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City of New Smyrna Beach Solar Feasibility Assessment

Florida Solar Energy Center

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FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

City of New Smyrna Beach Solar Feasibility Assessment

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Final Report for City Commission Review

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City of New Smyrna Beach
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Maintenance Operations Center
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City of New Smyrna Beach
Solar Feasibility Assessment

Executive Summary

The City of New Smyrna Beach is considering solar and renewable energy resources for their municipal facilities, and retained the Florida Solar Energy Center's interdisciplinary team of energy analysts and solar engineers to conduct energy audits and solar feasibility assessments for 18 facilities. The energy audits identified cost-effective measures for reducing building energy consumption in order to optimize the expenditures for solar equipment. The solar feasibility assessment details the best options for renewable energy, including sizing, installation costs, maintenance costs, system life expectancy, and return on investment. FSEC completed energy conservation and solar electric (photovoltaic - PV) feasibility analyses for the 18 buildings for the City of New Smyrna Beach, 17 of which are actively utilized buildings and one was a vacant building undergoing extensive renovation to serve as the City Hall Annex. A separate report was submitted on July 11, 2019 for that building based upon a site visit and building plan documents, with a subsequent presentation to the City Commission on August 13, 2019.

The City's interest first identifying energy conservation investments that would reduce building load prior to installing solar is consistent with sustainability goals for achieving "Net Zero" energy consumption. Net Zero energy is a term that indicates that all of the annual energy use of a building is offset by renewable energy such as PV. This is one of the primary goals of sustainability focused programs. It is typically more difficult to achieve these goals in older existing buildings than with new construction due to construction limitation or costs. However, this report provides detailed information about potential savings from energy conservation measures and the deployment of solar electric systems.

A combination of site visits, utility billing data analysis, and PV production potential analysis were used to help determine the potential for approaching net zero energy for each building.
Utility billing data was requested for each utilized building. The annual energy usage was normalized by the building area to determine energy use intensity (EUI). The EUI ranged from about 13 in the Maintenance and Operations facility to just over 130 in the Brannon Center, with a site average of 55.[1] A building with high EUI may still be able to achieve or approach a net zero energy target if there is adequate space on site for PV. Based upon high EUI, the Brannon Center, Police Department, and all four Fire Stations should be considered as priorities. These six buildings represent about one-third of the eighteen considered in this project. The Police Department and Fire Stations operate 24 hours every day and so it is expected that they would have higher EUI, but opportunities were identified that would help reduce energy use in these, as well as other buildings. The main body of the report provides recommendations for each building with the economic energy savings potential.

Energy Conservation Measures

Since it is unknown what budget may exist, return on investment (ROI) was determined for each individual type of energy conservation measure (ECM) on its own. After consideration of ECM with good

[1] A review of 81 Zero Energy certified and verified commercial buildings in the U.S. found the average EUI for all 81 buildings was 22. The six Florida office buildings in this study had an average EUI of 36 with a range from 7 to 92. (source: New Buildings Institute. "2019 Getting to Zero Project List")

savings potential and ROI of at least 3% annual or higher, five different types of ECMs were recommended for various buildings. The five types of ECMs are shown in Table ES-1 below in order of highest ROI to lowest ROI. The time to recover invested cost of retrofit is also shown as simple payback. These results are based upon estimated costs, savings and lifetimes. Actual results may vary. After the top ECM were identified, their applicability for each building was considered and a package of economical ECM were evaluated to estimate the ECM package annual energy savings potential (found in main report Table 3).

Table ES-1. Five of the Highest Priority Types of ECM Recommended Estimated Based Upon ROI

Energy Conservation Measure	Estimated lifespan of retrofit (Years)	Return on Investment / year	Return on Investment over lifetime of retrofit	Time to recover investment simple payback (Years)	Report details found here
Lighting control[a]	20	188.0 %	3,757 %	5.2	Section 3.4 Table 10
Retro Commissioning[b]	5	140.0 %	701 %	0.7	Table 12
Replace fluorescent fixtures with LED[c]	19	16.5 %	318 %	4.0	Table 7
Replace high ceiling HID/Metal Halide fixtures with LED	16	18.9 %	302 %	3.7	Table 7
Replace old straight cool 3-5 ton units with 16 SEER/8.5 HSPF heat pumps[d]	15	3.3 %	49 %	1.8	Table 5

a. Example using a fire station or office building with 11 occupancy sensor controls added
b. Average of Brannon Center and Police Department
c. Average of 5 most common type of office fixtures
d. A single unit between 3-5 tons

Other ECM retrofits were considered in addition to the five ECMs in Table ES-1, but were not prioritized in recommendations due to relatively low ROI, advanced level of testing or analysis needed to determine if appropriate, or fair amount of uncertainty of whether the measure would be successful.

Thermostat setpoints can have a significant impact on energy use and are easy to implement, however temperatures that are outside of employees' comfort zones may impact work performance. For this reason, setpoint change is of uncertain success unless tried on a building-by-building process. Raising cooling setpoints can result in immediate cooling energy reduction and may be done with no additional cost. This measure is best implemented in spaces where typical setpoints are lower than 75° F for cooling and above 70°F for heating. Residential research has found that there is from 8% to 14% cooling energy reduction for every 1° F increase in the cooling setpoint. In small, older commercial buildings there is about 8% cooling energy reduction for every degree increase in setpoint. If the changed setpoint can be maintained by using the existing thermostat, there is no cost to implement this measure and payback begins instantly. The fire stations and the police department had the lowest observed cooling setpoints- around 70°F. Using the four fire stations as an example, the average potential energy savings could be about $100 per station per year if cooling setpoint is raised 3 to 4°F. While this is an easy way to conserve energy, it would not be worth it if this diminished performance of first responders.

Central air duct leakage sealing was considered for City Hall, CRA / Economic Development, Golf Clubhouse, and Coronado Civic Center. These buildings were considered based upon age and type of construction, and location of ducts (attic), or presumed leaky ceiling space. Air tightness testing would be required to confirm if duct sealing is warranted, however a previous FSEC study of 10 small commercial buildings with duct repair had a measured average of 17% cooling energy savings. If warranted, sealing air ducts in five buildings may have an average lifetime ROI of 3.0% (0.2% per year) and payback in 5.7 years. Sealing air ducts can improve indoor air quality as well.

Painting older metal roofs with reflective white paint is another ECM to consider for buildings with R19 attic insulation or less. This may reflect about 70% of solar heat, which decreases the attic or ceiling space temperature and decreases the cooling load. FSEC studies found that, on average, annual cooling and heating energy can be reduced by about 25% in older commercial retail spaces with older metal roofs after they were painted white. Due to the uncertainty of how long the painted metal roof would remain in service before needing to be replaced, the estimated ROI has a high degree of uncertainty. Based on an assumed 5,000 ft^2 roof area and 10 year remaining service life of painted existing roof, total lifetime ROI is 7% (0.7% per year) and payback is 8.7 years. This demonstrates the benefit of considering white reflective metal roof when existing roof service life is over. This measure should also be considered for buildings that have trouble meeting cooling setpoints as it can reduce the need for higher cooling capacity air conditioning systems to maintain comfort.

Solar Electric Potential

Each building was analyzed for solar power production potential through site visits and mapping. Estimates of solar power production was calculated using PV Watts, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory. The potential for solar power production is influenced by roof orientation, shading from nearby trees and structures, and available roof space. FSEC's summary of the solar power production potential for each building is shown in Figure ES-1 (other details also found in Table 12 within main body of report). Note that smaller buildings, such as the Chamber of Commerce and the City Marina have lower potential for power production than larger buildings such as the Police Department. Some large buildings, such as City Hall, have lower potential solar production because of shading from nearby trees.

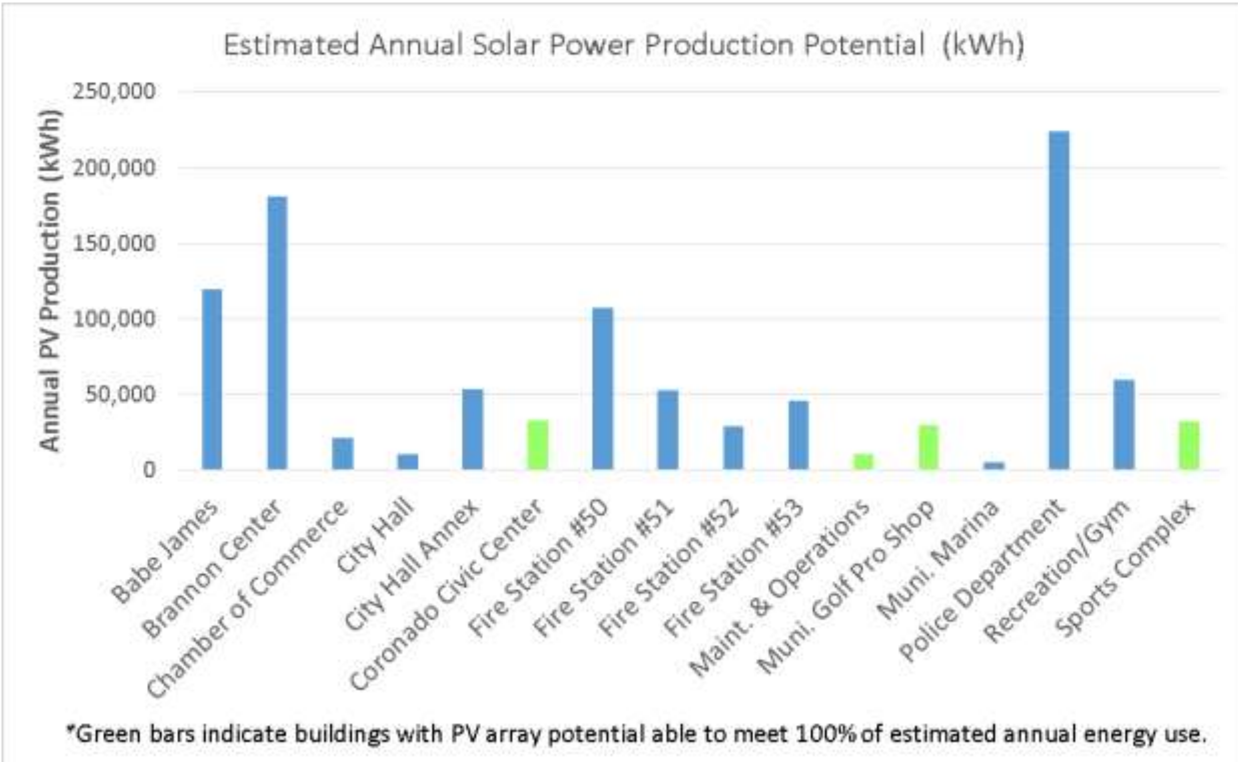

Figure ES-2. Estimated potential for solar power production considering shading, roof area and orientation.

Considering the existing annual energy of each building, without any of the recommended ECM's, four of the City's buildings could accommodate solar panels capable of producing far more power than needed. In general, any excess power generation is carried forward as a credit in subsequent months for the 12-month billing cycle. If an excess credit remains, the solar customer is paid for the remaining kWh production at a wholesale electric rate. For economic reasons, we do not recommend sizing systems beyond the average annual electrical use of the building.

FSEC would recommend installing only the number of PV panels needed to offset predicted annual energy use, resulting in a zero energy (ZE) building. The green bars in Figure ES-2 indicate potential to achieve a ZE building in four of the City's facilities: Coronado Civic Center, Maintenance and Operations Building, Municipal Golf Course Pro-shop, and the Sports Complex. The roof size of these buildings can accommodate one or more PV arrays that have the potential to completely offset estimated annual energy use. The blue bars show the estimated maximum offset in the other facilities based on available roof area and other sizing factors.

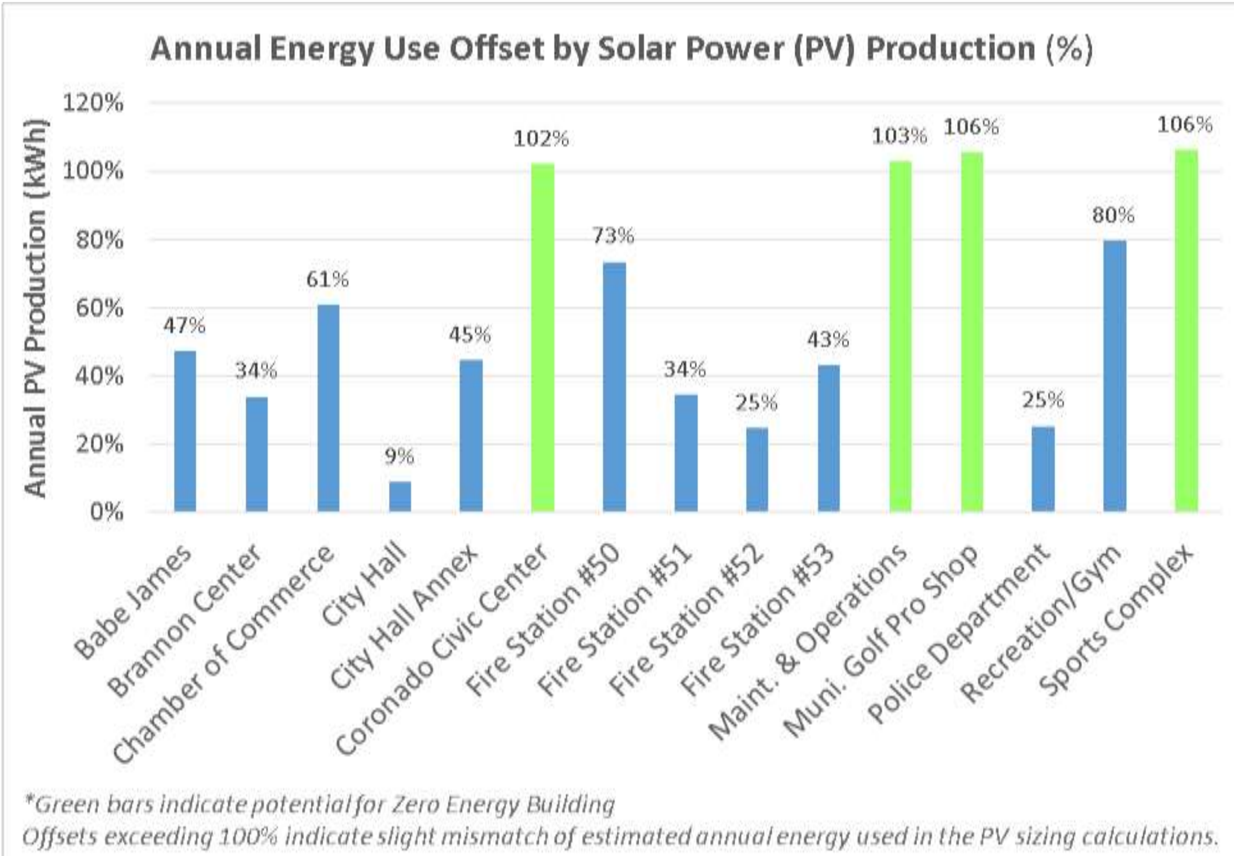

Figure ES-2. Portion of estimated existing annual electric energy use that could be offset by PV power production.

The current installed cost of a photovoltaic system in a commercial setting like the City of New Smyrna Beach facilities ranges between \$1.75 and \$2.00 per watt. The "PV System Installed Estimated Cost" shown in Table 12 of the full report are based on \$2.00 per watt to be conservative. Factors that influence actual cost include system location, mounting method and configuration, and PV panel selection. The average life expectancy of a photovoltaic panel is 25 to 30 years. Typical industry warranties run for 25 years, with the expectation that performance will degrade less than ½ percent per year. The panels are relatively maintenance free, especially in Florida where the climate is not as harsh as other regions and our rainfall tends to keep the panels clean. The balance of system components also come with warranties that are honored by the installing contractor and manufacturers.

The typical PV ROI per year is about 2%-3% for the City buildings, which may seem low, but it is emphasized here that PV is a mature technology and industry that is very dependable, has a long lifetime, reduces monthly energy expenditures, and reduces greenhouse gas emissions.

Table ES-1. Solar Power (PV) Production Potential and Economic Calculations

Building	Existing Annual Energy Use (kWh/yr)	PV System Capacity (kWdc)	Annual PV Production Potential (kWh/yr)	% Offset	PV System Annual Savings	PV Lifetime Savings	PV System Installed Cost	Simple Pay-back (years)	Return on Invest-ment
Babe James Community Center	253,163	84.90	119,268	47%	$ 11,929	$ 298,225	$ 169,800	14	76%
Brannon Center	534,480	124.00	181,061	34%	$ 18,106	$ 452,650	$ 248,000	13	83%
Chamber of Commerce	35,208	14.20	21,376	61%	$ 2,137	$ 53,425	$ 28,400	13	88%
City Hall	116,284	7.00	10,201	9%	$ 1,021	$ 25,525	$ 14,000	13	82%
City Hall Annex	120,662	48.00	53,743	45%	$ 6,448	$ 161,200	$ 96,000	14	68%
Coronado Civic Center	31,709	21.50	32,409	102%	$ 3,241	$ 81,025	$ 43,000	13	88%
Fire Station #50	146,054	78.50	107,170	73%	$ 10,717	$ 267,925	$ 157,000	14	71%
Fire Station #51	153,173	37.00	52,510	34%	$ 5,284	$ 132,100	$ 74,000	14	79%
Fire Station #52	115,564	18.60	28,580	25%	$ 2,857	$ 71,425	$ 37,200	13	92%
Fire Station #53	107,168	34.60	46,084	43%	$ 4,610	$ 115,250	$ 69,200	15	67%
Live Oak Cultural Center*	n/a	40.00	59,645		$ 5,964	$ 149,100	$ 80,000	13	86%
Maintenance Operations/Fleet	10,200	7.00	10,516	103%	$ 1,051	$ 26,275	$ 14,000	13	88%
Municipal Golf Course	28,445	20.00	30,047	106%	$ 3,005	$ 75,125	$ 40,000	13	88%
Municipal Marina*	n/a	4.00	5,326		$ 532	$ 13,300	$ 8,000	15	66%
Police Department	890,060	149.00	223,848	25%	$ 22,384	$ 559,600	$ 298,000	13	88%
Recreation/Gym	74,980	40.00	59,645	80%	$ 5,964	$ 149,100	$ 80,000	13	86%
Sports Complex	30,068	23.00	31,945	106%	$ 3,194	$ 79,850	$ 46,000	14	74%
TOTAL	2,647,218	751	1,073,374		$ 108,444	$ 2,711,100	$ 1,502,600		

*Not addressed due to inadequate or complications with utility data

The City has excellent candidates for solar power production in individual buildings resulting in significant offset of purchased power, with four buildings that could have all of the annual energy use offset by solar power - achieving net-zero energy status. The PVWatts reports provide a sketch of roof area for PV placement, a PVWatts Analysis of kWh production and monthly and annual energy cost savings. With that information, each building was analyzed for its solar potential, percentage of solar contribution with and without the adoption of recommended energy conservation measures, system cost, annual and lifetime system savings, simple payback, and return on investment. Using this data, the City will be able to make an informed decision about which buildings to consider for solar and how much solar and energy efficiency can contribute to their energy and greenhouse gas reduction goals. Solar PV has the potential to offset 40 percent of electric energy use across all the buildings evaluated if installed on all buildings as indicated. Expressed another way, the City can achieve 40 percent of ZE across all buildings in total using renewable (solar). If the City incorporated the ECM recommendations, the solar contribution would increase to 47%.

