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Creating Energy Independence

Energy Efficiency and Solar Feasibility Assessments at Five FDACS Sites

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Task 1

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1. Executive Summary

The Florida Energy Investment Collaborative (FEIC) is a project with goals to enable local governments to identify, prioritize, and schedule cost-effective options to meet their energy management goals and targets. To help achieve these goals, the Florida Department of Agriculture and Consumer Services (FDACS) has partnered with the FSEC Energy Research Center (FSEC) to conduct a pilot program to test the objectives of the FEIC. This pilot project is designed to evaluate and enhance the potential efficacy of government agency-owned or operated building energy sustainability activities.

This report provides the results of Level I energy audits conducted at five FDACS locations in order to identify opportunities for energy efficiency improvement as well as on-site solar PV energy potential. Reporting the energy audit and solar assessment results and prioritizing efficiency measures is the first task out of five tasks within the project. The additional project tasks have set goals to demonstrate energy efficiency retrofit effectiveness through measurement and verification of a chosen retrofit project, as well as to develop educational materials and conduct outreach to enable implementation of energy efficiency retrofits at the local government level.

FDACS selected the locations to have Level I energy audits and on-site solar PV feasibility assessments. The energy audits focused on identifying cost-effective energy efficiency measures (EEM) for reducing building energy consumption in order to optimize the expenditures for solar equipment. The solar feasibility assessment focused on the best options for renewable energy, including sizing, installation costs, maintenance costs, system life expectancy, and financial returns on investment.

The details of energy audit and solar feasibility results for each site are written as a separate section in this report that could be pulled as an excerpt if desired. Results are shown to reflect current energy use, potential reductions through specific efficiency measures, and further utility (source) energy reduction potential if solar PV is feasible on site. These results were compared to median energy use index (EUI) of existing buildings of similar type to compare to peer buildings. References are also provided within the report to EUI of very low energy buildings with the goal of using “Net Zero” utility energy for those with higher sustainability goals. 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 limitations and cost.

The Most Cost-Effective Types of EEM of the Five FDACS Sites

Cost-effectiveness was based upon simple payback, IRR, and positive NPV. Priority for improvements should be set towards buildings with EUI higher than similar peer type of building that have positive financial outcomes for the investment. Simple payback is not the best metric for buildings with high EUI and long future ownership periods.

The most commonly recommended cost-effective EEM was replacing florescent lamps and fixtures with LED equivalents. The retail costs have come down substantially for several different LED lamp types, and the long lifespan avoids re-lamping costs of shorter lifetime fluorescent lamps. LED lamps are particularly beneficial in high mount locations.

Depending upon installation cost and utility cost of energy, the payback may be possible within the 5 year warrantee period of the most common LED products. The LED retrofit costs were all based on FSEC estimates, except for the Hunt Extension Office, which had a real bid for LED change out. The lack of competitive bids may have resulted in much higher costs than otherwise expected. This one site was the only site to demonstrate poor economic benefit of LED retrofit based on the awarded bid cost and very low utility cost of energy.

The FSEC estimated LED installation costs may be undervalued in an uncompetitive market. The cost benefit of the Hunt office LED retrofit was re-evaluated using three times the FSEC estimated costs with a more-typical utility cost of $0.06/kWh and $15.00/ kW. Based on these different parameters, it demonstrated it was still possible to have a simple payback 10-11 years (half of LED rated life), an IRR around 6%, and positive NPV around $3,500.

The second most common recommended EEM was to replace old air conditioners and replace with heat pumps more efficient than the current Federal minimum efficiency standard. The estimated cost indicated in this report does not use an estimate of the total installed cost of more efficient heat pumps. The cost used is the estimated additional cost of the recommendation compared to the current minimum efficiency allowed.

Summary of Prioritized Energy Reduction

In an effort to prioritize improvements, the results of EEM are shown in Table ES-1. Next the combined result of recommended EEM packages along with solar PV are shown separately in Table ES-2. The rationale of combining EEM with PV results is that it is more cost-effective to reduce energy consumption and then size the PV for the reduced use. Table ES-1 can be used to prioritize EEM efforts and Table ES-2 can be used to prioritize greater sustainability efforts wherever solar PV is feasible. For the larger complex sites having several utility metered accounts, some low-use accounts were not prioritized and are not shown as they have low savings potential compared to some of the very high energy use facilities.

Table ES-1 compares the energy savings-related financial benefits for highest priority facilities from each of the five FDAC locations. Costs are based upon assumed estimates from research of readily available resources. Tables ES-1 and ES-2 have not prioritized by chosen FDACS sites. Specific facilities within an FDACS site are prioritized higher to lower for specific sites. The priority was established by the authors primarily based on IRR as long as there was a positive NPV. It is recognized that

availability of funds and timing the potential disruption of retrofits may supersede recommendations.

Table ES-1 Packaged EEM Recommendations Based on IRR and Lifecycle Benefits

	EEM Financial Benefits						
EEM Locations and Description	Lifecycle Gross Savings	Avoided Costs	Net EEM Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Lifetime (years)
Winter Haven Plant Industry Site							
Cowperthwaite Blgs. LED and HVAC	$38,163	$2,802	-$18,275	11%	$9,676	6.8	12-20
Hunt Office Complex							
Stuart Conf. Center* LED and ReCx HVAC	$35,276	$9,359	-$14,000	11%	$7,291	6.1	5-20
JW Hunt Office LED retrofit and HVAC	$29,242	$9,195	-$19,125	9%	$5,601	10.1	12-20
Extension Office & Ag. Center LED and HVAC	$114,666	$29,666	-$81,636 -$136,330**	6% -1%	$9,055 -$43,535	10.5 17.6	12-20
Conner Complex							
Conner Admin. Blg. LED	$399,860	$68,923	-$73,943	27%	$190,162	3.7	20
MI-1 Maint. Office LED and HVAC	$9,864	$1,088	-$3,473	16%	$3,445	5.7	12-20
Large Green Warehouse LED and HVAC	$56,540	$12,132	-$22,337	17%	$24,488	6.3	12-20
Labs 1-4 (Pods 1&2) LED	$149,583	$32,245	-$48,300	14%	$51,292	6.5	20
Labs 5-8 (Pods 3&4) LED	$149,583	$32,245	-$48,300	14%	$51,292	6.5	20
Lab Blg. 9-10 (Pod 5) LED	$89,293	$17,498	-$29,373	14%	$30,099	6.6	20
State Farmers Market Pompano Beach							
Myrick SFM Blg.6 Petroleum Lab Newer blg.	No major recommendations; has LED lights and controls; EUI of 92 kBtu/ft^2/y qualifies for “best practice” compared to Lab LBL/LBT S.E. U.S.10th percentile of peer lab blgs. Continue regular maintenance and periodic retro-commissioning.						
Myrick SFM Blg.7 Newer blg.	No major recommendations, but unoccupied space needs AC repair, Blg. meets current code with LED lights and controls. Low priority since tenant space use remains unknown.						

