20%	1.5% (estimated)
Utility-Derived (New Generation)	Continued investment in renewables- based on FPL forecast for 2030	TBD (FPL energy supply composition potentially 44% renewables by 2030[3]
Utility-Derived (City Purchase)	FPL renewable energy program to deliver needed remaining percentage	14% (TBD)
	Total Renewable Energy Composition:	20%

[3] Figure derived from the Florida Power and Light Ten-Year Power Plant Site Plan 2020-2029.

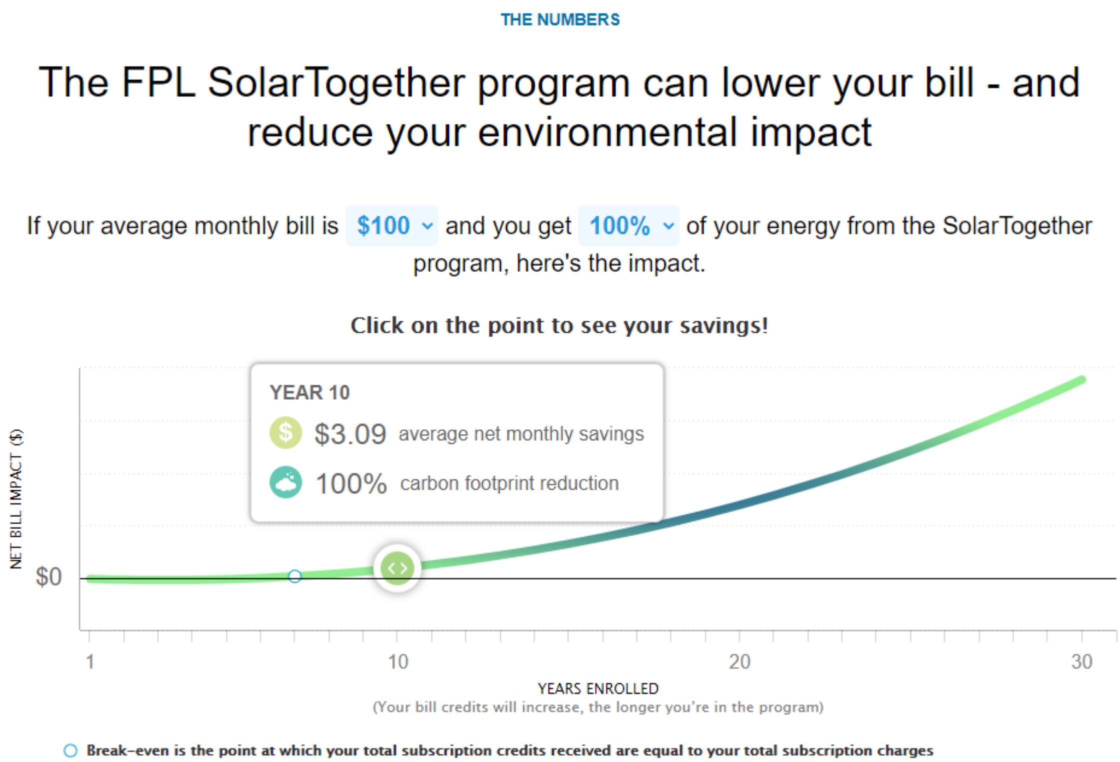


Figure 9: *SolarTogether* economics calculator (source: FPL). The utility charges a fixed fee relative to the allocated renewable power requested. The customer will receive credits that over a long enough time period will exceed the cost of the monthly subscription thus incurring cost savings versus a traditional account.

As per the FPL program, a subscription requires purchase at 1 kilowatt increments at a fixed cost of $6.76 per kilowatt and that this subscription charge will not change during participation within the program. Customers will experience a credit on their monthly FPL invoice as a result of this subscription into renewable energy, though this benefit will require further discussion with FPL to determine if it is applicable to the City of Fort Lauderdale. Should this credit apply, FPL states that at year seven of program participation a customer will achieve cost/credit parity (subscription charges are equal to the credits received). Past year seven it is then expected that a customer's monthly invoice will continue to decrease and provide cost savings versus a traditional account not participating in the *SolarTogether* program.