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1. Introduction

At the request of the City of New Smyrna Beach (the City), the Florida Solar Energy Center (FSEC) assessed of rooftop solar and building energy efficiency improvement potential for 17 city-owned facilities.

The intent has been to assist City leaders in identifying opportunities to reduce the City's overall electricity consumption.

The FSEC team (Appendix A) conducted Level 1 energy audit activities and site assessments including:

- On-site assessment
  - Solar feasibility measurements and characterization including orientation, roof shading (adjacent structures, encroaching trees, etc.), available roof area, system output, annualized savings
  - HVAC characterization
  - Lighting survey
  - Occupancy density, schedule, thermostat settings
- Post audit calculations
  - Solar system sizing estimates using industry-standard software PV Watts (Appendix C)
- Utility bill analysis – based on City-provided utility bills
  - Annual energy use
  - Weather corrected utility bill analysis to gauge cooling and heating as a portion of annual energy use
  - Energy use per square foot of conditioned space
- Conferring with City staff
  - Planned improvements
  - Controls and typical building operation

2. Energy Conservation Measures (ECM)

In commercial buildings, energy use is dominated by heating, cooling, and ventilation (HVAC) needs followed by lighting and office equipment. FSEC provides the following guidance based on audits of the City's facilities, informed utility bills analysis and previous work including both field work and research conducted by FSEC and others. Efficiency improvements may generate better return on investment numbers and they will reduce the amount of solar needed to reach zero energy status. General recommendations are also included.

2.1 Current Annual Energy Use of City's Building Portfolio

The City provided utility bill data that was used to examine the energy use intensity of each building and to determine each building's energy use attributable to heating and cooling. The latter is accomplished using a weather corrected utility bill analysis method described in Appendix B. Energy use intensity (EUI) normalizes annual energy use by conditioned area to produce a metric that can be used to compare buildings, identify relatively high energy use buildings, and prioritize energy conservation projects. EUI is expressed in $kBtu/ft^2$ to allow comparison of buildings with a mix of power sources. Table 1 shows estimated annual energy use, EUI, and estimates of the percent attributable to cooling and heating energy use. EUI ranges from about 13 in the Maintenance and Operations facility to just over 130 in the Brannon Center with an average of 55. A review of 81 Zero Energy certified and verified commercial buildings in the U.S. found the average EUI for all 81 buildings was 22 (source: New Buildings Institute. “2019 Getting to Zero Project List” Link to Net Zero EUI Project List document . The six Florida office buildings in this study had an average EUI of 36 with a range from 7 to 92. Buildings with special energy intensive equipment and very high annual business hours will have higher EUI.

Recommendations for individual buildings are included later in the report. Cooling and heating estimates are derived using weather patterns and utility bills. In some buildings, such as the Brannon Center, cooling and heating energy use is driven more by occupancy rather than weather patterns. FSEC did not have any occupancy data to be able to determine how much of an impact this may have had on the particularly higher than usual monthly energy use.

Table 1. Estimated Annual Energy Use, EUI cooling and heating %

Building	Annual Energy Use (kWh/yr)	EUI (kBtu/ft2)	% Annual Energy Use in Cooling	% Annual Energy Use in Heating
Babe James Community Center	253,163	49.46	49%	not discernable
Brannon Center	534,480	131.73	not dominated by weather	not dominated by weather
Chamber of Commerce	35,208	14.72	53%	8%
City Hall	116,284	34.82	38%	6%
City Hall Annex	120,662	34.82	38%	6%
Coronado Civic Center	31,709	54.10	not dominated by weather	not dominated by weather
CRA/Economic Development	6,568	21.69	no utility bills	no utility bills
Fire Station #50	146,054	72.88	24%	4%
Fire Station #51	153,173	77.59	32%	24%
Fire Station #52	115,564	81.81	25%	11%
Fire Station #53	107,168	79.41	28%	14%
Live Oak Cultural Center	no utility data		no utility data	no utility data
Maintenance Operations/Fleet	10,200*	12.93*	53%	28%
Municipal Marina	no utility data		no utility data	no utility data
Municipal Golf Course (Pro Shop)	28,445	29.36	not related to weather	not related to weather
Police Department	890,060	92.88	35%	not discernable
Recreation/Gym	74,980	20.29	87%	not discernable
Sports Complex	30,068	53.91	not dominated by weather	not dominated by weather

*Based on the site visit, the annual utility bill for this building is lower than expected.

2.2 Overall Potential Savings from Energy Conservation Measures

Analysis summarized in Table 2 and detailed in following sections reveals opportunity for significant energy savings from energy conservation measures (ECM) related to lighting change-outs, lighting controls, HVAC equipment replacement, and recommissioning.

Table 2. Savings from Recommended Energy Conservation Measures

		Potential Savings from Individual ECMs***				Potential Savings from ECM Package		
	Current Annual Energy Use Estimate	LED lighting change out	Add Lighting controls	Replace HVAC older than 9 years with Heat Pump	Retro-commission @ conservative 13% savings	Annual Savings with ECM Package	% Savings with ECM Package	Net Annual Energy Use with ECM Package
Building	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	% of existing	kWh/y
Babe James Center	253,163	16,029	5,940	13,334		35,303	13.9%	217,860
Brannon center	534,480				69,482	69,482	13.0%	464,998
Chamber of Commerce	35,208	3,551	842	3,781		8,174	23.2%	27,034
City Hall	116,284	3,092	926	3,787		7,805	6.7%	108,479
City Hall Annex*								
Coronado Civic Center	31,709	9,334		4,223		13,557	42.8%	18,152
CRA/Economic Development	6,568	167				167	2.5%	6,401
Fire Station #50	146,054	6,657	1,803			8,460	5.8%	137,595
Fire Station #51	153,173	6,593	1,785			8,378	5.5%	144,795
Fire Station #52	115,564	5,934	1,595			7,529	6.5%	108,035
Fire Station #53	107,168	5,793	1,556			7,349	6.9%	99,818
Live Oak Cultural Cntr	no utility data						0.0%	
Maintenance Operations/Fleet**	10,199	4,383		4,064		8,447	82.8%	1,752
Municipal Golf Course (Pro Shop)	28,445	746		4,927		5,673	19.9%	22,772
Municipal Marina	no utility data	271	142			413	0.0%	
Police Department	890,060	46,441			115,708	162,149	18.2%	727,911
Recreation/Gym	74,980	9,709	4,589	17,538		31,836	42.5%	43,144
Sports Complex	30,068	4,552	2,288			6,840	22.7%	23,228

*City Hall Annex addressed in prior report.
**Based on the site visit, the annual utility bill for this building is lower than expected.
*** ECM's selected based upon individual retrofit annual ROI of 3% or more.

2.3 HVAC Energy Savings

Commercial building energy use is typically dominated by heating, ventilation, and air conditioning (HVAC). HVAC energy can be reduced in two ways:

1. Increasing Equipment Efficiency and Improving System Performance
2. Reducing Conditioning Loads, Predominantly Heat and Humidity Gain

2.4 HVAC Equipment

Recommendations for HVAC Equipment More than Nine Years Old

The City's inventory of HVAC equipment is excellent. FSEC recommends replacing HVAC equipment over nine years old. Table 3 shows potential savings for six different sized air source split-DX HAC equipment. The results reflect heating and cooling savings that would occur from replacement of individual existing systems. Cooling energy efficiency ratio (EER) of 9 EER was assumed for existing systems to be replaced. Heating coefficient of performance (COP) was 1 COP. This represents electric strip heat, the poorest electric efficiency option. Most electric heating equipment was found to be inefficient electric strip heat instead of heat pump heating. The improved efficiency level used here is based upon good potential of obtaining a reasonable ROI. Estimates for ROI are shown below in Table 4.

Table 3. Annual Energy and Cost Savings for HVAC Capacity Range (represents expected reduction from existing)

Cooling Capacity	Cool and Heat Efficiency	Savings* kWh/yr.	Savings* $ / yr.
3 tons	from 9 SEER/COP 1 to 16 SEER/HSPF 8.5	8,769	877
5 tons	from 9 SEER COP 1 to 16 SEER HSPF 8.5	13,995	1,400
5.4 tons	from 9 EER/COP 1 to 10.1 EER/COP 3.2	2,829	283
10 tons	from 9 EER/COP 1 to 10.1 EER/COP 3.2	7,899	790
15 ton	from 9 EER/COP 1 to 9.3 EER/COP 3.1	8,399	840
20 tons	from 9 EER/COP 1 to 9.3 EER/COP 3.1	11,199	1,120
*Utility simplified cost $0.10/kWh used; 3000 hrs cooling and 270 hours heating per year used for >5 tons. 3 and 5 ton calculations based upon Daytona TMY weather data and assumed building thermal qualities for 50 year old building.			

For new heat pump cost benefit analysis, the savings must be determined based upon the current legal minimum SEER 14 (systems under 5 tons), not the existing SEER 9 systems. While some older existing air conditioning units may have been rated at about 10 SEER, it was assumed that age and degradation have older units performing at the lower SEER 9 efficiency. A cost benefit analysis was estimated for two capacities at 3 and 5 tons, which represents a large percentage of the buildings evaluated during site audit. Results are shown in Table 5. Equipment lifetime was assumed to be 15 years. Costs are based upon past analysis and do not represent specific equipment or quotes. Actual HVAC costs will vary widely depending upon the specific installation. Specific ROI was not estimated for systems larger than 5 tons due to inadequate cost data.

This shows that replacing split-DX air conditioners and inefficient electric strip heat with new heat pump is expected to be cost-effective with acceptable ROI.

Table 4. Estimated Lifecycle Benefit, Simple Payback, and Cost Differential from Increasing SEER 14/COP1 to SEER 16/HSPF 8.5 (heat pump) (represents expected savings compared to current minimum efficiency)

Cooling Capacity	Cooling and Heating Efficiency	Annual Savings	Annual Savings	Cost	Simple payback	15 yr Net Savings	15 yr ROI	Avg Annual ROI
		kWh/yr	$/yr	$	yrs	$	%	%
3 tons	from 14 SEER/COP 1 to 16 SEER/HSPF 8.5	4,096	410	$750	1.8	$5,394	719	48%
5 tons	from 14 SEER COP 1 to 16 SEER HSPF 8.5	6,547	655	$1,150	1.8	$8,671	754	50 %

Based on the potential savings these upgrades would still be attractive even if the costs were $1000 more than indicated. Payback would be about 3-4 years and avg. annual ROI about 10% and 17% for 3 ton and 5 ton respectively.

The heat pump cost and benefit was disaggregated from Table 4 to evaluate replacing electric strip heat COP 1 to heat pump HSPF 8.5. The results shown in Table 5 indicate that most of the benefits shown in Table 4 can be attributed to the heat pump portion. While heating hours are very low for New Smyrna Beach, heat pumps are economical since they are at least 3 times more efficient than electric strip heat. They also draw much lower amps and peak watts.

Table 5. Estimated Lifecycle Benefit, Simple Payback, and Cost Differential from Electric Strip Heat COP 1 to Heat Pump HSPF 8.5

Cooling Capacity	Cooling and Heating Efficiency	Annual Savings	Annual Savings	Cost	Simple payback	15 yr Net Savings	15 yr ROI	Average Annual ROI
		kWh/yr	$/yr	$	yrs	$	%	%
3 tons	from COP 1 to HSPF 8.5	3,045	304	$250	0.8	$4,317	1,727	115
5 tons	from COP 1 to HSPF 8.5	4,872	487	$400	0.8	$6,908	1,727	115

Based on the potential savings these upgrades would still be attractive even if the costs were $1000 more than estimated. Payback would be about 3-4 years and avg. annual ROI about 17% and 28% for 3 ton and 5 ton respectively.

General Recommendations for HVAC Equipment at Replacement

- Replace electric strip heating with heat pumps.
- Make City approval of system sizing and equipment selection part of the bid specifications. Approval can be based upon licensed engineer or HVAC contractor submittal of accurate cooling and heating load calculations. A correctly

sized system will provide better dehumidification than an oversized unit and use less energy. If occupancy tends to alternate between low and high periods, opt for two stage or multi-stage equipment.

- Insulate refrigerant lines.
- Provide training on optimum system operation and control to facility staff.
- Specify low sensible heat ratio (SHR) air conditioning equipment for spaces where indoor humidity is high.

General Recommended HVAC check-up, all buildings:

- Inspect accessible duct systems for disconnects and evidence of condensation (e.g. exposed metal collars at flex duct junctions). Many duct systems in ceiling spaces with roof insulation above are considered to be "in conditioned space." However, the roof insulation may be poor and ceiling space leaky to outdoors making duct repair a measureable benefit. Supply air lost into the ceiling space or attic does not arrive at intended spaces and may contribute to discomfort.
- Make sure all condensate lines are properly trapped and are regularly maintained to avoid blockage.
- Annually, survey building managers and investigate areas with consistent comfort complaints that often result in higher HVAC energy use. Specific check points should include equipment charge, temperature drop across the evaporator coil, supply temperature at air handler and register(s), air distribution disconnects and condensation points, out of range outside air ventilation rates, connections at supply air registers, return air bypasses, evidence in return plenums of moisture events (condensate blockage). Make note of potential new sources of heat and humidity that contribute to comfort complaints such as new auxiliary space heaters, central mainframe computers, fountains, as well as shade trees that may have been removed.

2.5 HVAC Load Reduction

Cooling load is from several sources outside and inside a building. Solar heat gain particularly through the roof assembly and windows has more impact generally on smaller buildings than very large ones. External cooling load is also from heat gain and humidity introduced to the conditioned space though outside air ventilation (also called mechanical ventilation or fresh air), building air infiltration leakage, and duct leakage. Internal sources of heat are generated by lighting, office equipment, and data centers as well as human activity.

Cooling Load from OA Ventilation:

Building ventilation is important for a healthier indoor environment. Outdoor air requires a lot of air conditioning energy to cool and dehumidify so it is important not to over-ventilate beyond the design occupancy. Overventilation results in longer AC runtime to reach comfortable conditions and sometimes chronically high indoor humidity levels. If a building is under ventilated, steps to increase ventilation should be undertaken. This will not save energy, but more importantly decrease potential health issues from higher concentrations of common indoor pollutants. Consider the following scenario for a large building where there was 500 cubic feet per minute (cfm) of outdoor mechanical ventilation more than the design occupancy. This is excess air is enough air for about 33 people and would require about 3 tons air conditioning capacity that must also be able to remove 16.7 pounds (2 gallons) of water from the air every hour. This would use about 3.1 kW of power and could represent an excess energy use of 6434 kWh/y worth about $643 in reduced ventilation energy cost (8 h/day, 5 days a week operation assumed).

Demand-based ventilation control can save significant energy in spaces that use a lot of OA, have wide range in occupancy and schedule of occupancy. In one study, replacing an existing old dedicated outside air system (DOAS) having no demand control with a new very high efficiency DOAS with demand control reduced energy use by 77%. Demand control accounted for 36% savings. These high savings are due to a 12 hour per day operation in a high school cafeteria, thus high variability in occupancy and schedule. Savings potential for more predictable occupancy, like office spaces that vary little from schedule, are small to none. A schedule-based control is best in this type of circumstance where the OA damper closes off ventilation after business hours.

ASHRAE 62.1-2016 standard sets the ventilation rates for commercial spaces with different uses. This standard has a history of some significantly big changes over serval decades meaning that buildings of different ages may have been designed with different ventilation rates. Older Florida buildings built when recommended ventilation was lower face a challenge in increasing OA with existing equipment that was not designed to manage the moisture load imposed by increased outside air. It is better to plan OA design changes around new cooling equipment that accounts for the new OA rate and control design.

General Recommendations for OA Ventilation All Buildings

- Work with a mechanical engineer with experience in determining design occupancy ventilation rates to calculate OA requirements served by each OA system and commission equipment to deliver the calculated ventilation flow. Prioritize evaluation in largest buildings with highest occupancy first.
- Utilize demand-based ventilation control in large assembly areas that have variable hours of use and high variability in occupancy. Carbon Dioxide sensor based control is a good option for such spaces. In areas where the number of occupants do not vary, but times of occupancy does vary, a simple occupancy sensor can be used to modulate a ventilation damper.
- It is common for older existing systems to have OA intakes on the return side of air conditioning system without damper control. This results in air ventilation whenever the air conditioner is operating which results in ventilation delivered based upon cooling load instead of occupancy. These types of OA systems should be phased-out as equipment is replaced. Automated damper control should be installed on all outdoor air intakes that closes during unoccupied periods and opens during occupied periods.

Cooling Load from Heat Generated By Lighting, Office Equipment, and Data Centers

All electricity used by lighting, office equipment, data centers, and other plug-in devices is ultimately converted into heat. Efficiency improvements in any of this equipment also reduces the cooling load they generate. Since electric lighting is a significant amount of total building energy, big reductions can result in noticeable reduction in cooling energy. The Advance Lighting Guidelines by Benya et al. 2003 stated that a Florida office space could have a 33% reduction in annual cooling energy from efficient lighting retrofit.

Aside from affecting the overall cooling load, heat produced by these devices can create “hot spots” where nearby spaces are uncomfortably warm. Sometimes these hot spots can drive thermostat operation. See Base Energy Use below for recommendations on these devices.

Cooling Load from Solar Heat Gain

Florida buildings receive most of their solar heat gain through the roof assembly, which is in the sun all day, and through windows, which transmit solar radiation directly to nearby surfaces. In buildings such as the Brannon Center, the size of occupancy and type of event rather than solar gain drives HVAC operation. Window heat gain is still important because it can disproportionately warm areas near windows causing discomfort. The glass in the Brannon Center’s windows is excellent and can serve as guide for new construction as well as replacement windows. As a rule, it is not cost effective to replace windows for the sake of energy savings. Roof heat gain is moderated by roof finish reflectivity, insulation, and maintaining air barriers between at conditioned spaces boundaries (e.g. between conditioned space and vented attic or between unvented ceiling space and outside).

General Recommendation at Replacement of Roofs and Windows:

- Within the class of windows needed for the building (e.g. impact resistant glass), select units that have solar heat gain coefficient below 0.5, concentrating on those with the highest visible transmittance, preferably near or above 0.5.
- At replacement of sloped roof finishes, select standing seam metal roofing (which is already in place in many of the buildings) with a light or white finish, aiming for total solar reflectance of 70% (0.7) or higher.
- At replacement of flat roofs, select white or lightest option available for the type of roof being installed. For example, if installing a single-ply rubber roofing membrane, choose white instead of black.

General Recommendation for Solar Heat Gain Check-up

- For all roofs, improve reflectivity with periodic cleaning to remove debris.
- For older metal roofing, application of bright white gloss paint may net savings or improved comfort by achieving higher reflectivity. Further reading: Cummings et al. 2000 & Parker et. al. 1997 studies can be found on FSEC publications online.
- For spaces where window heat gain creates chronic discomfort, consider window shading options (e.g. Bahama shutters, shade screens, landscaping, better interior blinds) or window film before window replacement. For window films, select a product with a ratio of light to solar heat gain greater than 1.0. This ratio

is often reported on technical data sheets available from tint manufacturers but can be calculated by dividing the visible light transmittance (Vt) by the solar heat gain coefficient (SHGC). For example, a window film having a Vt of 0.42 (sometimes written 42%) and SHGC of 0.39 has a ratio of light to solar heat gain of 0.42 divided by 0.39 resulting in 1.07, which meets the criteria of greater than 1. Unfortunately, window film contractors often do not have this information for the products they install, but the manufacturer's website or technical help line can provide it.