* Serves as FEMA operation center during declared emergencies.
** Based on real lighting retrofit bid and estimated HVAC change-out costs; only one qualified bidding contractor; lighting retrofit already funded and underway.

Based solely on EEM and IRR the Conner Building has the highest IRR of all facilities considered. For a much lower test project demonstration, the Conner MI-1 Maintenance Office could also be considered a reasonable option.

Table ES-2 shows a prioritized table based on the most cost-effective package of EEM with on-site solar PV. Low cost of utility energy as well as unsuitable site locations were the primary causes of poor solar financial benefits. Packages with negative NPV or with payback longer than 25 years were not considered. Some sites have suitable location for solar, but perhaps very low energy costs. Such sites should still be considered for demonstration of long-term sustainability efforts. The individual results may still be found within the main report body.

Table ES-2 EEM With Solar PV Economic Analysis Estimates

	EEM Financial Benefits						
Measure Locations and Description	Lifecycle Gross Savings	Avoided Costs	Net EEM Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Winter Haven Plant Industry Site							
Poor PV economics due to low utility cost of energy $0.049/kWh and less than ideal available PV orientation.							
Cowperthwaite Blgs. EEM & PV	$207,252	$20,802	-$166,275	1.6%	-$38,917	20.0	12-30
Hunt Office Complex							
Low utility cost of energy results in poor PV financial benefit. ($0.029/kWh & $9.30/kW)							
Stuart Conf. Center* EEM+PV	$121,724	$9,359	-$142,000	-1.4%	-$67,873	27.4	12-30
JW Hunt Office EEM+PV	$67,064	$9,195	-$75,125	-0.5%	-$27,284	23.9	12-30
Ext. Office & Ag. Cntr. EEM & PV	Lighting retrofit already underway; Site not ideal for solar PV						
Conner Complex							
(Different rates on site; GSD $0.062/kWh & $15.50/kW; GSND $0.101/kWh)							
Conner Admin. Blg. EEM & PV	$668,215	$68,923	-$273,943	9%	$146,585	9.5	20-30
MI-1 Maint. Office EEM & PV ($0.101/kWh)	$39,457	$1,088	-$19,473	6.1%	$4,462	12.2	12-30
Large Warehouse EEM & PV	$174,628	$12,132	-$108,337	4.7%	$7,243	14.5	12-30
Labs 1-4 (Pods 1&2) EEM & ground PV	$449,255	$32,245	-$266,300	4.3%	$7,765	15.2	20-30
State Farmers Market Pompano Beach							
Myrick SFM Blg.6 Petroleum Lab Newer blg.	Solar PV not feasible due to inadequate space.						
Myrick Blg.7 Solar PV ($0.120/kWh)	$180,185	$0	-$72,000	7.3%	$30,634	12.0	30

* Serves as FEMA operation center during declared emergencies.

The EEM and PV package at three facilities at the Conner Complex stand out as the best options. The Conner Lab package involves a large ground mount PV array that

may be aesthetically undesirable and have more unpredictable costs and is considered a low priority.

The top recommendations are:
1) Conner Admin. Building
2) MI-1 Maintenance Office and
3) the Large Green Warehouse.

These selections are largely due to the higher utility cost at the Conner Complex compared to Winter Haven and Bartow sites. While the Myrick Blg. 7 site in Pompano Beach had the highest cost of energy and is relatively efficient, it is only partially occupied and there is potential for much greater energy use in the tenant space that creates much more uncertainty about that specific location. The Conner Building has the best estimated financial returns with all things considered, but at highest first costs. The Maintenance Office offers the lowest first cost with expected positive returns. The large Warehouse could also be considered as a project with somewhat more moderate costs and substantial payback.

Based on EEM including PV package, the Conner Building has the highest IRR of all facilities considered. The Conner MI-1 Maintenance Office could also be considered as a much lower first-cost option.

2. Project Background

Climate change impacts are felt most at the local level and vary according to regional vulnerabilities. Cities and counties are best poised to address their most urgent needs for energy sustainability and resiliency. Many local governments in Florida have adopted aggressive renewable energy targets and zero emissions goals to mitigate the effects of global warming. Others are at least striving for economical energy efficiency measures in efforts to conserve resources. Communities require data and tools to identify how and in what ways they will achieve these goals in a cost-effective manner.

The Florida Energy Investment Collaborative (FEIC) seeks to enable local governments to identify, prioritize, and schedule cost-effective options to meet their energy goals and targets. Sharing best practices, collective procurement strategies, and funding mechanisms will help streamline the process and allow for replicability throughout the state.

To help achieve these goals, the Florida Department of Agriculture and Consumer Services (FDACS) has partnered with the FSEC Energy Research Center (FSEC) to conduct a pilot program to test the objectives of the FEIC. This pilot project is designed to evaluate and enhance the potential efficacy of government agency-owned or operated building energy sustainability activities.

FSEC has evaluated five FDACS facilities chosen by FDACS in order to identify opportunities for energy efficiency improvement and solar energy potential. Evaluation of these sites will help FDACS implement cost-effective improvements in support of energy management goals. These efforts will also be used to develop educational materials and outreach to help motivate FDACS and other local governments to begin planning and implementation of energy efficiency measures (EEM) and determining the feasibility of on-site solar renewable energy generation.

This report completes the Task 1 project deliverable requiring completion of ASHRAE level 1 energy audits with recommended improvements for the five sites shown in Table 1. The resources used to inform audit methods, analysis and cost estimates can be found in Appendix D.

Task 1: Identify and prioritize highest impact, cost-effective, and timely energy efficiency measures and solar energy feasibility for the following FDACS facilities

Table 1. Task 1 FDAC Facilities

Edward L. Myrick SFM Building 6 Consumer Services Petroleum Lab 1150 Hammondville Road Pompano Beach, FL 33069	Edward L. Myrick SFM Building 7 Tenant Office Space 1255 W. Atlantic Blvd Pompano Beach, FL 33069	Conner Complex 3125 Doyle Connor Blvd Tallahassee, FL 32399	Winter Haven Plant Industry Site 3027 Lake Alfred Road Winter Haven, FL 33881	Hunt Office Complex 1702 US Highway 17 South Bartow, FL 32609

A separate section is used for each site to briefly report description, findings, and recommendations for cost-effective improvements regarding site energy use and the feasibility for on-site solar generation. Sites with more than one electric utility meter account have been assessed according to each account. This is necessary to make basic economic analysis. For example, one site with four metered accounts would evaluate the energy uses of each specific account and feasibility of solar applied to each account separately.

A more general summary of recommendations based on all five sites is provided in the conclusion section. Details about general assumptions made regarding savings and costs of EEM are provided in Appendix A. A general description of the energy utility billing analysis methodology is provided in Appendix B. Details about on-site solar PV panels considerations and assessment methodology are provided in Appendix C.

Each site assessment process began with a request for energy utility billing data from each site contact after they were informed about the FEIC project goals. Some sites simply had one utility meter while others had multiple metered accounts on the same site. Each site assessment focused upon the buildings and equipment associated with the metered account data provided. Utility billing accounts on a specific site that were not provided or were redacted were understood to be intentionally left out and not of interest for assessment at this time.