An examination of what this potential cost would be to the City excluding any potential for credits, the following provides some scenarios using the CY2019 City Operations power demand of 241,662 kW to consider:

Table 4: FPL *SolarTogether* Renewable Energy Program Cost Matrix

Scenario	FPL Contribution to 20% Goal	Power Allocation (kW)	Cost of Subscription
Retrofit/FPL 50-50 Split	10%	24,166.2	$163,364
Identified from Study	16%	38,665.92	$261,382
Total RE Goal	20% (Goal Met)	48,332.4	$326,727
Total City Power Demand	20% (Goal Met)	241,662	$1,633,635

This program affords additional benefits similar to that of both the leasing and energy services models discussed earlier by freeing customers from both the maintenance and upfront costs required to independently install solar energy onsite as per figure 10 below.

Figure 10: Program Comparison versus Traditional Customer-owned PV (source: FPL)

	FPL Solar Together	CUSTOMER OWNED ROOFTOP SOLAR
No contracts	✓	
No upfront costs	✓	
No maintenance	✓	
Receive bill credits	✓	✓
Works even if you move	✓	
Works for homeowners, renters, condos	✓	
Receive Renewable Energy Certificates (RECs)	✓	✓
Requires solar panel ownership		✓

Finally, an additional advantage of this program is the amelioration of procurement requirements such as development, issuance, and evaluation of request for proposals from developers as the City already has existing accounts and relationships with FPL. Pursuit of this model provided funding and capacity exists would have immediate impacts upon achieving the renewable energy goal. To ascertain what the final cost would entail will require discussion with FPL as a next step to determine what capacity exists to serve the City's goal.

Non-Photovoltaic Renewable Energy Possibilities

While this study has focused strictly on strategies to achieve its renewable energy goal leveraging solar power, there does exist potential opportunity to supplement with other technologies. For example, at locations where photovoltaic energy was deemed infeasible due to lack of usable space, horizontal-access wind turbines may prove successful. Incorporating such technology would require an in-depth environmental assessment to ensure ideal conditions exist and is outside the scope of this study.

Additional possibilities exist that can leverage the City's coastal proximity by means of renewable tidal power technologies to offset energy usage of nearby facilities. As with the wind example listed above, an in-depth field assessment and analysis will be required to determine feasibility of this type of implementation and is outside the scope of this study.

IV. Recommendations

The following summarizes this study's action items on how the City can pursue a two-prong strategy for achieving its renewable energy target:

Determine the balance of retrofit versus utility options to pursue to support the City's goal

- Once determined, secure required funding to initiate implementation (general budget; municipal bond; third party grant funding)

Engage FPL

- The City Procurement Department and those tasked with monitoring energy consumption should establish a working group with Florida Power and Light to learn more of their *SolarTogether* program, its estimated costs and capacity to offset approximately 15 million kilowatt-hours per year.

- Should the *SolarTogether* program prove viable, the City should next identify which facilities it can pilot this program for performance and cost. Additional facilities can then be enrolled to the program until either the 15M kWh target is met or the City exceeds potential FPL program allocation.

Finalize Project Siting

- Identify which buildings from the list should be pursued first based on existing conditions, potential load offset, contribution to the 20% goal, and visibility to the community

- Conduct in-depth audits at selected buildings to refine system designs and ensure criteria are met (roof condition, potential for building replacement, distribution system condition, etc.)

Qualify Market Providers

- Draft and issue a 'Request for Proposals' for local solar developers. Rate and select a developer based on both cost per watt and experience with public entities.

Outreach and Optics Campaign

- Upon completion of project(s), coordinate outreach initiatives with Strategic Communications, City Manager's Office, and City Commission to announce to the community. Demonstration of the City's commitment to renewable energy will spur private sector interest and may accelerate community-level emissions reductions.

Conclusion

The Public Works Department's Sustainability and Climate Resiliency Program is available to provide additional guidance on this study including technical documentation, consultative resourcing in research and analytics, project planning support, and if funding were to become available, piloting of renewable technologies to continue the City's momentum in achieving its goals.