- One excellent window shading benefit is already being utilized by the City. Installing hurricane rated Bahama style shutters over windows provides substantial shading and improves building resiliency. Such shutters are being used on City Fire and police stations. These should be considered for other high EUI buildings with substantial east, west, and south exposures with no other shading and single pane glass.
- Inspect unvented ceiling spaces. At the underside of the roof deck and knee walls, replace missing or collapsed insulation and seal off unintended outside air flow into the unvented space.
- Inspect vented ceiling spaces. At the ceiling plane, replace missing insulation and air seal penetrations to prevent air from moving into the conditioned spaces.
- Typically, applying foam insulation to the underside of the roof deck and knee walls to convert vented into unvented ceiling cavities is not cost effective.

2.6 Non-HVAC Energy Savings

Non-HVAC energy use, also referred to as the "base load", is typically more consistent throughout the year because it is not influenced by weather. It includes lighting, desktop computers, office equipment, data centers, and all other plug in devices as well as water heating, which is negligent based on building uses under consideration.

2.7 Lighting

Interior lighting configurations vary widely from space to space. Calculations shown in Table 6 indicate results for a single fixture unless noted otherwise. Results from a single fixture can be scaled up for estimating impact of a specific project. In some cases budget may not allow retrofit of the entire building at once, but this could be completed in phases. The last row of Table 6 shows an example of savings and ROI for a package replacement of 38 T8 fixtures in fire station garages.

Table 6. Estimated Lifecycle Benefit, Simple Payback, and Cost Differential from Replacement of a Single Existing Lamp or Fixture with New LED.

Retrofit existing type	Assumed hours on/yr	LED life	Savings	Savings	Cost LED + labor	Simple payback	Lifetime savings net*	ROI	Avg Annual ROI
	hours	yrs	kWh/yr	$/yr	$	Yrs	$	%	%
T8 2 lamp	2,607	19.2	95	9.46	85	5.1	182	214	11
T8 3 lamp	2,607	19.2	156	15.6	115	4.6	300	261	14
T8 4 lamp	2,607	19.2	232	23.24	115	3.2	447	389	20
T12 2 lamp	2,607	19.2	144	14.35	85	3.7	276	325	17
HID/MH	2,816	16	538	53.83	285	3.7	860	302	19
CFL	2,607	19.2	75	7.54	36	3.4	145	403	21
Below is for replacement of 38 T8 2 lamp fixtures with LED in Fire Station Garages									
Fire Station garage- Replace 38 T8 lamps	5,110	9.8	7,091	709	3,230	3.4	6,935	215	22

*Lifetime savings based upon energy savings over LED lifetime, costs of LED material and labor installation as well as material and labor costs for re-lamping old existing light.

Exterior parking lot lighting

Energy audits found that several buildings already had LED parking lights installed. This is an excellent effort by the City of New Smyrna Beach and should continue to be implemented as budget allows. The parking lot lighting at the Police Department had 175 watt HID lamps replaced with 38 watt LED lamps. One exterior LED lamp replacement could save $69 per year with a return on investment after only 4.3 months if used 12 hours/day 7 days/week.

General Recommendations for Lighting Replacement

- Replace fluorescent fixtures with LED as budget permits.
- Samples of illumination were measured, and the team found several places where levels were higher than Illuminating Engineering Society recommendations. This indicates some potential to reduce lighting in some locations. Illumination need is subjective and may vary among different individuals. At fixture replacement, illumination target levels at specific locations should be determined by qualified illumination specialist who accounts for the types of tasks to be performed to inform lighting design calculations. Table 7 shows recommended illumination levels for some common types of spaces. There are free applications for smartphones that can measure light levels. A

more extensive lighting level evaluation could be conducted relatively inexpensively by City staff to consider if delamping should be considered before LED retrofits.

Table 7. Recommended Illumination by Task

Task Type	Illumination (foot candles)
Difficult inspection	100-200
Reading small type <8 point	50-100
Reading > 8 point type	20-50
Active storage large items	10-20
Active storage small items	20-50
Inactive storage	5-10
Toilets, lobby, corridor, waiting area	10-20

- Lighting power density (LPD Watts/ft^2) is another metric that can be used to look for potential over-lamping. We estimate that most buildings dominated with T8 fluorescent lamping had and average LPD around 1.1 Watts/ft^2. Examples of LPD new code limit and suggested very efficient targets are shown in Table 8. New light retrofits should strive for the very efficient LPD target. Specific lighting needs may require higher LPD.

Table 8. Examples of New LPD Limits and Suggested LPD Targets

Space Type	Maximum new code limit LPD (W/ft^2)	Very efficient target* LPD (W/ft2)
Open office	0.98	0.54
Enclosed office	1.11	0.61
Conference room	1.24	0.68
Lobby	0.90	0.49
Stairway	0.69	0.38
Restrooms	0.98	0.44
Fire station sleeping quarters	0.25	0.25
Gymnasium (physically active)	1.20	0.62

*Very efficient target may not be feasible where task illumination requires more lighting.

- At replacement of fluorescent general lighting such as ceiling mounted lighting in an office space, select LED fixtures and lamps (bulbs) and design for evenly distributed light. Compare manufacturers' data sheets on lumens, light distribution distances and patterns to the space being lit. More or fewer fixtures may be called for than the number of fixtures being removed. Spaces with higher than necessary illumination levels or LPD may be able to further reduce energy use by reduced lamping.

- If possible, evaluate a small sample of intended energy efficient lamp fixtures to confirm light quality is acceptable before committing to full implementation. Specify lamps with CRI>80 for offices or spaces where accurate identification of color and detail is important. The Energy Star® program offers learning resources for common single bulb applications. (https://www.energystar.gov/products/lighting_fans) and a tool for selecting LED bulbs: https://www.energystar.gov/products/choose_a_light .
- Develop a plan for ensuring lights are turned off at the close of business or install lighting controls, such as occupancy sensors or clock control, to turn off lights after hours. Also, add light controls that use occupancy sensors to turn lights off when a space is vacant. This should be implemented in spaces such as offices, meeting rooms, and storage spaces. Install daylight illumination sensors to auto dim or turn off lights in spaces with adequate natural daylight.
- Install LED exit signs.

General Recommendations for Lighting Quality and Control Audit

- Conduct a nighttime lighting audit to identify areas that are over-illuminated.
- Conduct annual audit of all lighting controls to verify effective performance. This includes exterior photo sensor or astrological clock controls, as well as interior occupancy sensors.

Lighting Occupancy Controls

Occupancy sensors reduce lighting during unoccupied hours. The technology is well established and reliable. Appropriate spaces for occupancy sensors include open and private office spaces, conference/meeting rooms, general assembly spaces, janitor/storage closets, and long hallways. Table 9 provides estimated cost benefit calculations for light control using a fire station as an example. The results show good ROI given the expected long life of controllers. Good ROI is expected for office and public assembly spaces as well.

Table 9. Estimated Lifecycle Benefit, Simple Payback, and Cost Differential from Lighting Control Installation.

Retrofit existing type	Control Life	Savings	Savings	Cost	Simple payback	Lifetime* savings net	ROI %	Average Annual ROI
	yrs	kWh/yr	$/yr	$	Yrs	$	%	%
Fire Station T8 Fluorescent Light control	20	1,697	170	880	5.2	33,060	3,757	188

Assumed 50% of fire station conditioned space and garage lighting can be controlled with 11 occupancy controls. Occupancy control savings 23.5% used based upon weighted average for different spaces (source: Abbaszadeh, S., Lee, A., and Kan, C.

2014. "California Lighting Solutions Workbook 2014 Update Report". The Cadmus Group, Inc.).

<u>Assumptions for lamp analysis</u>

- Fluorescent lamp life based upon 3 hr. on cycles, not based on manufacture rated continuously on lifetime. This decreases life by about 41%.
- T8: Life 12,500 hrs., re-lamping costs- $2.50/lamp and $10 install labor per fixture; ¼ ballast replacement at $58
- T12 life 10,000 hrs., re-lamping costs- $2.50/lamp and $10 install labor per fixture; ¼ ballast replacement at $58
- CFL life 8,000 hrs., re-lamping cost $5.00/lamp and $20 install labor per fixture
- HID life 15,000 hrs., re-lamping cost $26.00/lamp and $20 install labor per fixture

2.8 Computers, Office Equipment, and Data Centers

General Recommendations for Computers, Office Equipment, and Data Centers

- Consult guidance from The Energy Star® program on higher efficiency equipment for data centers (https://www.energystar.gov/products/data_center_equipment)
- Purchase for Energy Star® labeled computers and office equipment and enable power conservation options.
  Conduct a nighttime audit to identify equipment left on unnecessarily. Enable power saver modes where available and develop a plan for ensuring equipment is turned off at close of business.

2.9 Retro Commissioning (RxC)

Based upon study and analysis by Parrish et al. 2013, retro commissioning typically saves 16 percent on energy bills and produces a payback within one year. Existing buildings are expected to see an average of 13% whole building energy savings, but the range was 10% - 30%; Twenty-five percent of existing buildings saw savings of 30% or more. Estimates for RxC costs has median cost $0.30/ft^2 for existing buildings and $1.16/ft^2 for new construction. Source: Parrish, Granderson, Mercado, Mathew 2013. “Improving Energy Efficiency through Commissioning: Getting Started with Commissioning, Monitoring, and Maintaining Performance” Lawrence Berkeley National Laboratory. https://eta.lbl.gov/publications/improving-energy-efficiency-through.

Savings from RxC is most likely to occur in commercial buildings having space conditioning and lighting that utilize sensors, controls, and schedules to optimize operations and conserve energy. Like any complex system, one bad sensor or incorrect control input can result in increased energy use.

It is recommended to implement RxC about every 5 years. Two city buildings out of the 18 evaluated appear to be good candidates for RxC based upon building systems, controls, and high energy usage. Table 10 indicates estimated savings potentials for these two buildings at three different savings impacts.

Table 11 shows cost and benefit analysis for a conservative 13% savings estimate, which indicates very attractive benefits.

Table 10. Cost and Savings Potential from Retro Commissioning

Building	Cost $	Savings @ 13% kWh/yr	Savings @13% $ /yr	Savings @ 20% kWh/yr	Savings @20% $ /yr	Savings @ 30% kWh/yr	Savings @30% $ /yr
Brannon Center	4,153	69,482	8,401*	106,896	12,924	160,344	19,386
Police Dept.	9,809	115,708	11,588	178,012	17,828	267,018	26,742

* Brannon center average rate $0.121/kWh

Table 11. Cost and Benefit Analysis from Retro Commissioning With 13% Savings Impact

Building	Life yrs	Simple payback Yrs	Lifetime* savings net $	ROI %	Avg Annual ROI %
Brannon Center	5	0.5	37,851	911	182
Police Dept.	5	0.9	48,133	491	98

3. Energy Conservation Measures for Individual Buildings

Babe James
Implementing LED lighting retrofits, occupancy sensor light control and replacement of at least one older air conditioner could further reduce annual energy by about 35,303 kWh/y.

This would be a reduction of 13.9% from the currently use of 253,163 kWh/y in electricity. ECM total impact could reduce annual energy use down to 217,860 kWh/y.

Brannon Center
The Brannon Center had the worst EUI of all buildings evaluated. Any building with high usage will have higher EUI. It is unknown how much this is a factor. This newer building has LED lights, controls, and new cooling equipment operated by an energy management system. Review of billing history and site audit data identified retro commissioning (RxC) as an important conservation measure. RxC could further reduce annual energy by about 69,482 kWh/y.

This would be a reduction of 13.0% from the currently use of 534,480 kWh/y in electricity. ECM total impact could reduce annual energy use down to 464,998 kWh/y. The EUI would drop from 132 to 115.

This building was being cooled down to 70 degrees F during our site visit when no events were occurring. We were told that this was necessary to pre-cool in anticipation for an upcoming event due to one air conditioner out of order. This is understandable in this case; however, this can increase cooling energy use by 30% compared to a setpoint at 75F.

City Hall

City Hall has already been undergoing LED lighting retrofits. This, as well as the relatively newer air conditioning and heat pumps, has already helped lower the EUI to 35 kBtu/ft2/year. Completion of LED lighting retrofits, occupancy sensor light control, and replacement of two other older air conditioners could further reduce annual energy by about 7,805 kWh/year, which is a 6.7% reduction from current use of 116,284 kWh/year in electricity. The new EUI could be about 32 kBtu/ft2/year.

City Hall Annex

A report focused on the City Hall Annex renovation was provided earlier in the year.

Chamber of Commerce

Implementing LED lighting retrofits, occupancy sensor light control and replacement of at least two older air conditioners could further reduce annual energy by about 8,174 kWh/y.

This would be a reduction of 23.2% from the currently use of 35,208 kWh/y in electricity. ECM total impact could reduce annual energy use down to 27,034 kWh/y. The EUI could drop from 15 to 11. This is a reasonable EUI for an old historic building having greater limitations on modifications than non-historic.

Coronado Civic Center

Implementing LED lighting retrofits, occupancy sensor light control and replacement of at least two older air conditioners could further reduce annual energy by about 13,557 kWh/y.

This would be a reduction of 42.8% from the currently use of 31,709 kWh/y in electricity. ECM total impact could reduce annual energy use down to 18,152 kWh/y. The EUI could drop from 54 to 31. This is a reasonable EUI for an old historic building having greater limitations on modifications than non-historic.

CRA

This was a small building with a reasonably low EUI of 22 due to CFL lights and reasonable thermostat settings. Implementing LED lighting retrofits could further reduce annual energy by about 167 kWh/y.

This would be a reduction of 2.5% from the currently use of 6568 kWh/y in electricity. ECM total impact could reduce annual energy use down to 6401 kWh/y.

City Gym Live Oak

Weather conditions were conducive to using an infrared camera on this building during a hot afternoon. This showed that the roof was doing a reasonable job limiting heat transfer. The metal roof is a large factor in this benefit. Implementing LED lighting retrofits, occupancy sensor light control and replacement of at least two older air conditioners could further reduce annual energy by about 31,836 kWh/y.

This would be a reduction of 42.5% from the currently use of 74,980 kWh/y in electricity. ECM total impact could reduce annual energy use down to 43,144 kWh/y. The EUI could drop from 20 to 12.

Fire Station 50

Fire stations will have much higher EUI compared to other commercial building spaces since they are utilized 24 hours per day. They also are known to have very low cooling thermostat settings, which increases energy use. Domestic hot water use appears to also be a large end use. Although this station used gas hot water heaters, there was about 350 W of DHW recirculation loop pump power used. Timers indicated operation 12 hours per day. This alone would only represent 64 kWh/year.

Implementing LED lighting retrofits and occupancy sensor light control could further reduce annual energy by about 8,460 kWh/y.

This would be a reduction of 5.8% from the currently use of 146,054 kWh/y in electricity. ECM total impact could reduce annual energy use down to 137,595 kWh/y. The EUI could drop from 78 to 73.

Fire Station 51

Domestic hot water use appears to also be a large end use. It was not clear why two 120 gallon water heaters were required. This needs to be evaluated more fully for feasible options. It is recommended that a hot water use evaluation be done to determine amount of draw and use each day. Reduce capacity if possible. Consider a commercial hot water heat pump. These are available in 120 gallon size and only draw 1/3 of the power the existing electric tank draws. The COP is 4.2 compared to existing COP of 1. This means the heat pump DHW is about 4.2 times more efficient. We have no idea how much hot water is used, but suspect it is large. A side benefit is that cool air is produced that can be used for comfort cooling in proximity to the DHW.

Implementing LED lighting retrofits and occupancy sensor light control could further reduce annual energy by about 8,378 kWh/y.

This would be a reduction of 5.5% from the currently use of 153,173 kWh/y in electricity. ECM total impact could reduce annual energy use down to 144,795 kWh/y. The EUI could drop from 78 to 73.

Fire Station 52

Domestic hot water use appears to also be a large end use. It was not clear why two 120 gallon water heaters were required. This needs to be evaluated more fully as discussed under Fire Station 51.

Implementing LED lighting retrofits and occupancy sensor light control could further reduce annual energy by about 7,529 kWh/y.

This would be a reduction of 6.5% from the currently use of 115,564 kWh/y in electricity. ECM total impact could reduce annual energy use down to 108,035 kWh/y. The EUI could drop from 82 to 76.

Fire Station 53

Domestic hot water use appears to also be a large end use. This needs to be evaluated more fully as discussed under Fire Station 51.

Implementing LED lighting retrofits and occupancy sensor light control further reduce annual energy by about 7,349 kWh/y.

This would be a reduction of 6.9% from the currently use of 107,168 kWh/y in electricity. ECM total impact could reduce annual energy use down to 99,818 kWh/y. The EUI could drop from 79 to 74.

Maintenance and Operations

The utility billing data indicated a smaller than anticipated energy use for this building. Potential savings were based upon site-evaluated data during visits. Potential savings appear reasonable; however, they would appear to be very high relative to the low annual energy use indicated by billing data. Implementing LED lighting retrofits and replacement of at the older air conditioner may reduce annual energy by about 8,447 kWh/y.

This would be a reduction of 82.8% from the currently use of 10,200 kWh/y in electricity.

Municipal Golf Clubhouse (Pro Shop)

Implementing LED lighting retrofits, occupancy sensor light control and replacement of at least two older air conditioners could further reduce annual energy by about 5,673 kWh/y.

This would be a reduction of 19.9% from the currently use of 28,445 kWh/y in electricity. ECM total impact could reduce annual energy use down to 22,772 kWh/y. The EUI could drop from 29 to 24.

Municipal Marina

Utility bills were not available for this small building. Implementing LED lighting retrofits, occupancy sensor light control could further reduce annual energy by about 413 kWh/y.

Police Department

Police stations will have much higher EUI compared to other commercial building spaces since they are utilized 24 hours per day. Several office locations were observed to have very low cooling thermostat settings, which increases energy use.

Implementing LED lighting retrofits and RxC could further reduce annual energy by about 162,149 kWh/y.

This would be a reduction of 18.2% from the currently use of 890,060 kWh/y in electricity. ECM total impact could reduce annual energy use down to 727,911 kWh/y. The EUI could drop from 93 to 76.

Sports Complex Building

Implementing LED lighting retrofits and occupancy sensor light control further reduce annual energy by about 6,840 kWh/y.

This would be a reduction of 22.7% from the currently use of 30,068 kWh/y in electricity. ECM total impact could reduce annual energy use down to 23,228 kWh/y. The EUI could drop from 54 to 42.

4. Solar Feasibility and Potential Impact Overview

Potential for solar power production was calculated using PV Watts, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory at https://pvwatts.nrel.gov/. The analysis uses 30 years of actual weather data to estimate the amount of solar radiation available for a particular site during every hour of the year. Weather data is pulled from the weather station closest to the latitude and longitude of each site. The PV Watts reports are included in Appendix C. They provide a photo of the footprint and square meters required for the PV installation for each building. In addition, the system's capacity (expressed in terms of kilowatt-hours direct current – kWdc), production (kWh) and value (cost per kWh produced based on actual electric rates) is calculated. With that information, the economic analysis was conducted, providing estimated system cost, lifetime savings, simple payback and return on investment.