Site energy audit and solar assessments involved the following activities:

- Utility bill analysis – based on FDACS-provided utility bill history of at least two years
  - Annual total energy and monthly energy and peak power use
  - Energy and demand rates
  - Weather-adjusted utility bill analysis to estimate cooling and heating as a portion of annual energy use
  - Annual energy use per square foot of conditioned space
- On-site assessments

    - Solar feasibility observations and characterization including site orientation, shading (adjacent structures, encroaching trees, etc.), available roof or grounds area, system output, annualized savings
    - HVAC characterization (# units, age, condition, schedule, controls, sample indoor temperature and relative humidity measurements)
    - Lighting survey (# units, wattage, schedule, controls, sample illumination levels)
    - Large inefficient plug loads
    - Occupancy density and schedule
- Conferring with site staff
    - Recent and planned renovations
    - Typical building operating schedules and conditions
    - Regularly scheduled maintenance
- Post-audit calculations
    - Estimated lighting energy and power use
    - Estimated HVAC use when possible
    - Solar system sizing estimates using industry-standard software PV Watts

3. Edward L. Myrick SFM Building 6 Consumer Services Petroleum Laboratory

3.1 Site Description

This site is located at 1150 Hammondville Road, Pompano Beach on the north side of the Edward L. Myrick State Farmers Market and was visited March 2, 2023. This 5,778 ft^2 facility, presented in Figure 1, houses offices and a petroleum test lab responsible for testing fuels for performance concerns such as octane and presence of water from samples taken fuels used around the State of Florida. There are about nine occupants during business hours from 8am to 5pm, five days per week. There are other field inspectors that come and go as required.

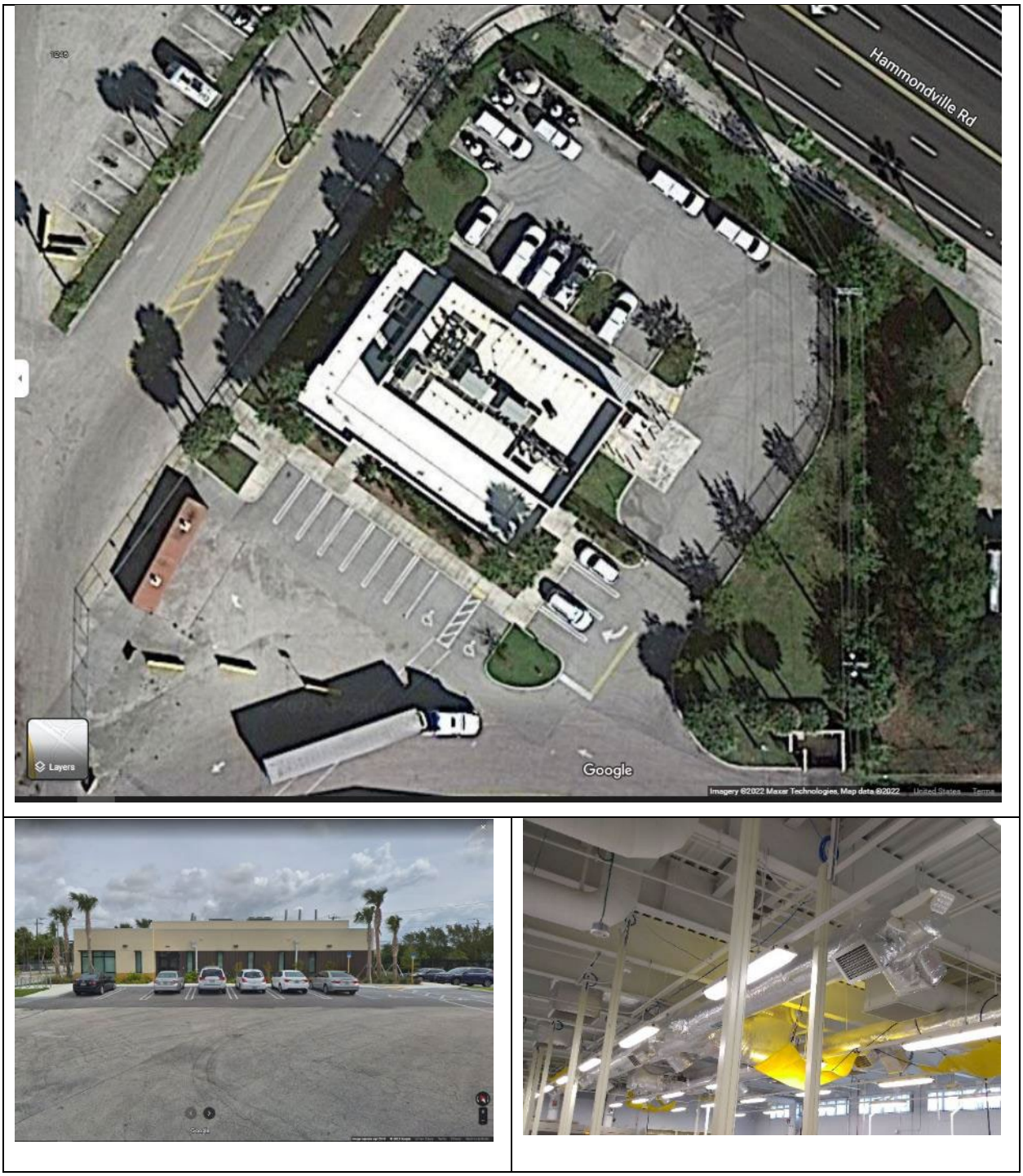


Figure 1. Edward L. Myrick SFM Building 6 Consumer Services Petroleum Laboratory.

The facility construction began in 2017 and consists of a single story with uninsulated CMU walls, tinted impact view glass, built up metal deck roof with rigid foam insulation on top covered by a white TPM roof covering. Lighting is provided by LED lamps and fixtures controlled by occupancy sensors in all occupied spaces. Exterior LED lighting is controlled by photocell and astrologic clock.

Space conditioning is provided by three roof top units (RTU). RTU 3 provides space heat, cooling, and ventilation for the office, bathrooms and conference spaces. RTU 1 and RTU 2 are designed to provide HVAC needs for the laboratory space which requires a large amount of ventilation and hood exhaust make-up air. All ducts are located in conditioned space, well insulated and labeled. All RTU are on an energy management system that can be observed remotely for several operational performance metrics such as airflow, static pressure, temperature, humidity, damper settings, staged heating and cooling status.

The building was well-maintained. It was comfortable clean and dry, adequately illuminated, with regular scheduled air filter replacement of the HVAC systems. The building manager reported an area where roof leakage was occurring over the office area of building, which was planned to be repaired in the near future. The seven lab fume exhaust hoods have a static pressure test at least once a month by staff and a third-party calibration of six fume hoods every year.

3.2 Site Energy Bill Analysis

Energy needs are provided through Florida Power and Light electric utility on General Service Demand (GSD-1) rate. Gas is not used for space heating, cooling, or on site power generation. The lab was designed to use gas fuel only for official testing operations, which have not been conducted in the past two years. Therefore, only utility electric energy need to be considered at this site.