The potential for solar power production is influenced by roof orientation, shading from nearby trees and structures, and available roof space. FSEC's summary of the solar power production potential for each building is shown in Figure 1 (see also Table 12). Note that smaller buildings, such as the Chamber of Commerce and the City Marina have lower potential for power production than larger buildings such as the Police Department. Some large buildings, such as City Hall, have lower potential solar production because of shading from nearby trees.

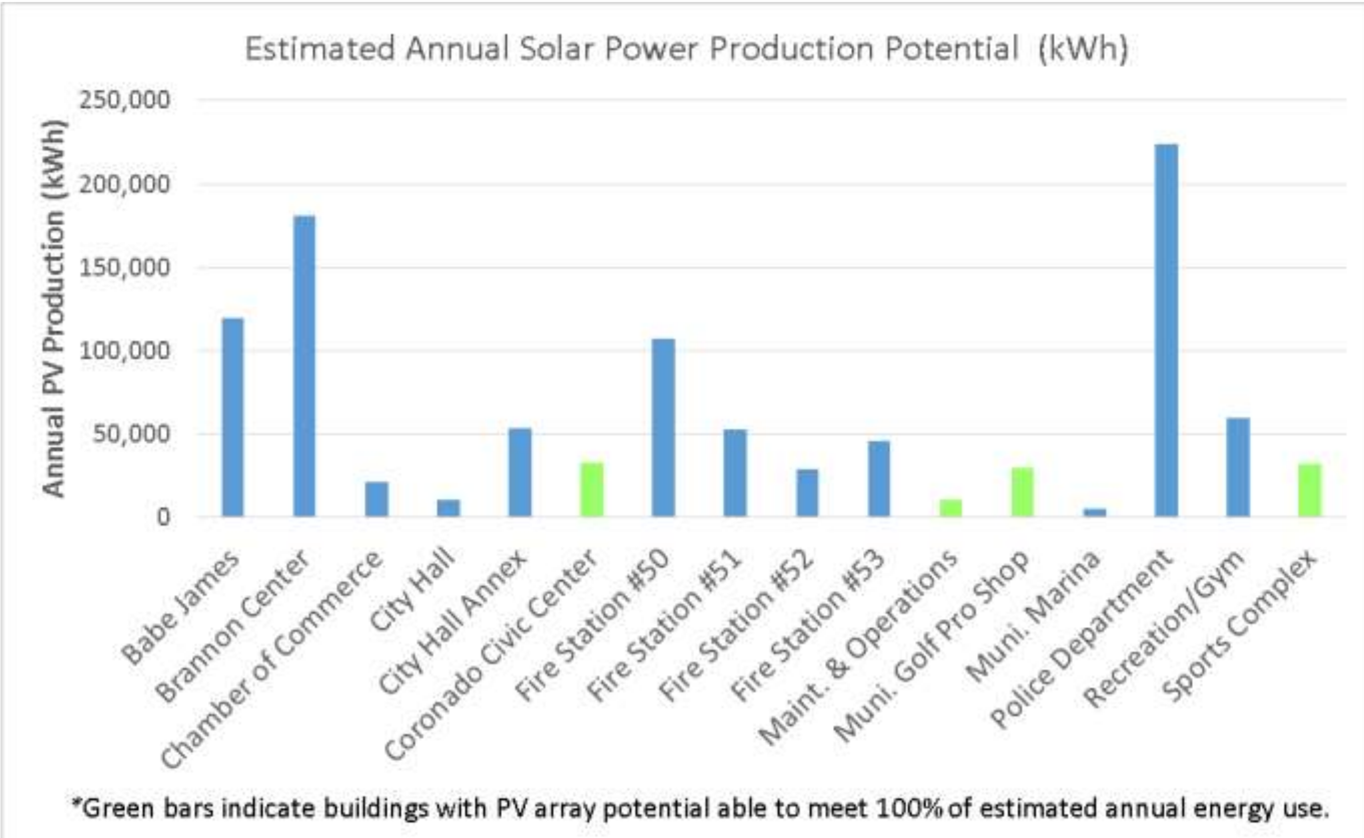


Figure 1. Estimated potential for solar power production considering shading, roof area and orientation.

4.1 Annual Balance of Produced and Purchased Power

Annual solar power production offsets a portion of annual energy use, reducing the amount of power purchased from the electric utility.

Considering the existing annual energy of each building, without any of the recommended ECM's, four of the City's buildings could accommodate solar panels capable of producing far more power than needed. In general, any excess power generation is carried forward as a credit in subsequent months for the 12-month billing cycle. If an excess credit remains, the solar customer is paid for the remaining kWh production at a wholesale electric rate. For economic reasons, we do not recommend sizing systems beyond the average annual electrical use. If there is a potential future use for excess power production, for example, if the city were to add electric vehicle charging stations to a site with high solar potential and low overall building energy load, that should be taken into consideration. The fact that the city operates a municipal electric utility will also be a factor in these types of issues.

FSEC would recommend installing only the number of PV panels needed to offset predicted annual energy use, resulting in a zero energy (ZE) building. The green bars in Figure 2 indicate potential to achieve a ZE building in four of the City's facilities: Coronado Civic Center, Maintenance and Operations Building, Municipal Golf Course

Pro-shop, and the Sports Complex. The roof size of these buildings can accommodate one or more PV arrays that have the potential to completely offset estimated annual energy use. The blue bars show the in estimated maximum offset in the other facilities based on available roof area and other sizing factors. Three buildings are omitted from Figure 2 for reasons noted in Table 12 which shows the values used to produce Figures 1 and 2.

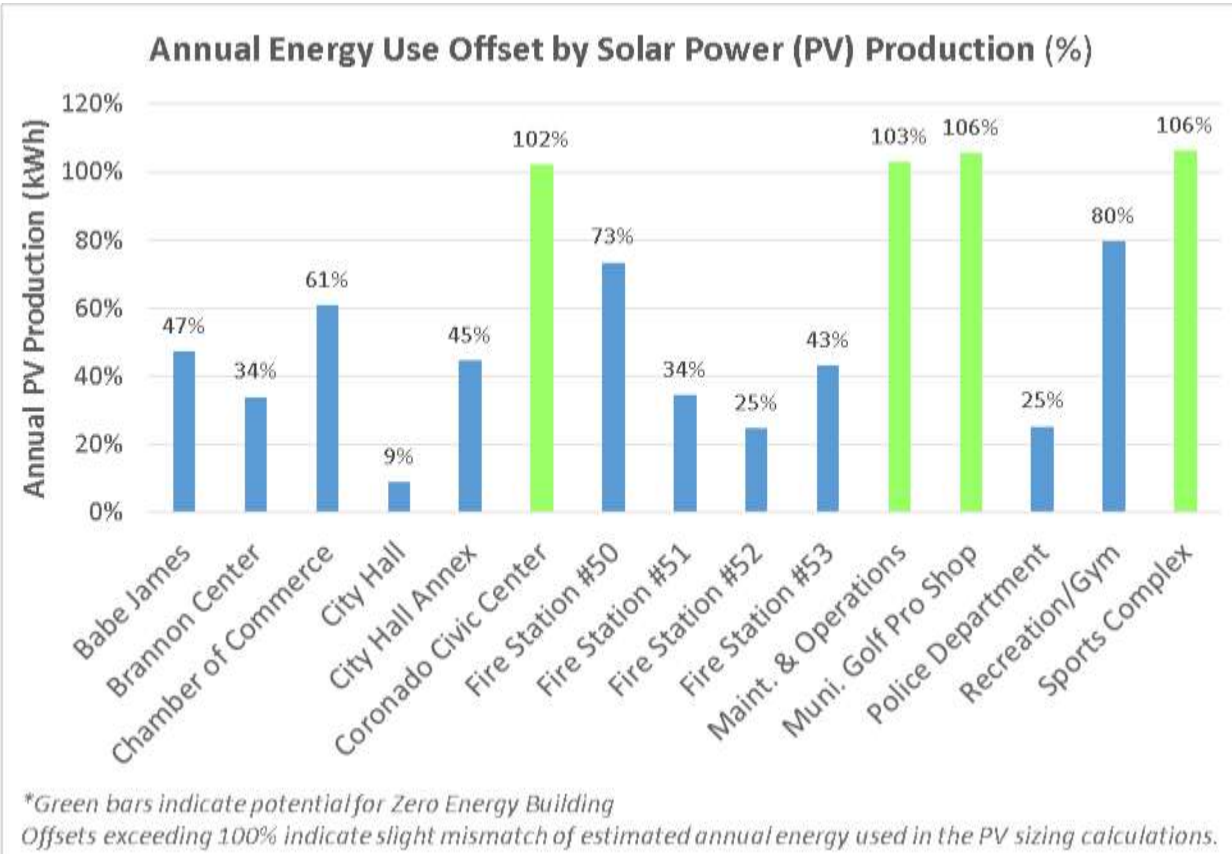


Figure 2. Portion of estimated existing annual energy use that could potentially be offset by PV power production.

Table 12. Solar Power (PV) Production Potential and Economic Calculations

Building	Existing Annual Energy Use (kWh/yr)	PV System Capacity (kWdc)	Annual PV Production Potential (kWh/yr)	% Offset	PV System Annual Savings	PV Lifetime Savings	PV System Installed Cost	Simple Pay-back (years)	Return on Invest-ment
Babe James Community Center	253,163	84.90	119,268	47%	$ 11,929	$ 298,225	$ 169,800	14	76%
Brannon Center	534,480	124.00	181,061	34%	$ 18,106	$ 452,650	$ 248,000	13	83%
Chamber of Commerce	35,208	14.20	21,376	61%	$ 2,137	$ 53,425	$ 28,400	13	88%
City Hall	116,284	7.00	10,201	9%	$ 1,021	$ 25,525	$ 14,000	13	82%
City Hall Annex	120,662	48.00	53,743	45%	$ 6,448	$ 161,200	$ 96,000	14	68%
Coronado Civic Center	31,709	21.50	32,409	102%	$ 3,241	$ 81,025	$ 43,000	13	88%
Fire Station #50	146,054	78.50	107,170	73%	$ 10,717	$ 267,925	$ 157,000	14	71%
Fire Station #51	153,173	37.00	52,510	34%	$ 5,284	$ 132,100	$ 74,000	14	79%
Fire Station #52	115,564	18.60	28,580	25%	$ 2,857	$ 71,425	$ 37,200	13	92%
Fire Station #53	107,168	34.60	46,084	43%	$ 4,610	$ 115,250	$ 69,200	15	67%
Live Oak Cultural Center*	n/a	40.00	59,645		$ 5,964	$ 149,100	$ 80,000	13	86%
Maintenance Operations/Fleet	10,200	7.00	10,516	103%	$ 1,051	$ 26,275	$ 14,000	13	88%
Municipal Golf Course	28,445	20.00	30,047	106%	$ 3,005	$ 75,125	$ 40,000	13	88%
Municipal Marina*	n/a	4.00	5,326		$ 532	$ 13,300	$ 8,000	15	66%
Police Department	890,060	149.00	223,848	25%	$ 22,384	$ 559,600	$ 298,000	13	88%
Recreation/Gym	74,980	40.00	59,645	80%	$ 5,964	$ 149,100	$ 80,000	13	86%
Sports Complex	30,068	23.00	31,945	106%	$ 3,194	$ 79,850	$ 46,000	14	74%
TOTAL	2,647,218	751	1,073,374		$ 108,444	$ 2,711,100	$ 1,502,600		

*Not addressed due to inadequate or complications with utility data

4.2 Estimated Installed Cost and Simple Payback

The cost of photovoltaic systems has continued to decline over the years for a variety of reasons. The US Department of Energy's SunShot Program has targeted cost reduction as a major priority, with a goal of reducing the total costs of solar energy by 75 percent, making it cost competitive at large scale with other forms of energy without subsidies by the end of the decade. These goals target the utility sector as well as the commercial and residential sector. The current installed cost of a photovoltaic system in a commercial setting like the City of New Smyrna Beach facilities ranges between $1.75 and $2.00 per watt. The "PV System Installed Estimated Cost" shown in Table 12 above are based on $2.00 per watt to be conservative. Factors that influence actual cost include system location, mounting method and configuration, and PV panel selection.

4.3 Life Expectancy, Ongoing Maintenance Cost

The average life expectancy of a photovoltaic panel is anywhere from 25 to 30 years. Typical industry warranties run for 25 years, with the expectation that performance will degrade less than ½ percent per year. The panels are relatively maintenance free, especially in Florida where the climate is not as harsh as other regions and our rainfall tends to keep the panels clean. The balance of system components also come with warranties that are honored by the installing contractor and manufacturers.

4.4 Performance Monitoring

Most PV systems on the market today come with monitoring capabilities that will allow maintenance staff to check system performance. For large commercial installations at multiple sites within the city, the contractor selected for installation should provide a minimum period of service and maintenance. Many solar companies now routinely offer this service. However, given the potential scale of the city's solar footprint, it is recommended that at least two physical plant/maintenance personnel be trained by the equipment providers on routine maintenance and troubleshooting.

4.5 General Recommendations for Solar System Installations

Orientation and Panel Location

The preferable orientation for solar panels is facing the southern sky; however, east and west facing panels can be effective as well. For public buildings, FSEC recommends rooftop solar systems over ground-mounted because they are less vulnerable to vandalism. The recommended location for solar panels on each building is provided in Appendix C. For buildings with limited roof space, a canopy over parking can provide an alternative location.

Attachment and roof loading: For existing structures, it is paramount to engage a structural engineer to evaluate the roof support system as part of preliminary design work. The exact weight of the PV panel will have to be determined once a specific PV panel has been selected. Some assumptions have been made based on commonly used panels on commercial building rooftops. Assuming each panel is 65” x 39” and each panel and its associated rack support fixture weighs 41 pounds (lbs.) Solar PV panels with associated support systems (aka racking) will add approximately three pounds for each square foot of collector area. It is very common for the PV installer to work directly with the roofing contractor to coordinate attachment roof penetration by the roofing contractor to maintain any roof warrantee.

Ballasted mounting is another option; however, the weight can be significantly higher ranging from four to six pounds per square foot of collector area. The advantage of ballasted systems is the avoidance of roof penetrations, since they rely on weight to resist live loads such as uplift. Florida building code allows use of ballasted systems on roof with less than 1 in 12 pitch. However, unless the existing roof structure can accommodate the additional load, ballasted mounting may be impractical and excessively expensive.

4.6 Solar Feasibility Conclusion

The City has excellent candidates for solar power production in individual buildings resulting in significant offset of purchased power, with four buildings that could potentially have all of the annual energy use offset by solar power - achieving zero energy status. The sizing calculations including a sketch of roof area for PV placement, a PVWatts Analysis of kWh production and monthly and annual energy cost savings. With that information, each building was analyzed for its solar potential, percentage of solar contribution with and without the adoption of recommended energy conservation measures, system cost, annual and lifetime system savings, simple payback and return on investment. Using this data, the City will be able to make an informed decision about which buildings to consider for solar and how much solar and energy efficiency can contribute to their energy and greenhouse gas reduction goals. If the energy use of the buildings audited in this report represented 100% of the electricity consumed by the City, solar PV has the potential to offset 40 percent, or to express as a goal, the City can achieve a 40 percent renewable (solar) goal in the time it takes to install these systems. If the City incorporated the ECM recommendations, the solar contribution would increase to 47%.

5. Solar Assessments for Individual Buildings

Babe James

Three roof elevations were considered. East roof can accommodate 23.9 kWdc producing 32,112 kWh per year; South roof can accommodate 36.0 kWdc producing 52,462 kWh per year; and, West roof can accommodate 25.0 kWdc producing 34,694 kWh per year, for a total available PV system capacity of 84.9 kWdc producing 119,268 kWh per year. Current annual kWh consumption of 253,163 could be offset by 47%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 35,303 kWh to 217,860 kWh, allowing the solar to provide 55% of the building's electrical load.

Solar Potential	84.9 kWdc	119,268 kWh/year
Installed Cost	$2/Watt	$169,800
Annual/Lifetime Savings	$11,929	$298,225
Simple Payback/Return on Investment	14.2 Years	Investment Gain - $128,425 ROI - 75.63% Annualized ROI - 2.28%

Brannon Center

The West roof elevation was considered. It can accommodate a PV system capacity of 124.0 kWdc producing 181,061 kWh per year. Current annual kWh consumption of 534,480 could be offset by 34%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 69,482 kWh to 464,998 kWh, allowing the solar to provide 39% of the building electrical load.

Solar Potential	124.0 kWdc	181,061 kWh/year
Installed Cost	$2/Watt	$248,000
Annual/Lifetime Savings	$18,106	$452,650
Simple Payback/Return on Investment	13.7 Years	Investment Gain - $204,650 ROI – 82.52% Annualized ROI – 2.44%

Chamber of Commerce

The South roof elevation was considered. It can accommodate a PV system capacity of 14.2 kWdc producing 21,376 kWh per year. Current annual kWh consumption of 35,208 could be offset by 61%

If additional energy savings measures were taken, annual electric consumption could be reduced by 8,174 kWh to 27,034 kWh, allowing the solar to provide 79% of the building electrical load.

Solar Potential	14.2 kWdc	21,376 kWh/year
Installed Cost	$2/Watt	$28,400
Annual/Lifetime Savings	$2,137	$53,425
Simple Payback/Return on Investment	13.3 Years	Investment Gain - $25,025 ROI – 88.12% Annualized ROI – 2.56%

City Hall

A portion of the flat roof elevation was considered. It can accommodate a PV system capacity of 7.0 kWdc producing 10,201 kWh per year. Current annual kWh consumption of 116,284 could be offset by 9%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 7,805 kWh to 108,479 kWh, allowing the solar to provide 9.4% of the building electrical load.

Solar Potential	7.0 kWdc	10,201 kWh/year
Installed Cost	$2/Watt	$14,000
Annual/Lifetime Savings	$1,021	$25,500
Simple Payback/Return on Investment	13.7 Years	Investment Gain - $11,500 ROI – 82.14% Annualized ROI – 2.43%

City Hall Annex

This building is undergoing renovation; analysis was based upon site visit of existing structure and plans. A full report was previously submitted. Roof area without regard for potential elevator equipment will accommodate a PV system capacity of 60 kWdc, producing 80,615 kWh per year. Assuming an area is needed for elevator equipment, the roof will accommodate a PV system capacity of 48kWdc, producing 53,743 kWh per year. Not able to determine offset of electrical load, just the potential production.

Solar Potential	48 kWdc	64,492 kWh/year
Installed Cost	$2/Watt	$96,000
Annual/Lifetime Savings	$6,448	$161,200
Simple Payback/Return on Investment	$14.9 Years	Investment Gain – $63,200 ROI – 64.49% Annualized ROI – 2.01%

Coronado Civic Center

The South roof elevation was considered. It can accommodate a PV system capacity of 31.5 kWdc producing 48,373 kWh per year. Current annual kWh consumption of 31,709 is significantly less than the potential solar contribution. In order to be a net zero (rather than excess) generator with solar, a system size of 21.5 kWdc is recommended, generating 32,409 kWh per year. This size system is a better load match, unless future electrical consumption is expected to increase (for example, with the addition of electric vehicle charging equipment). Current annual kWh consumption of 31,709 kWh/y could be offset by 102%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 13,584 kWh to 18,152 kWh. Since a PV system can already meet at least 100% of annual energy use, ECM would allow a smaller PV system at less cost to be installed that can still meet 100 % of energy use.

Solar Potential	21.5 kWdc	32,409 kWh/year
Installed Cost	$2/Watt	$43,000
Annual/Lifetime Savings	$3,241	$81,025
Simple Payback/Return on Investment	13.3 Years	Investment Gain - $38,025 ROI – 88.43% Annualized ROI – 2.57%

Fire Station 50

The East and West roof elevations were considered. The East roof can accommodate 36.0 kWdc producing 49,584 kWh per year. The West roof can accommodate 42.5 kWdc producing 57,586 kWh per year. Total available capacity is 78.5 kWdc producing 107,170 kWh per year. Current annual kWh consumption of 146,054 kWh could be offset by kWh or 73%.

If additional energy saving measures were taken, annual electric consumption could be reduced by 8,460 to 137,594 kWh, allowing the solar to provide 78% of the building electrical load.

Solar Potential	78.5 kWdc	107,170 kWh/year
Installed Cost	$2/Watt	$157,000
Annual/Lifetime Savings	$10,717	$267,925
Simple Payback/Return on Investment	14.6 years	Investment Gain - $110,925 ROI – 70.65% Annualized ROI – 2.16%

Fire Station 51

The East and West roof elevations were considered. The East roof can accommodate a PV system capacity of 18.0 kWdc producing 25,164 kWh per year. The West roof can accommodate a PV system capacity of 19.0 kWdc producing 27,718 kWh per year.

Total available capacity is 37 kWdc producing 52,882 kWh per year. Current annual kWh consumption of 153,173 kWh could be offset by 34%.

If additional energy saving measures were taken, annual electric consumption could be reduced by 8,378 to 144,795 kWh, allowing the solar to provide 36% of the building electrical load.

Solar Potential	37 kWdc	52,882 kWh/year
Installed Cost	$2/Watt	$74,000
Annual/Lifetime Savings	$5,284	$132,100
Simple Payback/Return on Investment	14 years	Investment Gain - $58,100 ROI – 78.51% Annualized ROI – 2.35%

Fire Station 52

The South roof elevation was considered. It can accommodate a PV system capacity of 18.6 kWdc producing 28,580 kWh per year. Current annual kWh consumption of 115,564 could be offset by 25%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 7,529 to 108,035 kWh, allowing the solar to provide 26% of the building electrical load.

Solar Potential	18.6 kWdc	28,580 kWh/year
Installed Cost	$2/Watt	$37,200
Annual/Lifetime Savings	$2,857	$71,425
Simple Payback/Return on Investment		Investment Gain - $34,225 ROI – 92% Annualized ROI – 2.64%

Fire Station 53

The East and West roof elevations were considered. Each can accommodate a PV system capacity of 17.3 kWdc/year for a total of 34.6 kWdc/year, producing 23,402 kWh (E) and 22,682 kWh (W) per year for a total of 46,084 kWh per year. Current annual kWh consumption of 107,168 could be offset by 43%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 7,349 to 99,819 kWh, allowing the solar to provide 46% of the building electrical load.

Solar Potential	34.6 kWdc	46,084 kWh/year
Installed Cost	$2/Watt	$69,200
Annual/Lifetime Savings	$4,610	$115,250
Simple Payback/Return on Investment	15 years	Investment Gain - $46,050 ROI – 66.55% Annualized ROI – 2.06%

Live Oak Cultural Center

The footprint of the South roof elevation was considered. The South roof can accommodate a PV system capacity of 40.0 kWdc producing 59,645 kWh per year. This building was very new and did not have enough utility billing data to determine how much a PV system could offset annual energy use.

Solar Potential	40 kWdc	59645 kWh/year
Installed Cost	$2/Watt	$80,000
Annual/Lifetime Savings	$5,964	$149,100
Simple Payback/Return on Investment	13.4 years	Investment Gain - $69,100 ROI – 86.38% Annualized ROI – 2.52%

Maintenance Operations/Fleet

The South roof elevation was considered. It can accommodate a PV system capacity of 73 kWdc producing 109,670 kWh per year. Current annual kWh consumption of 10,200 is significantly less than the potential solar contribution. In order to be a net zero (rather than excess) generator with solar, a system size of 7kWdc is recommended, generating 10,516 kWh per year. This size system is a better load match, unless future electrical consumption is expected to increase. Current annual kWh consumption of 10,200 kWh/y could be offset by 102%. As previously noted in Table 2, utility billing data indicated lower energy use than expected. However if energy use is in fact higher or operations increase such that more energy would be needed in the future, PV can be increased from the 7 kWdc system proposed up to a system that has about time times greater production.

If additional energy savings measures were taken, annual electric consumption could be reduced by 8,447 kWh to 1,753 kWh. Since a PV system can already meet at least 100% of annual energy use, ECM would allow a smaller PV system at less cost to be installed that can still meet 100 % of energy use.

Solar Potential	7kWdc	10,516 kWh/year
Installed Cost	$2/Watt	$14,000
Annual/Lifetime Savings	$1,051	$26,275
Simple Payback/Return on Investment	13.3 years	Investment Gain - $12,275 ROI – 87.68% Annualized ROI – 2.55%

Municipal Golf Clubhouse (Pro Shop)

The Southeast roof elevation was considered. It can accommodate a PV system capacity of 23.5 kWdc producing 35,305 kWh per year. Current annual kWh consumption of 28,445 is significantly less than the potential solar contribution. In order to be a net zero (rather than excess) generator with solar, a system size of 20 kWdc is recommended, generating 30,047 kWh per year. This size system is a better load

match, unless future electrical consumption is expected to increase. Therefore PV can produce 106% of existing building energy use.
If additional energy savings measures were taken, annual electric consumption could be further reduced by 5,673 kWh to 22,772 kWh. Since a PV system can already meet at least 100% of annual energy use, ECM would allow a smaller PV system at less cost to be installed that can still meet 100% of energy use.

Solar Potential	20 kWdc	30,047 kWh/year
Installed Cost	$2/Watt	$40,000
Annual/Lifetime Savings	$3,005	$75,125
Simple Payback/Return on Investment	13.3 years	Investment Gain - $35,125 ROI – 87.81% Annualized ROI – 2.55%

Municipal Marina

The West roof elevation was considered. It can accommodate a PV system capacity of 4.0 kWdc producing 5,326 kWh per year. Current annual kWh consumption was not available for further analysis. Therefore it is unknown how much PV can offset existing energy.

Solar Potential	4kWdc	5,326 kWh/year
Installed Cost	$2/Watt	$8,000
Annual/Lifetime Savings	$532	$13,300
Simple Payback/Return on Investment	15 years	Investment Gain - $5,300 ROI – 66.25% Annualized ROI – 2.05%

Police Department

The Southeast roof elevation was considered. It can accommodate a PV system capacity of 149 kWdc producing 223,848 kWh per year. Current annual kWh consumption of 890,060 can be potentially offset by 25%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 162,149 kWh to 727,911 kWh, allowing the solar to provide 31% of the building electrical load.

Solar Potential	149 kWdc	223,848 kWh/year
Installed Cost	$2/Watt	$298,000
Annual/Lifetime Savings	$22,384	$559,600
Simple Payback/Return on Investment	13.3 years	Investment Gain - $261,600 ROI – 87.79% Annualized ROI – 2.55%

Recreation/Gym

The South roof elevation was considered. It can accommodate a PV system capacity of 40.0 kWdc producing 59,645 kWh per year. Current annual kWh consumption of 74,980 can be potentially offset by 80%.

If additional energy savings measures were taken, annual electric consumption could be reduced by 31,836 kWh to 43,144. Implementing ECM would reduce the energy use down to that PV could not only meet at least 100% of energy use, but also allow the system to be downsized decreasing PV cost.

Solar Potential	40 kWdc	59,645 kWh/year
Installed Cost	$2/Watt	$80,000
Annual/Lifetime Savings	$5,964	$149,100
Simple Payback/Return on Investment	13.4 years	Investment Gain - $69,100 ROI – 86.38% Annualized ROI – 2.52%

Sports Complex Building

The Southeast roof elevation was considered. It can accommodate a PV system capacity of 71.0 kWdc producing 98,613 kWh per year. Current annual kWh consumption of 30,068 is significantly less than the potential solar contribution. In order to be a net zero (rather than excess) generator with solar, a system size of 23 kWdc is recommended, generating 31,945 kWh per year. This size system is a better load match, unless future electrical consumption is expected to increase. Therefore PV can produce 106% of existing building energy use.

If additional energy savings measures were taken, annual electric consumption could be further reduced by 6,840 kWh to 23,228 kWh. Since a PV system can already meet at least 100% of annual energy use, ECM would allow a smaller PV system at less cost to be installed that can still meet 100% of energy use.

Solar Potential	23 kWdc	31,945 kWh/year
Installed Cost	$2/Watt	$46,000
Annual/Lifetime Savings	$3,194	$79,850
Simple Payback/Return on Investment	14.4 years	Investment Gain - $33,850 ROI – 73.59% Annualized ROI – 2.23%

Individual PV array sizing calculations are provided in Appendix C.

Appendix A – FSEC Team

Karen Fenaughty has been a research analyst with the FSEC for 10 years. During this time, she been lead or co-lead on several grants. Karen's primary expertise is applying weather normalization and statistical analysis methods to custom sub-metered, utility, and advanced metering infrastructure (AMI) data to determine the energy use changes and peak load impacts of retrofit measures. She participates in project design, develops outreach and recruits research partners, coordinates with project participants, provides technical assistance to project sponsors, and publishes and presents research findings. Karen holds Bachelor and Master's degrees from the University of South Florida and the University of Alaska Anchorage.

Colleen Kettles is the Acting Director of the Energy Systems Research and Education Division at the Florida Solar Energy Center. She has more than 35 years of legal and policy research, program development and implementation in the fields of solar energy, energy efficiency, and alternative fuel vehicles. She serves as an instructor in the area of solar energy policy and trade regulation at workshops and short courses. Colleen is a graduate of the University of Florida College of Law and is a member of the American Bar Association and the Florida Bar and its Energy Committee. She represents FSEC on the Building Officials Association of Florida, Smart Electric Power Association Community Solar Working Group, Interstate Renewable Energy Council, and the Florida Solar Energy Industries Association.

Janet McIlvaine is a Senior Research Analyst in FSEC's Buildings Research Division. She has 29 years of experience with energy use simulation, analysis, and improvement implementation in institutional, commercial, and residential buildings with a focus in non-profit and public affordable housing programs. Janet is a graduate of Clemson University.

Donard Metzger is a Senior Engineer and is the primary solar laboratory instructor at the Florida Solar Energy Center. He has been instrumental in the development of the training laboratories and instructional material. Mr. Metzger has also designed, installed and instrumented an inverter test facility and long term photovoltaic module test beds at FSEC. Mr. Metzger has also been instrumental in various photovoltaic related application and research projects at FSEC and is a Certified Solar Contractor licensed by the State of Florida. In addition to the applications research work that Donard has conducted at FSEC, he also has invaluable experience in the design and installation of grid-connected as well as stand-alone photovoltaic systems.

Keith R. Showalter is an Assistant in Energy Research at the Florida Solar Energy Center. He has served as the Principal Software Engineer responsible for development of solar design programs to produce NEC code compliant PV system schematics and drawings. As a PV Systems Testing Engineer, he has developed module testing procedures, planning array installations, quality management, misc. fieldwork (instrumentation, troubleshooting, testing, etc.), PHP web app development, spreadsheet data analysis, Python data analysis. His previous work at the Kennedy Space Center supported Shuttle program launch structure modifications. Keith received his BS in Mechanical Engineering from Florida International University.

Chuck Withers has been research faculty at the Florida Solar Energy Center for over 30 years. During this time, he has been involved in energy and indoor air environment studies of hundreds of residential and commercial buildings. Chuck is primary author of 17 building science-related research publications and author/co-author of over 100 other research papers, reports, and training manuals. He has also been an instructor in several building-science continuing education courses over the past 20 years. Chuck earned his Bachelor degree at Slippery Rock University of Pennsylvania.

Appendix B – Utility Bill Analysis, Cooling and Heating Energy Use Disaggregation Methodology

Weather normalization provides an estimate for the buildings annual energy use for a typical year, which allows for better comparisons among buildings with different energy use periods reported and a more accurate measurement of energy use changes which can otherwise be obscured by warmer or cooler weather, year over year. The normalization process also allows for the disaggregation of cooling energy, heating energy, and baseload energy (all non-heating/cooling needs), which can provide a basis for energy use projections (Figure D-1).

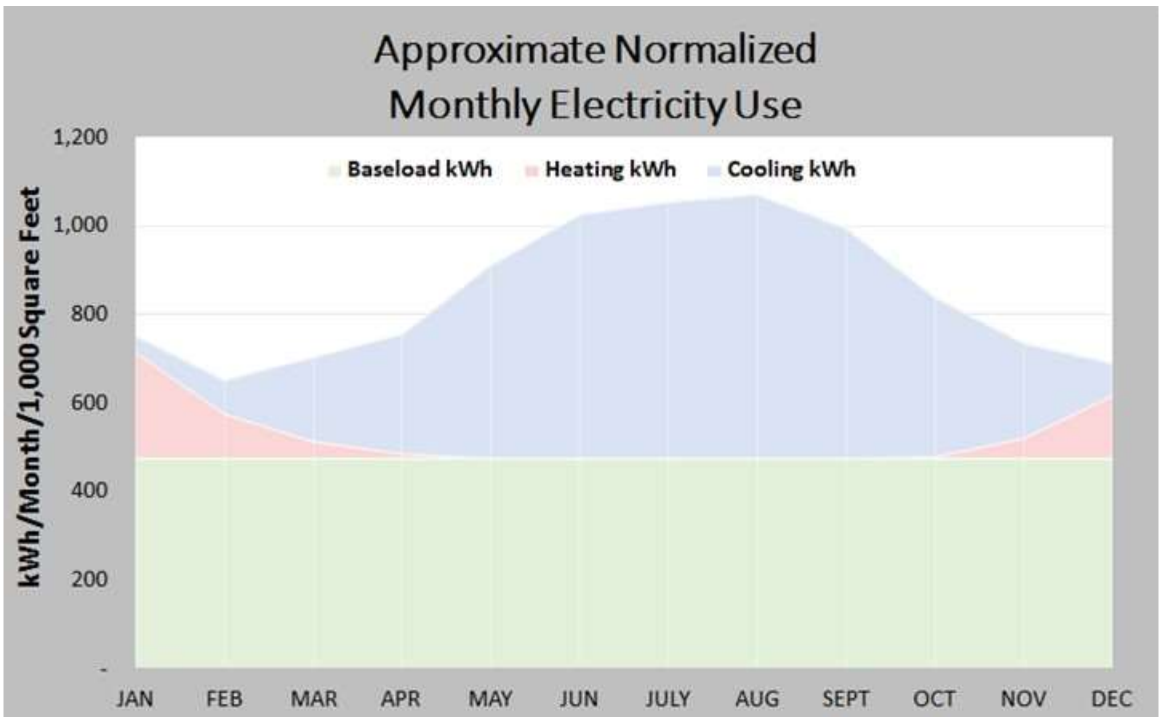


Figure D-1 Example of disaggregation of monthly energy use into cooling, heating, and base loads.

Monthly electric energy use were normalized to the Typical Meteorological Year (TMY) 3 weather for the local area. This involves first identifying daily heating degree days and cooing degree days for the precise monthly metered periods and conducting a linear regression to find the association between outdoor temperatures and monthly energy use. Secondly, the resulting statistical relationship is applied to a normalized set of weather data, in this case, TMY3. The result is an annual energy use for a 'typical' year. Sometime the actual annual energy use will be higher, other times lower, than this normalized use.

Some of the audited buildings had either insufficient data available for this type of evaluation or there was no discernable relationship between the outdoor temperature and the building's energy use. In such cases, the most recent annual energy use data were assumed and when insufficient data were available, annual estimates were projected.

To convert energy use into cost, we applied $0.10/kWh. The $0.10/kWh factor is the gross sum of the annual kWh and total electric cost for a whole year provided by city staff for 12 buildings. The $/kWh was calculated for each of 12 buildings and the average was $0.100. (One building was excluded for unreliable results.)
The figure below shows an example of the profile of estimated end use based upon utility billing analysis for the City Hall building. Cooling energy is highest during the warmest months and heating, while small, can be seen during the colder months. Analysis did not show weather as a significant indicator in monthly energy variability in several buildings. This doesn't mean that no cooling or heating energy is expected. It indicates that building energy use is dominated more by occupancy and internal loads.

Appendix C – PV Watts Sizing Reports For Individual Buildings

Babe James Center

201 N Myrtle Ave

System Capacity: 23.9 kWdc (160 m2)

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

32,112 kWh/Year*

System output may range from 30,708 to 32,976 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.31	1,839	184
February	3.86	1,958	196
March	5.27	2,923	292
April	6.51	3,417	342
May	6.88	3,700	370
June	6.63	3,363	336
July	6.25	3,311	331
August	6.10	3,206	321
September	4.97	2,579	258
October	4.24	2,317	232
November	3.52	1,858	186
December	2.94	1,642	164
Annual	**5.04**	**32,113**	**$ 3,212**

Location and Station Identification

Requested Location	Babe James 201 North Myrtle Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.1 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Residential)*

DC System Size	23.9 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	70°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.3%

System Capacity: 36.0 kWdc (240 m2)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

52,462 kWh/Year*

System output may range from 50,169 to 53,873 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	4.17	3,518	352
February	4.58	3,488	349
March	5.85	4,861	486
April	6.81	5,361	536
May	6.92	5,586	559
June	6.49	4,947	495
July	6.18	4,916	492
August	6.25	4,915	491
September	5.33	4,147	415
October	4.91	4,033	403
November	4.38	3,489	349
December	3.77	3,201	320
Annual	**5.47**	**52,462**	**$ 5,247**

Location and Station Identification

Requested Location	Babe James 201 North Myrtle Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.1 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	36 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	160°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	16.6%

System Capacity: 25.0 kWdc (167 m2)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

34,694 kWh/Year*

System output may range from 33,178 to 35,627 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.76	2,197	220
February	4.23	2,237	224
March	5.58	3,224	322
April	6.67	3,655	366
May	6.89	3,868	387
June	6.35	3,363	336
July	6.10	3,376	338
August	6.03	3,297	330
September	5.05	2,728	273
October	4.56	2,601	260
November	3.93	2,174	217
December	3.36	1,974	197
Annual	**5.21**	**34,694**	**$ 3,470**

Location and Station Identification

Requested Location	Babe James 201 North Myrtle Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.1 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Residential)*

DC System Size	25 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	250°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