The adjusted 2022 total annual energy use was 155,151 kWh. Normalizing the site energy use by conditioned area established and energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 92 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 2. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption. The annual peak kW represents the highest monthly peak and the average peak over the entire year.

Table 2. 2002 Normalized Utility Energy Use Summary

Floor Area (ft^2)	Annual Energy (kWh)	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	Utility Energy Cost ($/kWh)	Utility Monthly Peak Power Cost ($/kW)
5,778	155,151	(61 / 51)*	91.7	$0.06435	$11.93

* 61 kW maximum peak in June.

This site is comprised of both office and laboratory space. Since the laboratory buildings typically have office spaces, historical EUI data of lab buildings also includes the office space. Lab EUI Data collected by Lawrence Berkeley National Lab (LBNL) does not show any significant correlation of % of lab area to EUI, therefore comparison to Lab EUI is most suitable for this site. The EUI for existing lab buildings as well as EUI target

goal of net zero energy (NZE) is shown in Table 3. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The Building 6 Petroleum Lab EUI of 92 is less than the 10th percentile of the LBNL Laboratory Benchmark Tool (LBT). This is considered to be operating at “Best practice” according to LBNL guidance. Standard practice is within 50th-25th percentile of peer group and Good practice is within 25th-10th percentile. The LBNL LBT peer group consists of 92 Bio/Chem labs located in hot humid climate zones 1A, 2A, and 3A (southeast United States). The Petroleum Lab EUI is less than 100, which is considered relatively low enough to be considered for NZE application, if adequate renewable energy resource could be obtained to supplement the current energy use. Unfortunately, the site is not suitable for practical on-site solar PV generation.

Table 3. EUI Comparison to Lab Buildings for Existing Labs and NZE Target Goal

EUI of Existing Buildings of Various Age (kBtu/ft^2/yr)			EUI of NZE Target Goal (kBtu/ft^2/yr)
Lab LBL/LBT S.E. U.S. mean (peer)	Lab LBL/LBT S.E. U.S. 10th percentile (peer)	Lab CBECS Data (peer)	Lab NZE
409	169	115	<100

A linear regression analysis was conducted with data from the monthly utility bills which were provided for the Building 6 Petroleum Lab site, to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. The detailed description of this methodology can be found in Appendix B.

The model predicts an annual baseload energy use of 82,289 kWh (58% of total), cooling energy of 65,862 kWh/y (43%) and total of 155,151 kWh/y . These results are presented graphically in Figure 2, with baseload shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. The baseload is mostly regular lab HVAC operations as well as lighting.

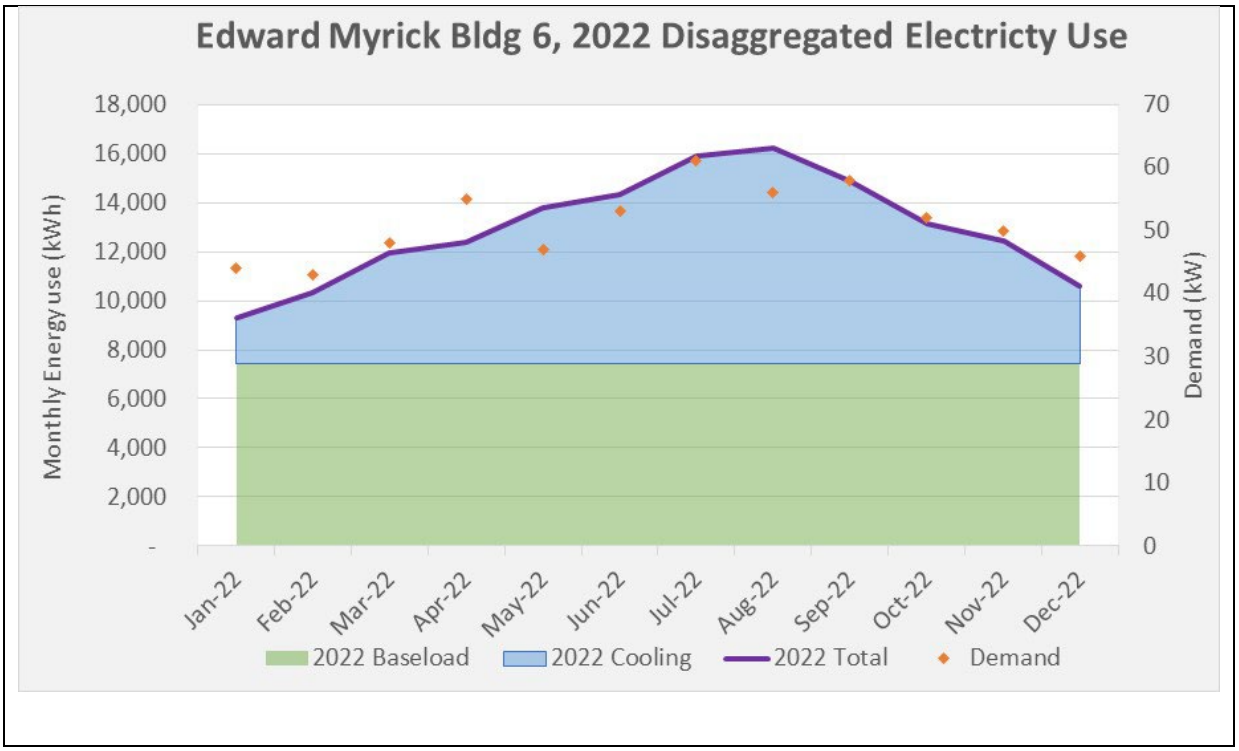


Figure 2. Building 6 Petroleum Lab 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

3.3 Relevant Findings

Building 6 Petroleum Lab is a newer building with very efficient lighting, and good HVAC schedules and controls. The laboratory fume exhaust hoods are maintained and calibrated at regular frequency. This is critically important for health and safety as well as energy conservation. The key is to maintain effective fume capture with as little exhaust flow and power as necessary. Much of the energy consumed at the lab is from the RTU 1 and RTU 2 that must condition a large amount of outdoor air to make up for all the exhaust air required to safely remove pollutants. Maintaining the exhausts to ensure that no more air and power is used than is necessary for effective capture will minimize the amount of energy-intensive air conditioning of outside makeup air.

Capture at the hood can be disturbed by high air velocity from other mechanical systems such as the space conditioning supply discharge. There was one area near Hood # 2 where there was a noticeable air velocity blown across the face of the hood as felt by the site audit team and visible by holding up a sheet of paper. This air was coming directly from the supply air grille just above and to the left of the hood. This hood was off and unneeded during the site visit. Redirection of that specific supply air vent may enable better capture with less flow for Hood 2.

Overall, this building is operating effectively and efficiently for a major laboratory.

3.4 Recommendations

3.4.1 Recommended Energy Efficiency Measures

This site uses a lot of energy and power for the building size, however the EUI is relatively low compared to other laboratories. The majority of power and energy are required for critical lab operations.
There are only a few general recommendations to be made primarily regarding maintenance.

1. Adjust Lab supply air discharge as needed. Consider the potential of space conditioning supply air discharge to disturb capture and adjust direction as needed. Make supply air adjustments before third-party calibration of hoods.
2. Confirm HVAC performance on a regular basis. Monitor the HVAC status of RTU 1, 2, and 3 at regular intervals and compare to a baseline of expected design parameters to ensure system sensors are giving correct readings and hardware is responding to inputs correctly. Have suspect sensors or operations inspected and repaired in timely manner.
3. Retro-commission HVAC and lighting systems and controls. Have an HVAC contractor familiar with your systems perform a detailed evaluation of RTU performance at least every 5 years or sooner as required. Lighting controls should also be re-commissioned to ensure they are working correctly. Retro-commissioning typically saves at least 13% on energy bills with a payback typically within a year.

3.4.2 On-site Solar Renewable Energy Generation Potential

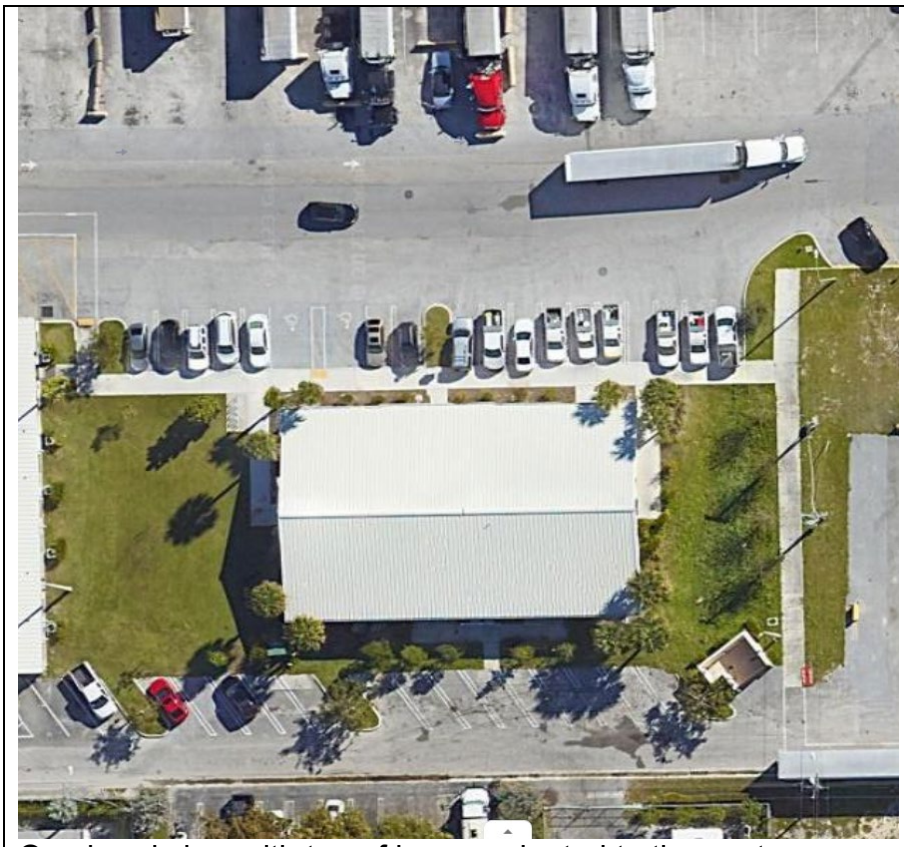
This site does not offer suitable locations for mounting solar PV panels. The small amount of available roof over office portion of the building will have shading from trees on each corner as well as shading from the parapet walls. The grounds around the building must permit a lot of traffic from commercial trucking operations and numerous other vehicles visiting the State Farmers Market complex. Therefore ground mounted PV is also not suitable for this site.

4. Edward L. Myrick SFM Building 7 Tenant Office Space

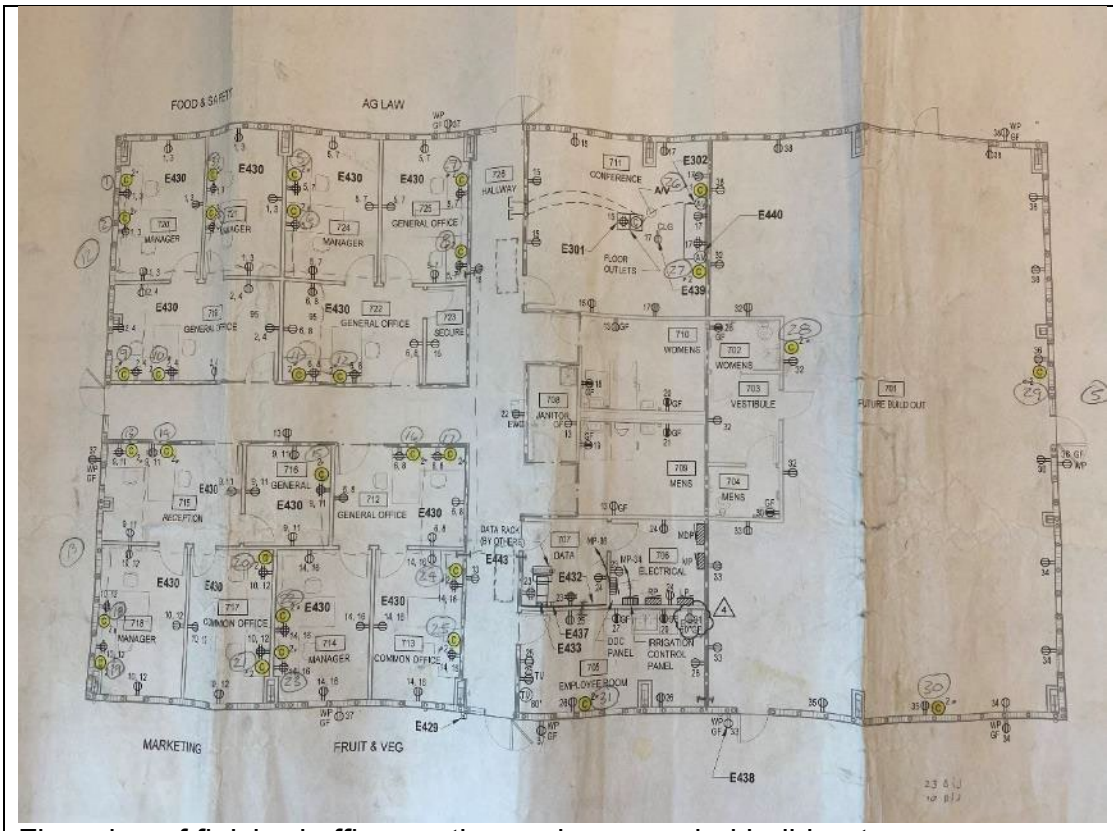
4.1 Site Description

This site is located at 1255 W. Atlantic Blvd, Pompano Beach and was visited March 1, 2023. The building, presented in Figure 3, was built as office space to support FDACS fruit inspection, food safety, and agriculture law operations under 4,216 ft^2 and another 2,256 ft^2 is an unoccupied build-out available for another tenant. The total of 6,472 ft^2 of both spaces is all on one electric utility account. The office space is built to support at least 12 full-time occupants during business hours from 8am to 5pm. There are other inspectors or visitors that are part of a normal variability in occupancy. The build-out was completed without any interior walls but otherwise complete with lighting, HVAC

and finished acoustical tile ceiling. The space is being considered for food or restaurant retail.