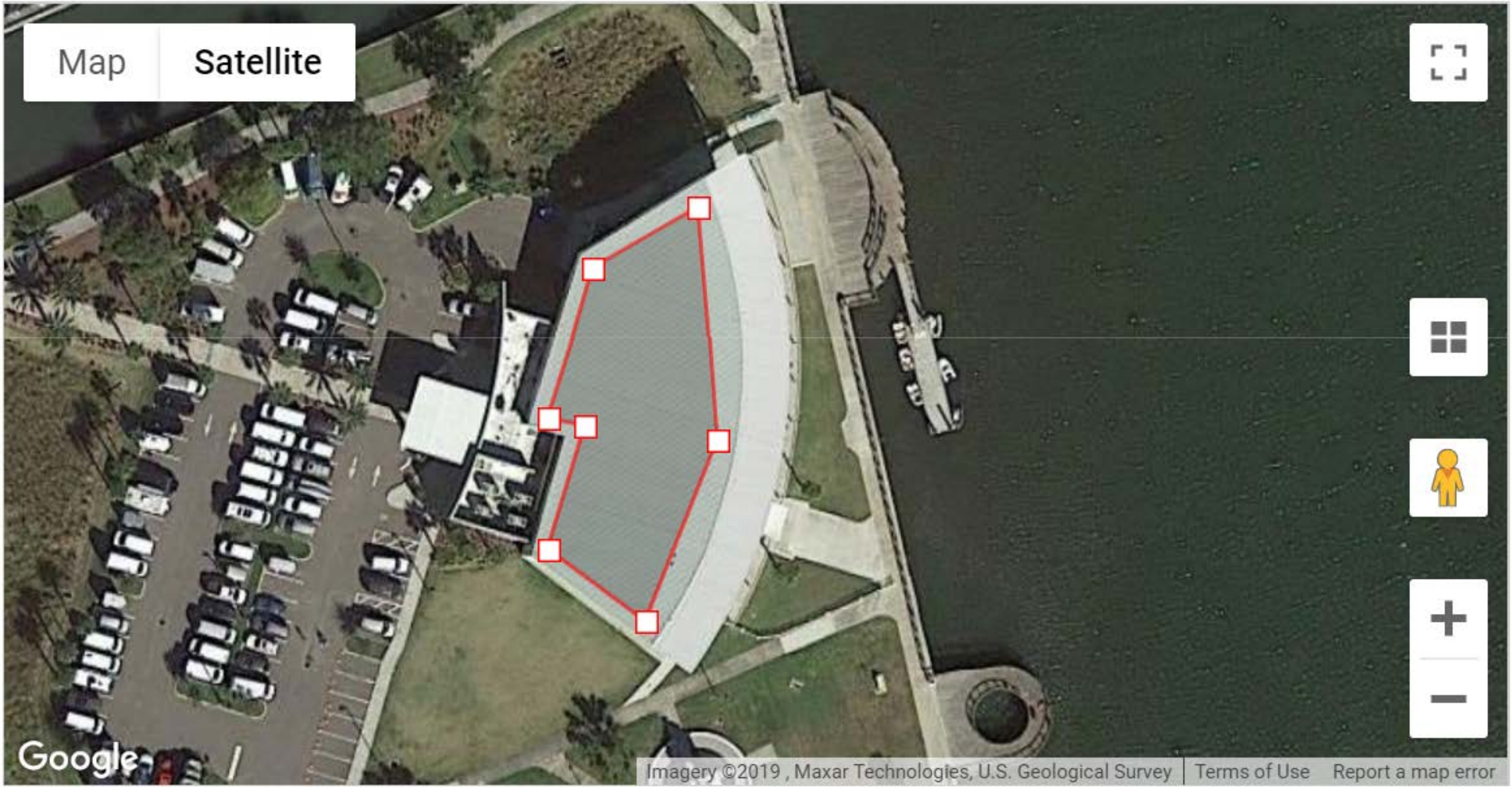
Performance Metrics

Capacity Factor	15.8%

Brannon Center

105 S Riverside Dr

System Capacity: 124.0 kWdc (827 m2)



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

181,061 kWh/Year*

System output may range from 173,149 to 185,931 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.07	11,936	1,194
February	4.60	12,100	1,210
March	5.81	16,640	1,664
April	6.75	18,529	1,853
May	6.92	19,028	1,903
June	6.55	17,177	1,718
July	6.35	17,244	1,724
August	6.15	16,883	1,688
September	5.41	14,364	1,436
October	4.88	13,830	1,383
November	4.43	12,336	1,234
December	3.76	10,993	1,099
Annual	**5.47**	**181,060**	**$ 18,106**

Location and Station Identification

Requested Location	Brannon Center New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.09, -80.94 1.7 mi
Latitude	29.09° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	124 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	16.7%

Chamber of Commerce

115 Canal St

System Capacity: 14.2 kWdc (94 m2)

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RESULTS

21,376 kWh/Year*

System output may range from 20,442 to 21,951 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.69	1,558	156
February	4.99	1,493	149
March	6.10	1,990	199
April	6.84	2,117	212
May	6.76	2,149	215
June	6.30	1,895	189
July	6.00	1,884	188
August	6.25	1,936	194
September	5.50	1,682	168
October	5.27	1,704	170
November	4.89	1,535	154
December	4.28	1,432	143
Annual	**5.66**	**21,375**	**$ 2,137**

Location and Station Identification

Requested Location	Chamber of Commerce 115 Canal Street New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.6 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	14.2 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	160°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

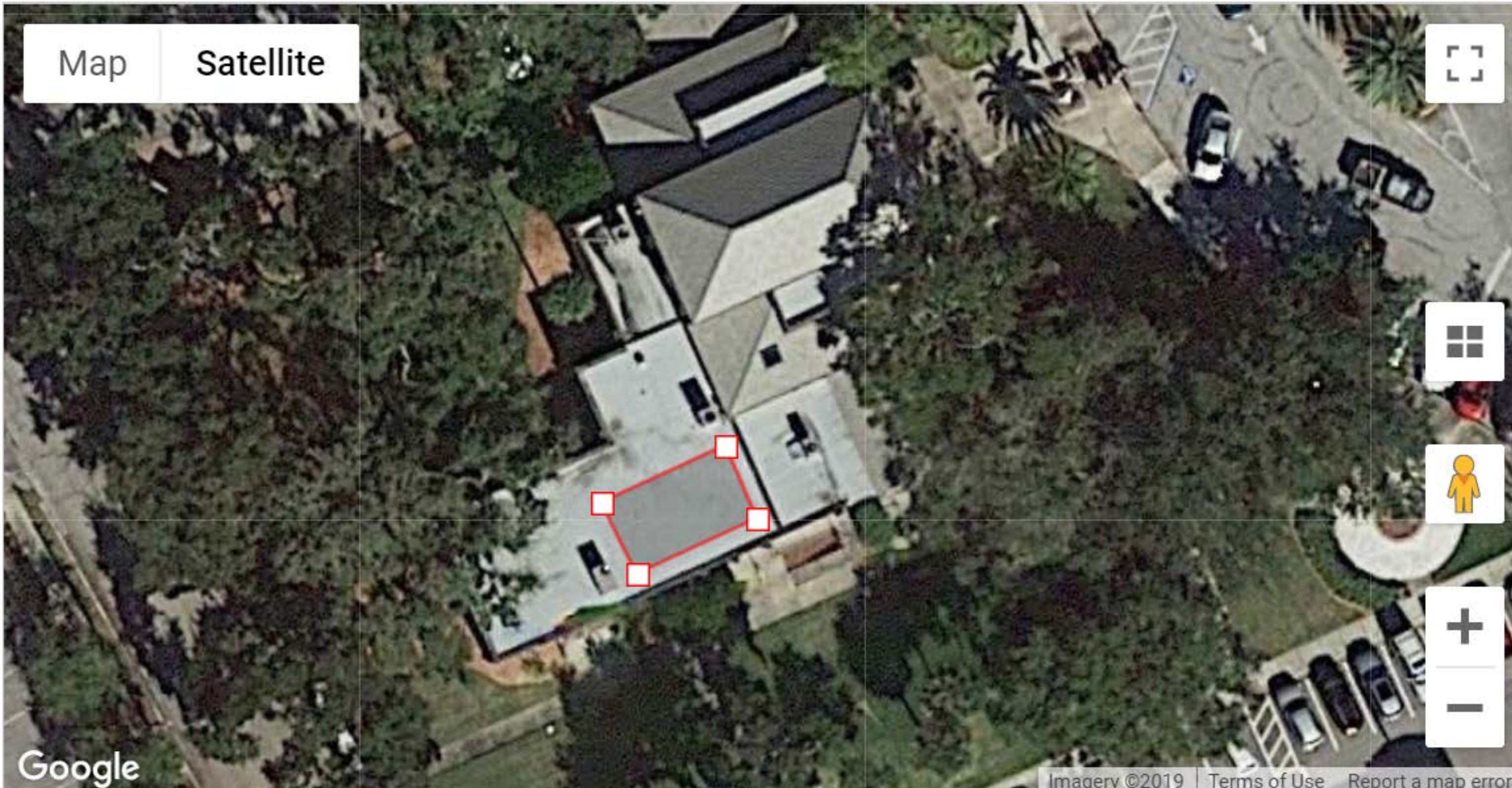
Performance Metrics

Capacity Factor	17.2%

City Hall

210 Sams Ave

System Capacity: 7.0 kWdc (47 m2)



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RESULTS

10,201 kWh/Year*

System output may range from 9,755 to 10,475 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.17	684	68
February	4.58	678	68
March	5.85	945	95
April	6.81	1,042	104
May	6.92	1,086	109
June	6.49	962	96
July	6.18	956	96
August	6.25	956	96
September	5.33	806	81
October	4.91	784	78
November	4.38	678	68
December	3.77	622	62
Annual	**5.47**	**10,199**	**$ 1,021**

Location and Station Identification

Requested Location	City Hall 210 Sams Ave New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.5 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	7 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	160°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	16.6%

City Hall Annex

210 Sams Ave

System Capacity: 60.0 kWdc (400 m2)

NREL
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RESULTS

80,615 kWh/Year*

System output may range from 77,092 to 82,784 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	3.31	4,615	462
February	3.86	4,916	492
March	5.27	7,337	734
April	6.51	8,578	858
May	6.88	9,288	929
June	6.63	8,442	844
July	6.25	8,312	831
August	6.10	8,048	805
September	4.97	6,475	647
October	4.24	5,818	582
November	3.52	4,664	466
December	2.94	4,123	412
Annual	**5.04**	**80,616**	**$ 8,062**

Location and Station Identification

Requested Location	City Hall Annex 210 Sams Ave New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.5 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	60 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	70°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.3%

System Capacity: 48.0 kWdc (320 m2)

NREL
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RESULTS

64,492 kWh/Year*

System output may range from 61,674 to 66,227 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.31	3,692	369
February	3.86	3,933	393
March	5.27	5,870	587
April	6.51	6,862	686
May	6.88	7,430	743
June	6.63	6,754	675
July	6.25	6,649	665
August	6.10	6,439	644
September	4.97	5,180	518
October	4.24	4,654	465
November	3.52	3,731	373
December	2.94	3,298	330
Annual	**5.04**	**64,492**	**$ 6,448**

Location and Station Identification

Requested Location	City Hall Annex 210 Sams Avenue, New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.5 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	48 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	70°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

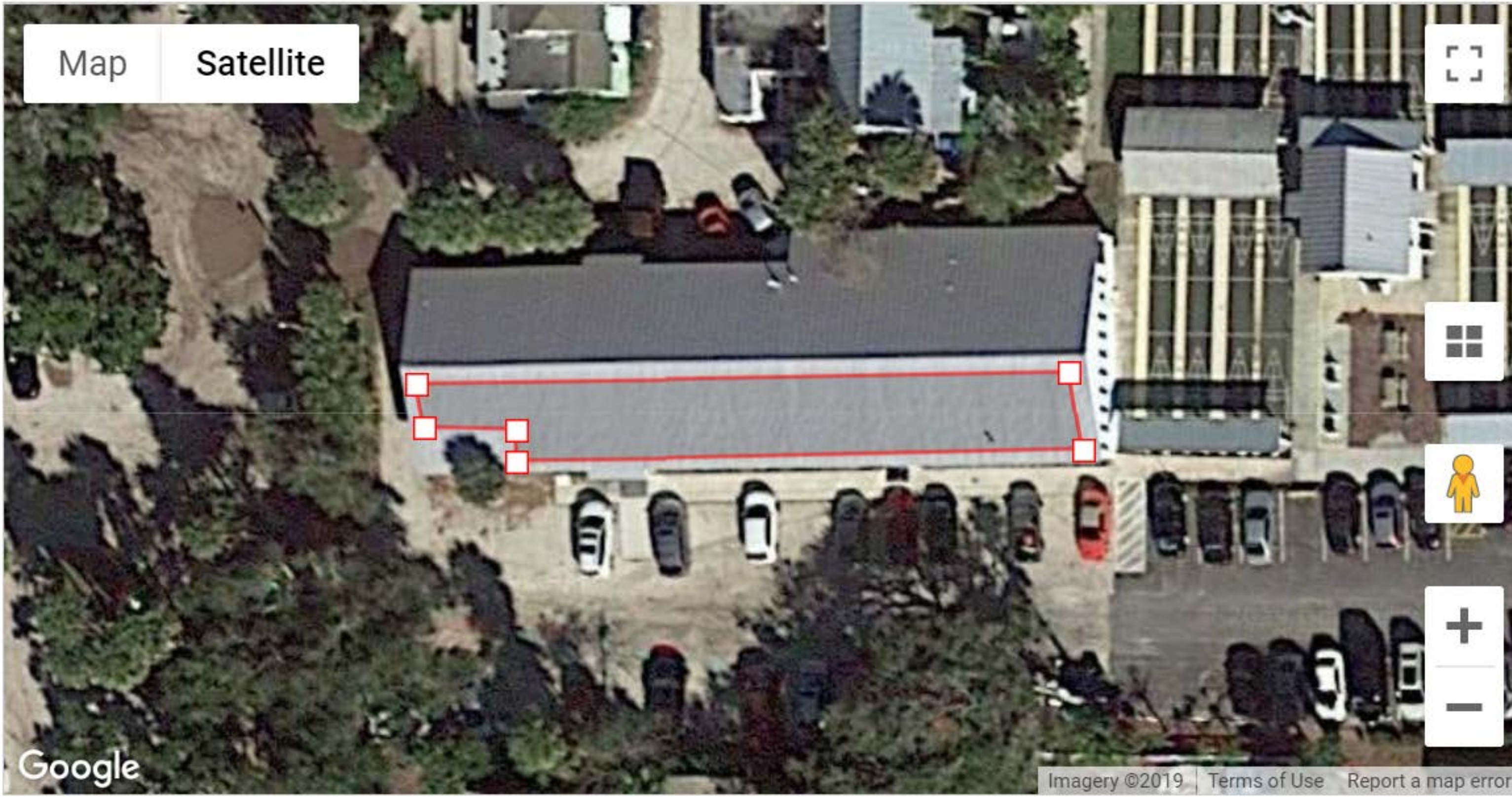
Performance Metrics

Capacity Factor	15.3%

Coronado Civic Center

223 Flagler Ave

System Capacity: 31.5 kWdc (210 m2)



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RESULTS

32,409 kWh/Year*

System output may range from 30,992 to 33,280 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.60	2,338	234
February	5.00	2,274	227
March	6.08	3,007	301
April	6.78	3,223	322
May	6.71	3,200	320
June	6.28	2,859	286
July	6.16	2,897	290
August	6.11	2,904	290
September	5.58	2,557	256
October	5.26	2,575	257
November	4.98	2,401	240
December	4.29	2,175	218
Annual	**5.65**	**32,410**	**$ 3,241**

Location and Station Identification

Requested Location	Coronado Civic Center New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.09, -80.94 1.7 mi
Latitude	29.09° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	21.5 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

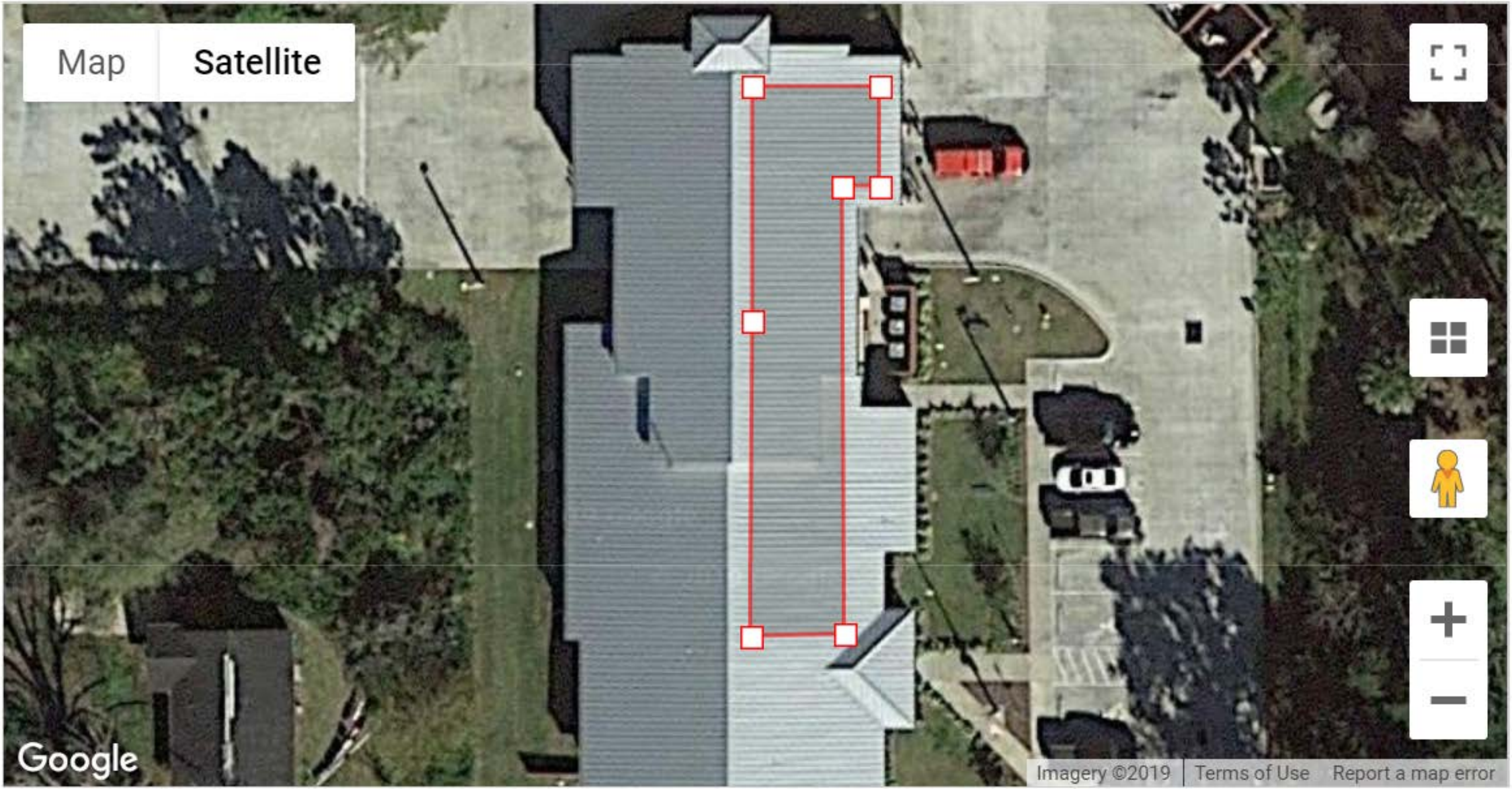
Performance Metrics

Capacity Factor	17.2%

Fire Station #50

100 SR 44

System Capacity: 36.0 kWdc (240 m2)



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RESULTS

49,584 kWh/Year*

System output may range from 47,418 to 50,918 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.54	2,975	298
February	4.06	3,101	310
March	5.43	4,527	453
April	6.59	5,208	521
May	6.90	5,581	558
June	6.62	5,057	506
July	6.25	4,982	498
August	6.17	4,872	487
September	5.08	3,971	397
October	4.43	3,645	364
November	3.76	2,992	299
December	3.17	2,674	267
Annual	**5.17**	**49,585**	**$ 4,958**

Location and Station Identification

Requested Location	Fire Station 50 New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.3 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	36 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	90°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

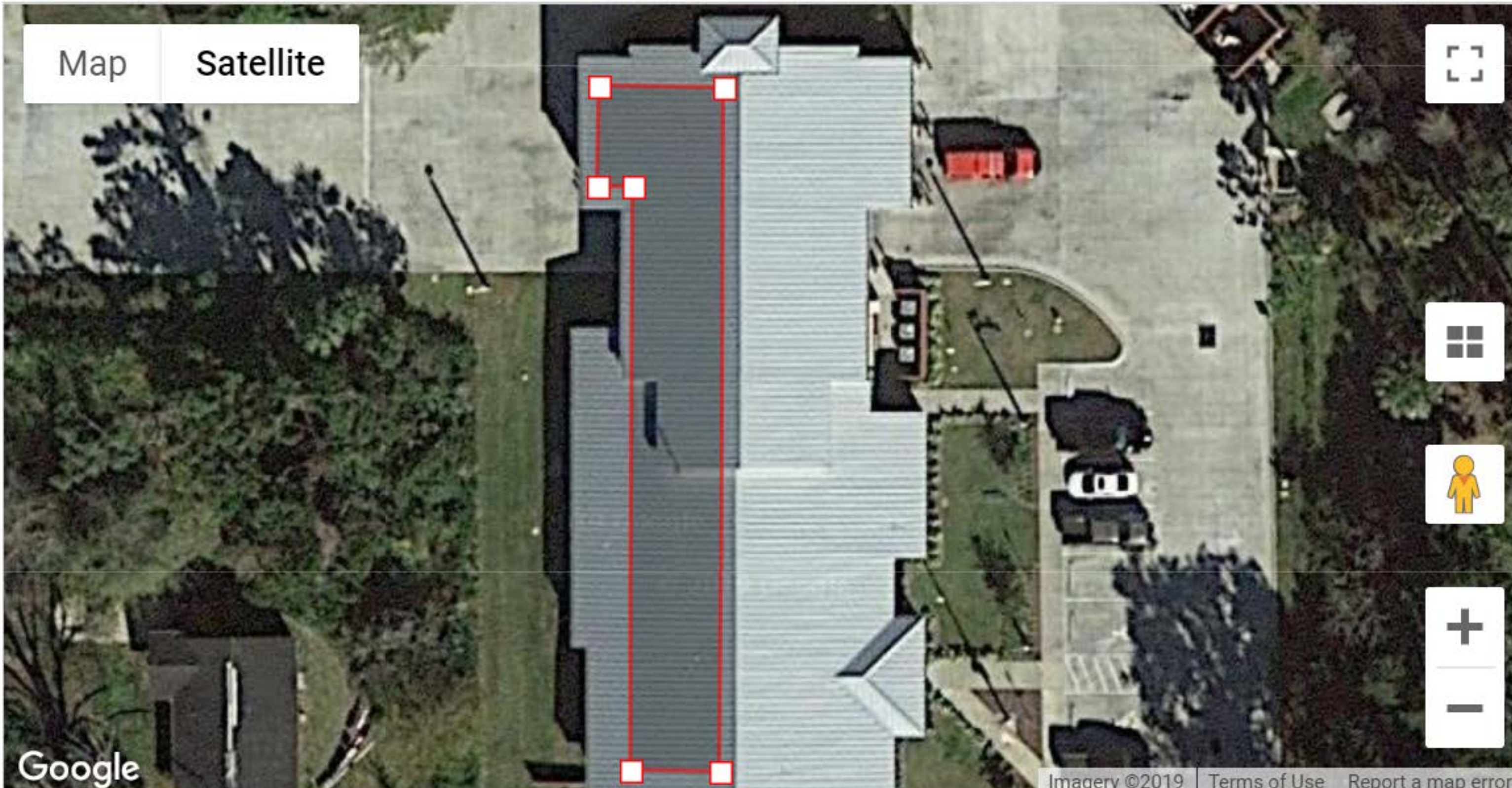
Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.7%

System Capacity: 42.5 kWdc (283 m2)



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RESULTS

57,586 kWh/Year*

System output may range from 55,070 to 59,135 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.53	3,497	350
February	4.04	3,630	363
March	5.42	5,337	534
April	6.59	6,144	614
May	6.88	6,569	657
June	6.36	5,728	573
July	6.11	5,745	574
August	5.96	5,553	555
September	4.93	4,539	454
October	4.37	4,244	424
November	3.70	3,477	348
December	3.15	3,126	313
Annual	**5.09**	**57,589**	**$ 5,759**

Location and Station Identification

Requested Location	Fire Station 50 New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.3 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	42.5 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	270°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

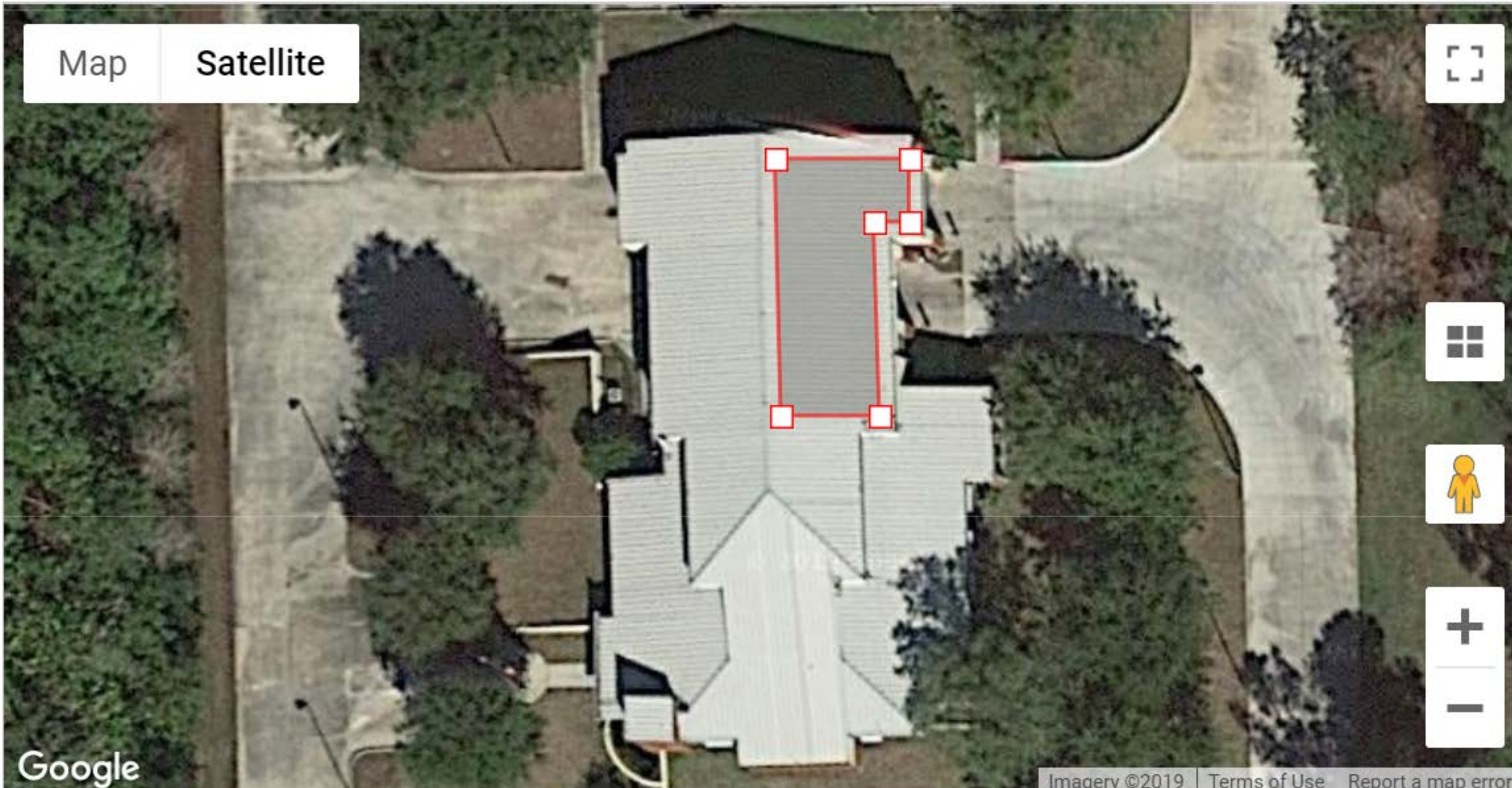
Performance Metrics

Capacity Factor	15.5%

Fire Station #51

3151 SR 44

System Capacity: 18.0 kWdc (120 m2)



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RESULTS

25,164 kWh/Year*

System output may range from 24,064 to 25,841 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.54	1,504	150
February	4.06	1,570	157
March	5.43	2,297	230
April	6.59	2,646	265
May	6.90	2,834	283
June	6.62	2,575	257
July	6.25	2,532	253
August	6.17	2,480	248
September	5.08	2,015	201
October	4.43	1,845	184
November	3.76	1,514	151
December	3.17	1,351	135
Annual	**5.17**	**25,163**	**$ 2,514**

Location and Station Identification

Requested Location	Fire Station 51 New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.3 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Residential)*

DC System Size	18 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	10°
Array Azimuth	90°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

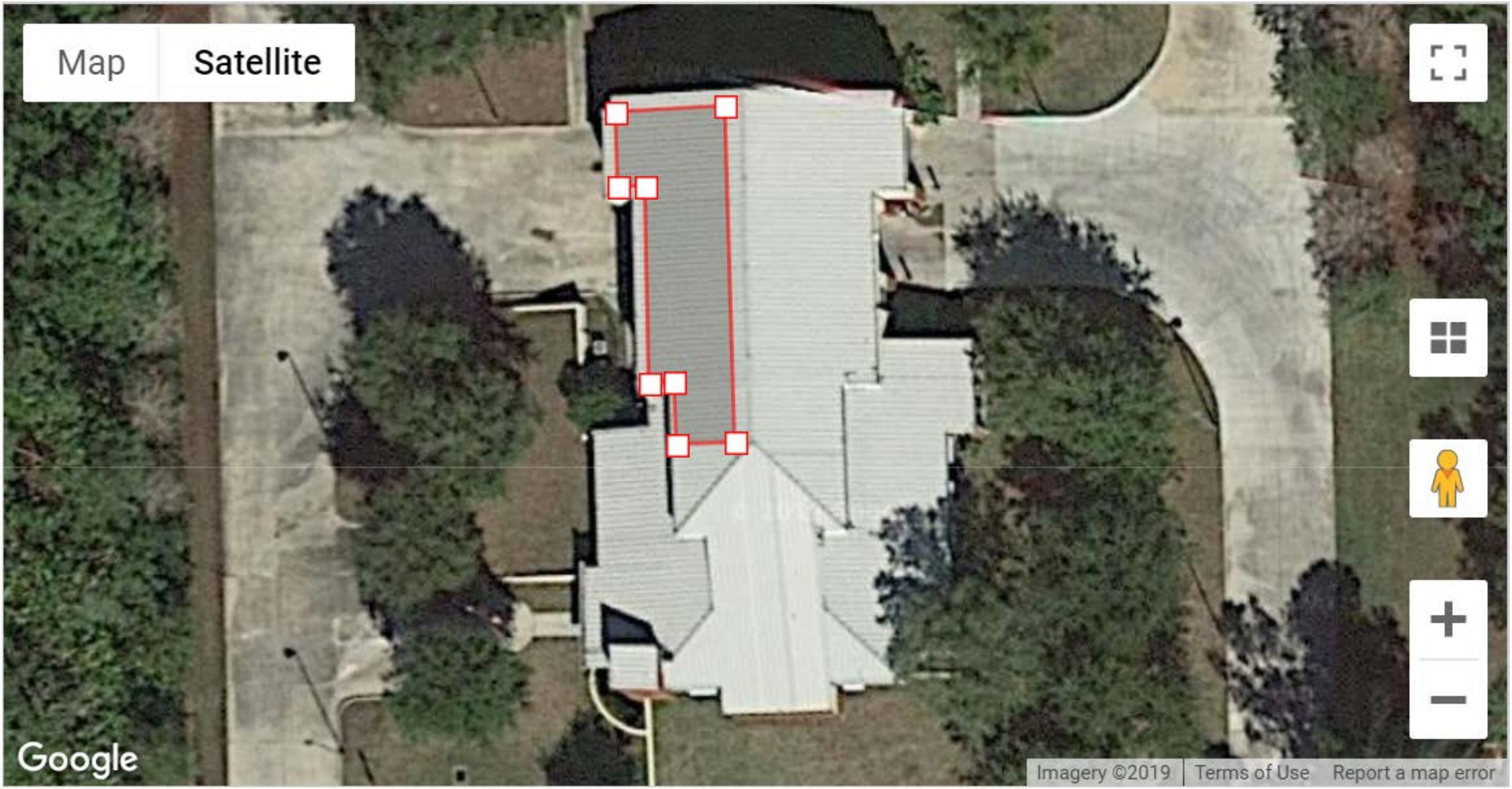
Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	16.0%

System Capacity: 19.0 kWdc (127 m2)



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RESULTS

27,718 kWh/Year*

System output may range from 26,507 to 28,464 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.21	1,875	187
February	4.61	1,852	185
March	5.88	2,576	258
April	6.83	2,833	283
May	6.93	2,947	295
June	6.44	2,591	259
July	6.15	2,583	258
August	6.22	2,582	258
September	5.33	2,184	218
October	4.94	2,138	214
November	4.41	1,854	185
December	3.81	1,704	170
Annual	**5.48**	**27,719**	**$ 2,770**

Location and Station Identification

Requested Location	Fire Station 51 New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.3 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	19 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

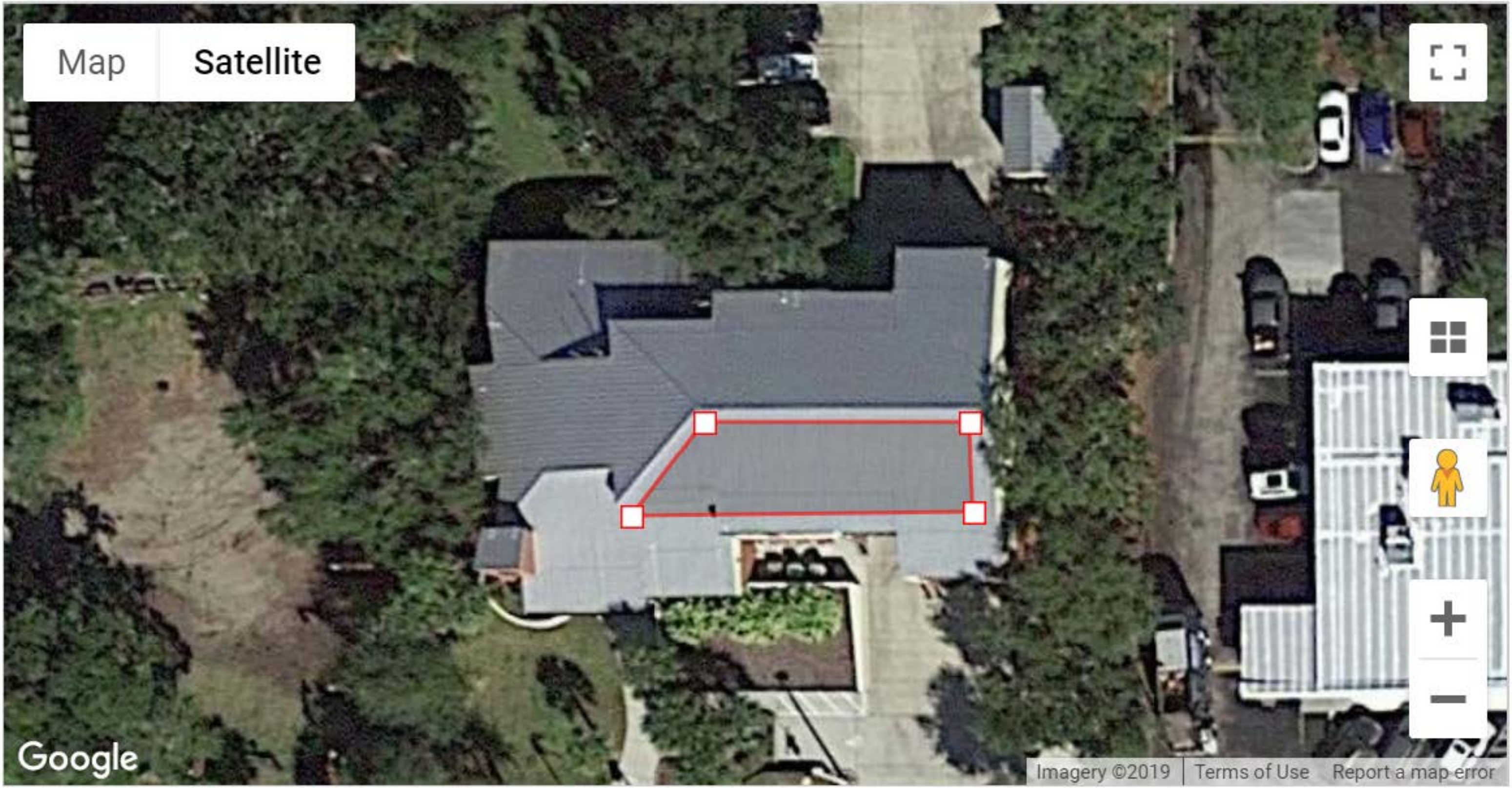
Performance Metrics

Capacity Factor	16.7%

Fire Station #52

500 East 3rd Ave

System Capacity: 18.6 kWdc (124 m2)



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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

28,580 kWh/Year*

System output may range from 27,331 to 29,349 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.63	2,073	207
February	5.00	1,988	199
March	6.16	2,693	269
April	6.91	2,822	282
May	6.73	2,852	285
June	6.01	2,408	241
July	6.09	2,539	254
August	6.02	2,471	247
September	5.63	2,301	230
October	5.36	2,319	232
November	5.05	2,154	215
December	4.38	1,962	196
Annual	**5.66**	**28,582**	**$ 2,857**

Location and Station Identification

Requested Location	Fire Station 52 500 East 3rd Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.9 1.3 mi
Latitude	29.01° N
Longitude	80.9° W

PV System Specifications *(Commercial)*

DC System Size	18.6 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.5%

Fire Station #53

238 Industrial Park Ave

System Capacity: 17.3 kWdc (115 m2)

NREL
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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

23,402 kWh/Year*

System output may range from 22,380 to 24,032 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.43	1,393	139
February	4.06	1,500	150
March	5.30	2,124	212
April	6.29	2,398	240
May	6.86	2,629	263
June	6.56	2,408	241
July	6.16	2,360	236
August	6.07	2,308	231
September	5.06	1,900	190
October	4.32	1,716	172
November	3.60	1,395	140
December	3.12	1,271	127
Annual	**5.07**	**23,402**	**$ 2,341**

Location and Station Identification

Requested Location	238 Industrial Park Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.2 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Residential)*

DC System Size	17.3 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	90°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.4%

System Capacity: 17.3 kWdc (115 m2)

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

22,682 kWh/Year*

System output may range from 21,691 to 23,292 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.46	1,399	140
February	4.11	1,513	151
March	5.28	2,116	212
April	6.25	2,380	238
May	6.79	2,593	259
June	6.03	2,211	221
July	5.89	2,255	226
August	5.68	2,156	216
September	4.76	1,784	178
October	4.26	1,684	168
November	3.48	1,346	135
December	3.07	1,245	125
Annual	**4.92**	**22,682**	**$ 2,269**

Location and Station Identification

Requested Location	238 Industrial Park Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.2 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	17.3 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	270°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.0%

Live Oak Cultural Center

1050 Live Oak St

System Capacity: 40.0 kWdc (267 m2)

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

59,645 kWh/Year*

System output may range from 57,038 to 61,249 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.61	4,324	432
February	5.17	4,318	432
March	6.02	5,540	554
April	6.74	5,902	590
May	6.62	5,941	594
June	6.10	5,171	517
July	6.17	5,408	541
August	5.86	5,160	516
September	5.20	4,559	456
October	5.47	5,001	500
November	4.84	4,293	429
December	4.27	4,028	403
Annual	**5.59**	**59,645**	**$ 5,964**

Location and Station Identification

Requested Location	Live Oak Cultural Center, New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.98 0.8 mi
Latitude	29.05° N
Longitude	80.98° W

PV System Specifications *(Commercial)*

DC System Size	40 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.0%

Maintenance Operations/Fleet

124 Industrial Park Ave.

System Capacity: 73.0 kWdc (487 m2)

NREL
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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

109,670 kWh/Year*

System output may range from 104,878 to 112,620 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.70	8,027	803
February	5.12	7,909	791
March	6.13	10,278	1,028
April	6.68	10,683	1,068
May	6.86	11,032	1,103
June	6.23	9,632	963
July	5.97	9,633	963
August	6.19	9,862	986
September	5.53	8,686	869
October	5.28	8,776	878
November	4.73	7,717	772
December	4.32	7,435	743
Annual	**5.65**	**109,670**	**$ 10,967**

Location and Station Identification

Requested Location	Maintenance Operations Fleet 124 Industrial Park Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.1 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	73 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.1%

NREL
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RESULTS

10,516 kWh/Year*

System output may range from 10,057 to 10,799 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.70	770	77
February	5.12	758	76
March	6.13	986	99
April	6.68	1,024	102
May	6.86	1,058	106
June	6.23	924	92
July	5.97	924	92
August	6.19	946	95
September	5.53	833	83
October	5.28	842	84
November	4.73	740	74
December	4.32	713	71
Annual	**5.65**	**10,518**	**$ 1,051**

Location and Station Identification

Requested Location	Maintenance and Operations 124 Industrial Park Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.1 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	7 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.1%

Municipal Marina
201 N. Riverside Dr.