Overhead view with top of image oriented to the east



Floorplan of finished office section and unoccupied build-out space.

East entry side

West back side

Figure 3. Edward L. Myrick SFM Building 7 Tenant Office Space

The facility construction began in 2018 and consists of a single story with uninsulated CMU walls, double-pane low-e tinted impact view glass, with a truss supported sloped metal standing seam roof. Vinyl-backed fiberglass insulation blanket is located on the underside of the metal roof deck (R value undetermined). Lighting is provided by LED lamps and fixtures controlled by occupancy sensors in all occupied spaces. Exterior LED lighting is controlled by photocell and astrologic clock.

Office space conditioning is provided by three different split-DX heat pumps. There was one 3 ton central ducted system, one 5 ton central ducted system and one ductless ¾ ton minisplit available for supplemental conditioning of a conference room if needed. One ductless minisplit AC unit was used to cool the data communications room. All ducts are located in conditioned space, well insulated and labeled. All primary cooling systems are on an energy management system that can be observed remotely to set the interior set points and check for space conditions as well as operational heating and cooling status.

The building was well-maintained. It was comfortable clean and dry, adequately illuminated, with regular scheduled air filter replacement of the HVAC systems.

4.2 Site Energy Bill Analysis

Energy needs are provided through Florida Power and Light electric utility on General Service Non-Demand / Business (GS-1) rate. Gas is not used for space heating, cooling, or on site power generation. Therefore, only utility electric energy need to be considered at this site.

The adjusted 2022 total annual energy use was 50,140 kWh. Normalizing the site energy use by conditioned area established and energy use index (EUI) which can be compared to other buildings of similar use and size. If the entire 6,472 ft^2 area of the building is used, the EUI is only 26.5 $kBtu/ft^2/yr$, but currently only 65% of the building is being used. If only the 4,216 ft^2 of occupied office space is considered, the EUI is 40.5 $kBtu/ft^2/yr$. This latter EUI is unfairly inflated since the unoccupied space is actively air conditioned. An estimated EUI is offered here with some assumptions. It was assumed that the total building cooling energy represents 50% of the total energy use. Based on the cooling capacity for each space, the unoccupied space cooling energy is assumed to account for 42% of the total cooling or

The summary of site energy use, EUI, and utility cost is shown in Table 4. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption. The annual peak kW represents the highest monthly peak and the average peak over the entire year.

Table 4.2022 Normalized Utility Energy Use Summary

	Floor Area (ft^2)	Annual Energy (kWh)	EUI $kBtu/ft^2/yr$	Utility Energy Cost ($/kWh)
Total Energy Including Unoccupied Area	6,472	50,140	26.5	$0.11697
Total Energy Using Only Occupied Area	4,216	50,140	40.5	$0.11697
Estimated Energy for Occupied Office Only	4,216	39,611*	32.1*	$0.11697

* Estimated 50,140 – 10,529 est. unocc. cooling = 39,611 kWh/y.

The EUI for existing lab buildings as well as EUI target goal of net zero energy (NZE) is shown in Table 5. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The Building 7 Office Space estimated EUI of 32, considering only the current occupied office space, is 39% better than the CBECS office average of existing offices. It is 3% better than comparison to typical offices in compliance with ASHRAE 90.1-2016 standard. These comparisons are provided here for current feedback on the office space and will not be relevant once the build-out space is occupied. The EUI for the whole building on this one utility account could easily double if a food service occupies the tenant section. If it becomes office space, the EUI may be still remain similar to 32 kBtu/ft^2/yr.

The current adjusted office space EUI is 39% higher than the target for a net zero energy (NZE) office building in Florida. NZE can still be attained for offices with higher EUI if the building has enough suitable location for on-site renewable energy. The Building 7 Office rooftop could be considered for solar energy production, which is discussed in greater detail in the 4.4 Recommendations section of this report. The unknown future use of the build-out section creates large uncertainty in the appropriate amount of solar to be considered for this location.

Table 5. EUI Comparison to Existing Office Buildings and NZE Target Goal

EUI of Existing (kBtu/ft^2/yr)		EUI of NZE Target Goal (kBtu/ft^2/yr)
Office CBECS Data (peer)	Office ASHRAE 90.1 2016 (code comparison)	Office NZE (FL)
52.9	33	23

A linear regression analysis was conducted with data from the monthly utility bills which were provided for the Building 7 Tenant Office Space site, to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. The detailed description of this methodology can be found in Appendix B..

The model predicts an annual baseload energy use of only 5,297 kWh (11% of total), cooling energy of 44,843 kWh/y (89%) and total of 50,140 kWh/y . These results are presented graphically in Figure 4, with baseload shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. The low baseload would appear to be well controlled efficient light and plug loads. Cooling is estimated to be most of the energy use.