System Capacity: 4.0 kWdc (26 m2)

NREL
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RESULTS

5,326 kWh/Year*

System output may range from 5,093 to 5,469 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.58	335	33
February	4.05	343	34
March	5.37	497	50
April	6.47	568	57
May	6.71	603	60
June	6.06	513	51
July	5.89	521	52
August	5.75	503	50
September	4.80	416	42
October	4.36	398	40
November	3.73	329	33
December	3.18	299	30
Annual	**5.00**	**5,325**	**$ 532**

Location and Station Identification

Requested Location	Marina 201 North Riverside Drive, New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.01, -80.94 1.6 mi
Latitude	29.01° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	4 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	265°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

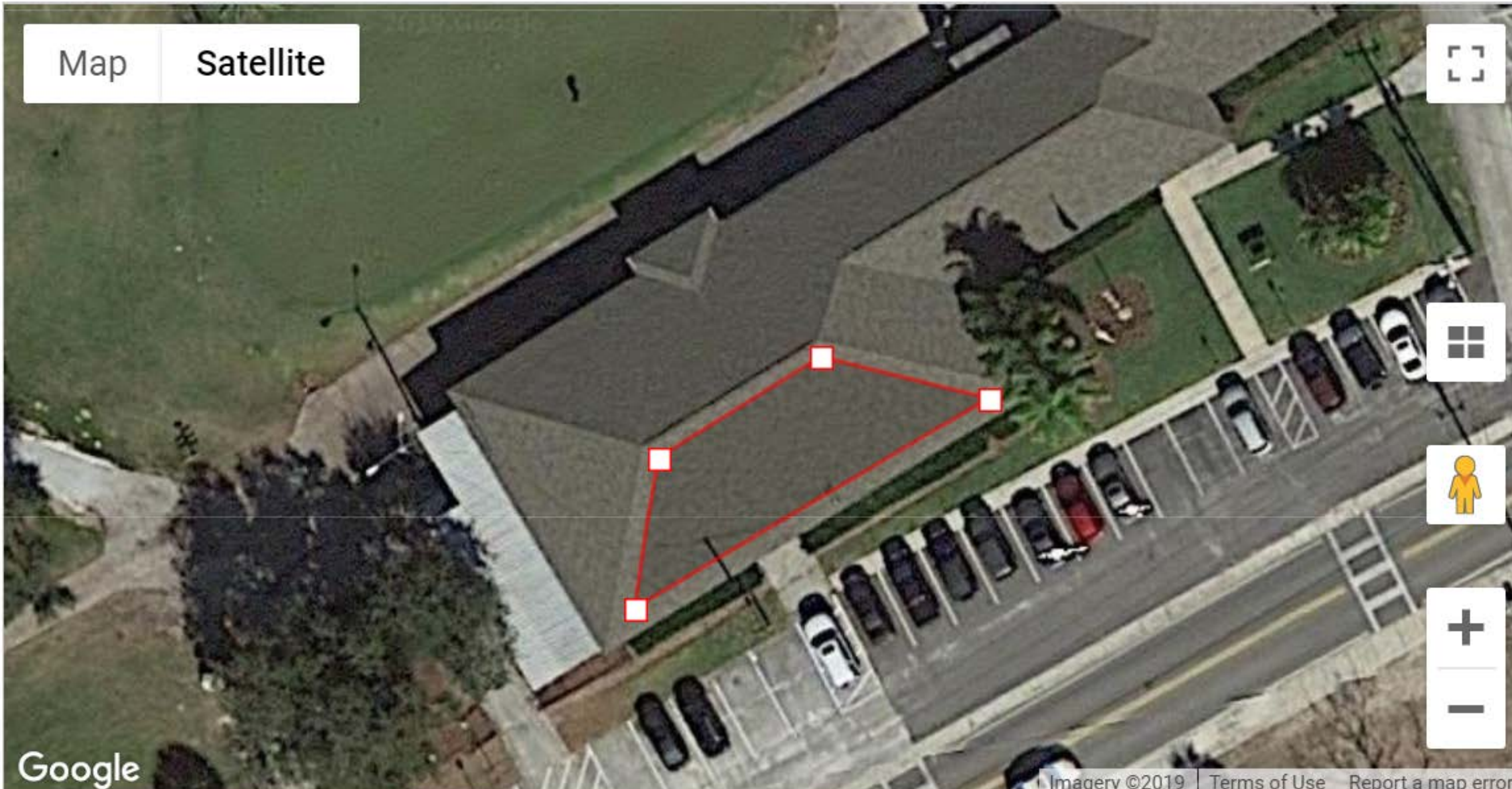
Performance Metrics

Capacity Factor	15.2%

Municipal Golf Course

1000 Wayne Ave

System Capacity: 23.5 kWdc (157 m2)



NREL
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RESULTS

35,305 kWh/Year*

System output may range from 33,762 to 36,255 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	4.70	2,584	258
February	5.12	2,546	255
March	6.13	3,309	331
April	6.68	3,439	344
May	6.86	3,551	355
June	6.23	3,101	310
July	5.97	3,101	310
August	6.19	3,175	317
September	5.53	2,796	280
October	5.28	2,825	283
November	4.73	2,484	248
December	4.32	2,393	239
Annual	**5.65**	**35,304**	**$ 3,530**

Location and Station Identification

Requested Location	Municipal Golf Course 1000 Wayne Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 1.4 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	23.5 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.1%

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RESULTS

30,047 kWh/Year*

System output may range from 28,734 to 30,855 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.70	2,199	220
February	5.12	2,167	217
March	6.13	2,816	282
April	6.68	2,927	293
May	6.86	3,023	302
June	6.23	2,639	264
July	5.97	2,639	264
August	6.19	2,702	270
September	5.53	2,380	238
October	5.28	2,405	240
November	4.73	2,114	211
December	4.32	2,037	204
Annual	**5.65**	**30,048**	**$ 3,005**

Location and Station Identification

Requested Location	Municipal Golf Course New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.8 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Residential)*

DC System Size	20 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

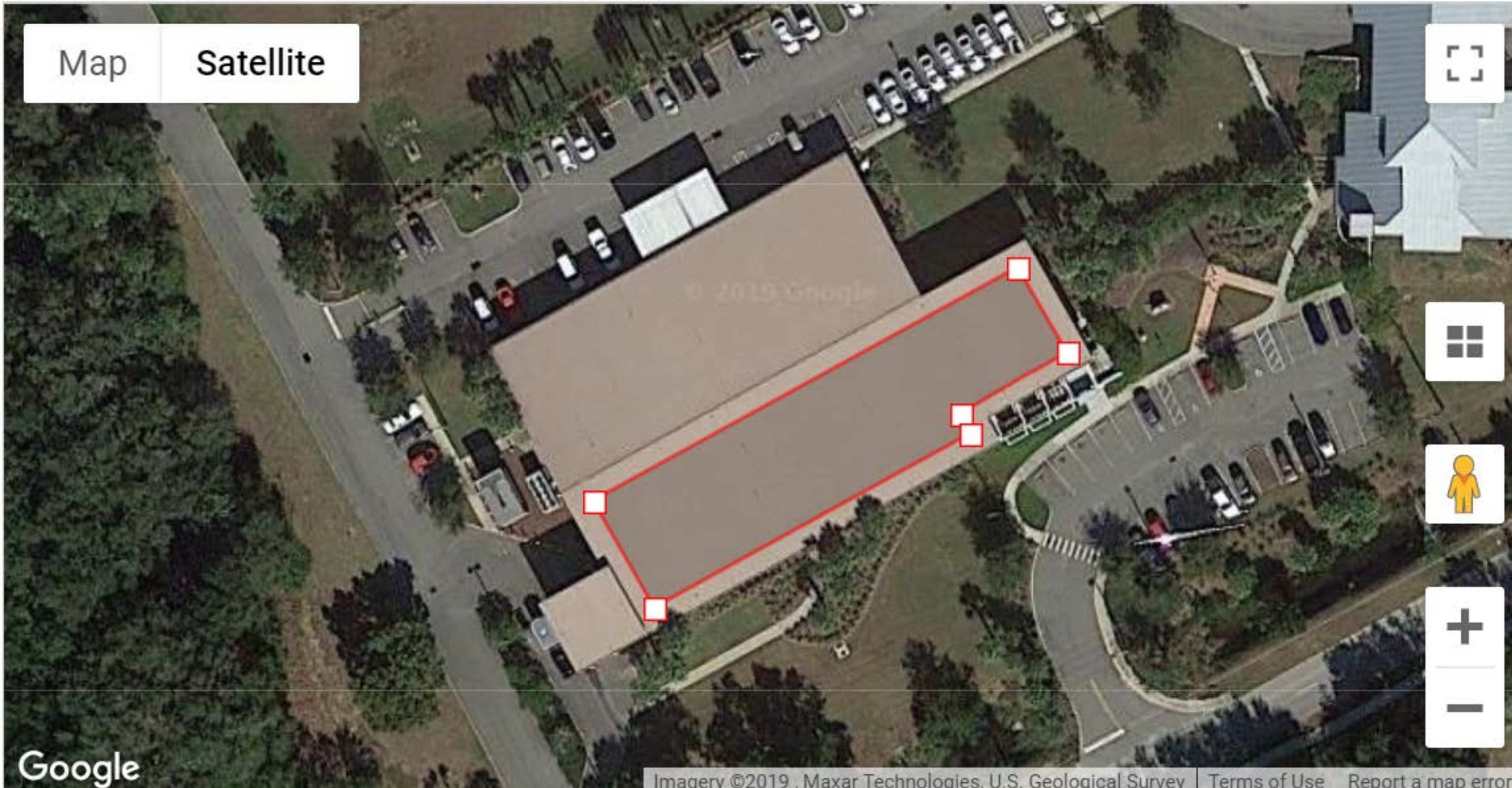
Performance Metrics

Capacity Factor	17.1%

Police Dept.

246 Industrial Park Ave.

System Capacity: 149.0 kWdc (993 m2)



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

223,848 kWh/Year*

System output may range from 214,066 to 229,869 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.70	16,383	1,638
February	5.12	16,144	1,614
March	6.13	20,979	2,098
April	6.68	21,805	2,181
May	6.86	22,518	2,252
June	6.23	19,660	1,966
July	5.97	19,662	1,966
August	6.19	20,128	2,013
September	5.53	17,728	1,773
October	5.28	17,914	1,791
November	4.73	15,751	1,575
December	4.32	15,175	1,517
Annual	**5.65**	**223,847**	**$ 22,384**

Location and Station Identification

Requested Location	Police Station 246 Industrial Park Ave. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.2 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	149 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

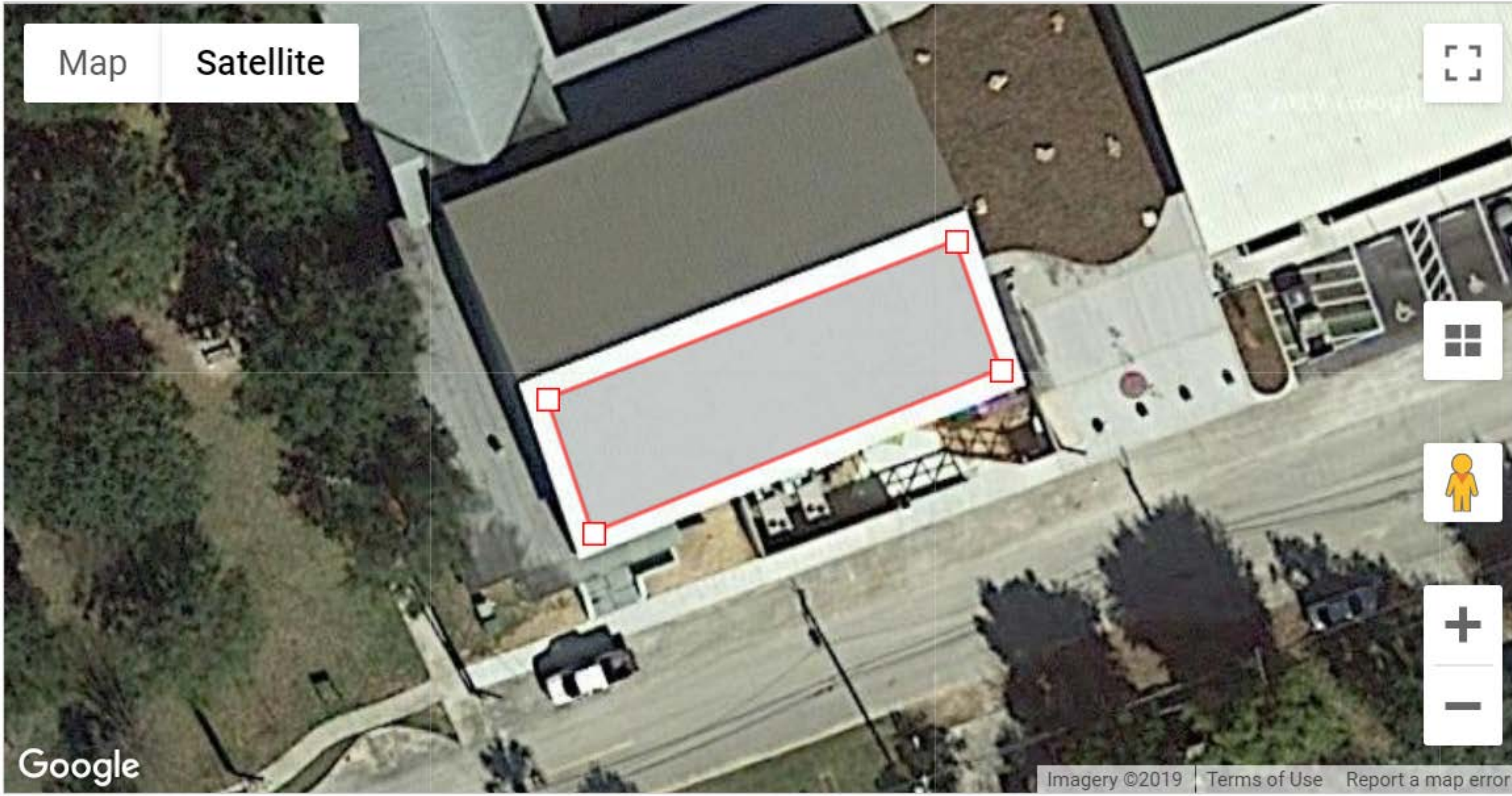
Performance Metrics

Capacity Factor	17.1%

Recreation/Gym

1000 Live Oak Street

System Capacity: 40.0 kWdc (267 m2)



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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

59,645 kWh/Year*

System output may range from 57,038 to 61,249 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.61	4,324	432
February	5.17	4,318	432
March	6.02	5,540	554
April	6.74	5,902	590
May	6.62	5,941	594
June	6.10	5,171	517
July	6.17	5,408	541
August	5.86	5,160	516
September	5.20	4,559	456
October	5.47	5,001	500
November	4.84	4,293	429
December	4.27	4,028	403
Annual	**5.59**	**59,645**	**$ 5,964**

Location and Station Identification

Requested Location	Live Oak Cultural Center, New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.98 0.8 mi
Latitude	29.05° N
Longitude	80.98° W

PV System Specifications *(Residential)*

DC System Size	40 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	20°
Array Azimuth	170°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	17.0%

Sports Complex

1800 Turnbull Bay Road

System Capacity: 71.0 kWdc (473 m2)

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

98,613 kWh/Year*

System output may range from 94,304 to 101,266 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.61	6,000	600
February	4.25	6,421	642
March	5.50	9,036	904
April	6.48	10,126	1,013
May	7.04	11,048	1,105
June	6.60	9,938	994
July	6.24	9,818	982
August	6.16	9,595	960
September	5.16	7,942	794
October	4.49	7,292	729
November	3.74	5,942	594
December	3.27	5,455	545
Annual	**5.21**	**98,613**	**$ 9,862**

Location and Station Identification

Requested Location	Sports Complex 1800 Turnbull Bay Rd. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.7 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	71 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	100°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.9%

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

31,945 kWh/Year*

System output may range from 30,549 to 32,805 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.61	1,944	194
February	4.25	2,080	208
March	5.50	2,927	293
April	6.48	3,280	328
May	7.04	3,579	358
June	6.60	3,219	322
July	6.24	3,180	318
August	6.16	3,108	311
September	5.16	2,573	257
October	4.49	2,362	236
November	3.74	1,925	192
December	3.27	1,767	177
Annual	**5.21**	**31,944**	**$ 3,194**

Location and Station Identification

Requested Location	Sports Complex 1800 Turnbull Bay Rd. New Smyrna Beach FL
Weather Data Source	Lat, Lon: 29.05, -80.94 0.7 mi
Latitude	29.05° N
Longitude	80.94° W

PV System Specifications *(Commercial)*

DC System Size	23 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	10°
Array Azimuth	100°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.100 $/kWh

Performance Metrics

Capacity Factor	15.9%

Appendix D – References and Resources

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