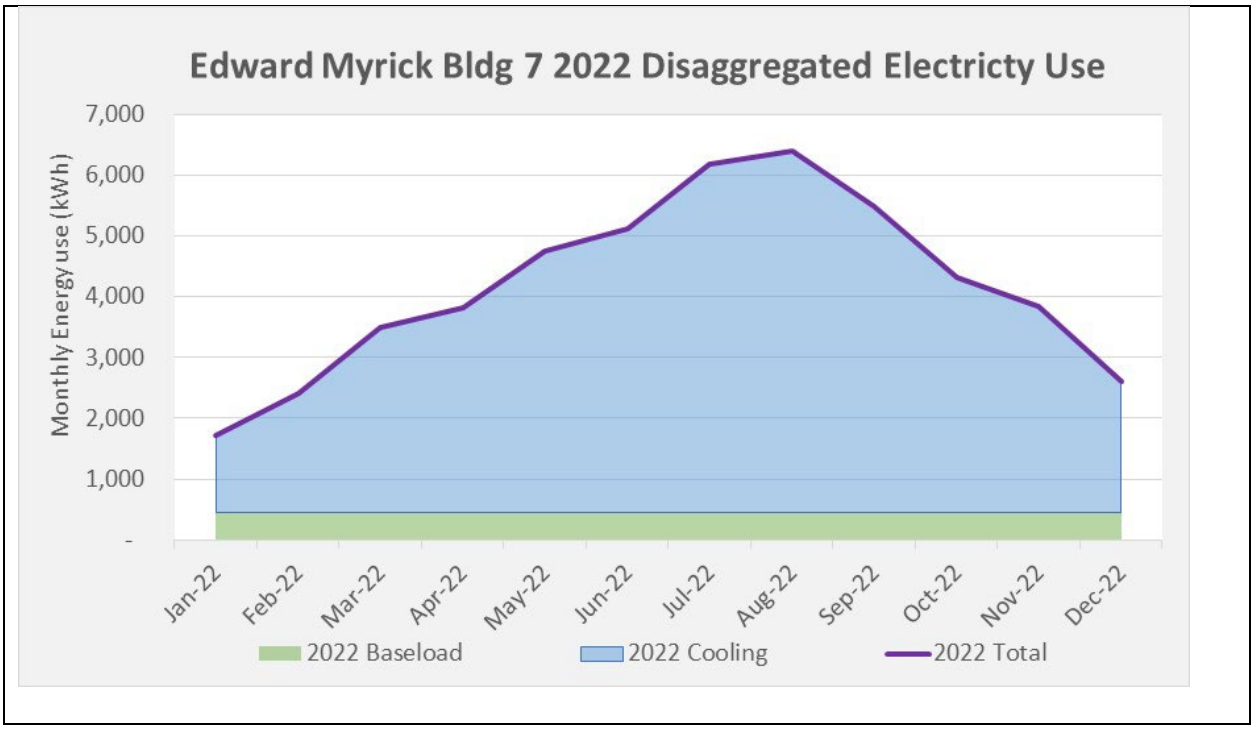


Figure 4. Building 7 Office 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

4.3 Relevant Findings

Building 7 office building is a newer building with very efficient lighting and lighting controls. The Lennox heat pumps are more efficient than minimal efficiency systems at the same capacity. They have a rated efficiency up to 16.2 SEER and 9.7 HSPF and are controlled by an energy management system used to maintain setpoints and monitor indoor conditions.

One of the 5 ton heat pumps (CU3) serving the unoccupied build-out section was not working correctly during the site visit. It was short-cycling and not cooling adequately, which would increase energy use.

The interior illumination levels were sampled during the site visit and indicated desktop level illumination mostly met or occasionally exceeded minimal lighting level IESNA recommendations with electric lighting on and window blinds not closed. Some office areas had illumination as high as 83 foot candles with lights on and window blinds mostly open. Generally illumination of 30-50 fc is adequate in office environments where visual tasks are focused on electronic monitors. However office task lighting around 60-75 fc is acceptable for visual tasks such as reading fine print on paper. Higher illumination with daylighting present may be an indication that some dimming controls are not operating correctly. A lighting professional would be able to comprehensively verify that the dimming controls do function and that they are located in the optimum location.

Overall, this building is operating effectively and efficiently, but should have regularly scheduled services on HVAC and lighting controls.

4.4 Recommendations

4.4.1 Recommended Energy Efficiency Measures

This building is fairly new and reasonably efficient, however efficiency can wane as systems age. Here are a few general recommendations to be made primarily regarding operations and maintenance.

1. Consider adjusting interior temperatures. Maintain indoor cooling setpoints between 73°F-75°F during business hours and set up to 80°F during non-business hours. There is approximately an 8% reduction in cooling energy use for every 1 degree the cooling setpoint is raised.
2. Confirm HVAC performance regularly. Monitor the HVAC status of the four primary heat pumps at regular intervals to ensure each one is cooling as expected. Have suspect sensors or systems inspected and repaired in a timely manner.
3. Verify that occupancy controls are working correctly. Also verify that the daylight dimming feature works in spaces with windows at a time with abundant daylight available. The test should be done without window blinds covering windows. During normal daily operations, encourage at least partial opening of window shades for some natural daylight.
4. Retro-Commission HVAC and Lighting Systems and Controls. Have a detailed evaluation of the central cooling systems performance at least once a year. The refrigerant charge, supply air temperature and total system airflow should be verified to be correct. Lighting controls should also be verified to be working as intended. Building retro-commissioning should be completed at least every 5 years to help maintain maximum efficiency. Retro-commissioning can save 16% median energy with a payback of about one year (Parrish et al 2013 LBNL).

4.4.2 On-site Solar Renewable Energy Generation Potential

The east and west facing metal standing seam roof offers a suitable opportunity for on-site solar. However, the unknown business requirements of the unoccupied 2,256 ft^2 build-out creates a large unknown that makes it difficult to optimize the PV system size. The potential for several different tenants and business energy needs over a the expected 30 year lifespan of the PV investment must also be considered.

The possibility of a food-related service was noted by the audit staff. Food services are much more energy intensive. The CBECS data base indicates EUI that range from 231 $kBtu/ft^2/yr$ for convenience store up to 403 $kBtu/ft^2/yr$ for fast food restaurants. The implication from the assuming lowest food EUI in the 2,256 ft^2 space would double the current total building site energy use from 50,140 kWh/y possibly up to 153,090 kWh/y or more.

Given the uncertainty of future use of the build-out, a conservative recommendation of on-site installed solar PV is offered here. Oversizing the PV for more than what is consumed offers poor economic return since savings are based upon consumed utility power.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 36 kW PV installation are provided in Tables 6, 7 and 8. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial output for the investment. A PV system with a total of 36 kW rated output was based on the meeting the current occupied office and only the base air conditioning of the unoccupied unit (the recent actual energy use). It is not designed to meet any increase in energy associated with occupied build-out. The proposed system consists of 18 kW array on the east roof and another 18 kW array on the west roof. An illustration of the proposed installation is shown in Figure 5.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility peak and energy charges were used based on the most recent utility billing data from the service provider, FPL. There is no peak power charge currently. The current energy charge of $0.11697 / kWh was used in financial analysis. Standard service charges and fees not associated with energy use were not included in energy cost analysis.

Figure 5. Arial view of potential PV panel arrays shown over east and west roof portions. Approximate locations are indicated and are not shown to scale.

Table 6. SFM Blg.7 Tenant Office 36 kW Solar PV Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	Energy Savings Description	Peak (kW)	PV Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
Solar PV	Rooftop Total 36 kW	No peak charge	51,348 102%*	0	$6,006	-$72,000	12.0

* % of actual annual total utility energy use of 50,140 kWh.

Table 7. SFM Blg.7 Tenant Office 36 kW Solar PV IRR and Lifecycle Benefits

Measure ID	Energy Savings Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Solar PV	$180,185	$0	$0	-$72,000	7.3%	$30,634	12.0	30

Table 8. Reduction of Utility Energy Use With 36 kW Solar PV for Site With No Tenant

	Annual Utility (kWh)	EUI ($kBtu/ft^2/yr$)
Current Energy; EUI Using Only Occupied Area	50,140	40.5
Current Est. Energy and EUI of Only Occupied Area	39,611*	32.1*
Future Potential With 36 kW Solar PV; Current Energy, EUI Using Occup. Area	50,140 – 51,348= -1,208**	0.0**

*Total energy decreased to estimate only energy of current occupied space.
**Will not reflect actual use with build-out occupied and part of existing electric billing account; This estimate provided to demonstrate NZE potential if only the 4,216 ft^2 occupied office was only use on the account.

PVWatts® Output Summary Reports

Note that the information and disclaimer below applies to all PVWatts® Results posted herein this report.

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 //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.

Disclaimer: The PVWatts® Model ("Model")
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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (openrack) PV system at this location.

RESULTS

26,035 kWh/Year*

System output may range from 24,500 to 27,284 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.56	1,544
February	4.56	1,805
March	5.58	2,408
April	6.46	2,660
May	6.59	2,777
June	6.02	2,422
July	6.29	2,619
August	5.96	2,466
September	5.24	2,112
October	4.76	2,032
November	3.99	1,677
December	3.48	1,513
Annual	5.21	26,035

Location and Station Identification	
Requested Location	1255 W. Atlantic Blvd, Pompano Beach
Weather Data Source	Lat, Lng: 26.25, -80.14 1.3 mi
Latitude	26.25° N
Longitude	80.14° W

PV System Specifications	
DC System Size	18 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	15°
Array Azimuth	90°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 0%, Feb 0%, Mar 0%, Apr 0%, May 0%, June 0%; July 0%, Aug 0%, Sept 0%, Oct 0%, Nov 0%, Dec 0%

Performance Metrics	
DC Capacity Factor	15.9%

18 kW roof mount array on east roof.

RESULTS

25,313 kWh/Year*

System output may range from 23,918 to 26,528 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.50	1,520
February	4.51	1,779
March	5.47	2,348
April	6.36	2,609
May	6.36	2,669
June	5.68	2,280
July	6.15	2,553
August	5.83	2,409
September	5.15	2,074
October	4.68	1,995
November	3.86	1,617
December	3.37	1,460
Annual	5.08	25,313

Location and Station Identification	
Requested Location	1255 W. Atlantic Blvd, Pompano Beach
Weather Data Source	Lat, Lng: 26.25, -80.14 1.3 mi
Latitude	26.25° N
Longitude	80.14° W

PV System Specifications	
DC System Size	18 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	15°
Array Azimuth	270°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 0%, Feb 0%, Mar 0%, Apr 0%, May 0%, June 0%; July 0%, Aug 0%, Sept 0%, Oct 0%, Nov 0%, Dec 0%

Performance Metrics	
DC Capacity Factor	15.9%

18 kW roof mount array on west roof.

5. Winter Haven Plant Industry Site

Cowperthwaite Buildings as they looked after original construction.

Cowperthwaite Buildings after recent roof and window renovations.

Figure 6. Winter Haven Plant Industry site.

5.1 Site Description

This site was visited March 8, 2023 from about 10am through 12:20pm. The complex, shown in Figure 6, houses offices and labs as well as several unconditioned greenhouses and shop / storage facilities. The primary business function is to inspect and study various types of citrus plants with a focus on pest eradication and control. This includes an environmentally controlled budding lab that provides the genesis for potential new cultivars of commercial citrus in Florida. Much of the grounds are used to grow more than 250 cultivars of citrus.

The Cowperthwaite facility was the primary focus of energy assessments. It is a 1950's original structure having had major energy-impacting improvements over several years. Daily operations at the Cowperthwaite facility occur from 8am-5pm. It is comprised of two building sections connected by an unconditioned corridor. The total conditioned area is 8,651 ft^2. The east building houses the budding lab, a conference space, and some small rooms. The west building is office space. The occupancy varies through the day as inspectors leave offices to go out to perform site visits. There was no indication that operations were impacted significantly during the COVID-19.

The building was maintained well. It was comfortable clean and dry, adequately illuminated, with regular scheduled air filter replacement of the HVAC systems.

Due to the specific needs of plants within greenhouses, gas energy (heat) and electric fan energy is utilized only as weather dictates. No recommendations are made regarding the greenhouse operations.

5.2 Site Energy Billing Data Analysis and EUI

Three different energy utility bill accounts were provided for this site assessment covering the period from January 2021 through December 2022. Since electric billing provided a comparison to the previous year, we were also able to look at 2020 data. One electric metered account was solely for outdoor street lamps. The second electric account covered the Cowperthwaite buildings. A gas utility account only applied to greenhouse heating and emergency back-up generation.

Gas was not used for conditioned space or domestic hot water heating. Gas was only used as needed to warm greenhouse plants or run emergency generators during loss of grid power. Given the unpredictable and minimal use of gas, gas energy use will not be considered in site analysis. No recommendations are offered here for reducing gas use due to the limited use for emergencies.

TECO is the electric utility A total of three years (2020-2022) of electric billing data were used. There was no significant long-term change in occupancy or operations reported related to the COVID pandemic during 2021-2022. Energy and demand use was drastically higher from October 2021 through February 2022 compared to the same period in 2020. It was discovered that major building renovations had occurred that included replacing all exterior windows and the utility meter. During this same unusual use period, the meter reading on the bills were noted as "estimated". The billing estimates occurred just after the new meter was changed out and during the renovation period. Most of the interior lighting in the east building section had also undergone an upgrade from fluorescent to LED about the same anomaly period.

Normally the most recent year after retrofits would be used for establishing a current baseline for further efficiency considerations. Full use of the 2022 year could not be used since retrofits had not been completed until around the end of February 2022, and the disruption of removing and replacing windows one at a time had a noticeable winter

peak power increase of 70% (from 30 kW to 51 kW) compared to 2020 during these months. Furthermore, the utility "estimated" bills made January and February 2022 more unreliable. Therefore, the first two months of 2022 were replaced with the first two months of 2020 since it would not have had any operational interference occurring then.

The adjusted 2022 total annual energy use was 132,276 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 52.2 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 9. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption.

Table 9. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	$/kWh	$/peak kW
8,651	132,276	(37 / 34)*	52.2	$0.04992	$16.53

* 37 kW based on estimate disregarding winter 2022 anomaly of 51kW

This site is comprised of about 90% office space and approximately 10% laboratory space with relatively low exhaust and ventilation requirements compared to whole buildings classified as laboratories. The electric baseload energy use is about 10%-15% higher than most office buildings which is believed to be due to the lab appliances. Since much of the Cowperthwaite building offices support work beyond the bud lab, we suggest comparing this site EUI of 52.2 to a hybrid weighted EUI consisting of 90% office and 10% lab.

Table 10 shows different published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for office and also for lab spaces. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for. For fairer comparison, the weighted hybrid EUI comparison was derived once for existing buildings and also for the NZE target.

Lawrence Berkeley National Lab (LBNL) considers a lab EUI less than the 10th percentile of peer group using the LBNL Laboratory Benchmark Tool (LBT) to be operating at "Best practice". The LBNL LBT peer group consists of 92 different Bio/Chem labs located in hot humid climate zones 1A, 2A, and 3A (southeast United States). The 10th percentile EUI of this group is 169 kBtu/ft^2/y.

The Winter Haven Plant Industry Cowperthwaite Building EUI of 52.2. is less than the derived existing building hybrid of 64.5, which indicates that it is more efficient than existing buildings similar in use. With further energy efficiency improvement, the EUI could be reduced closer to the NZE weighted target EUI of 31.

Table 10. EUI Comparison to Office, Lab, and Weighted Hybrid Spaces for Existing and NZE Target Goals

EUI of Existing Buildings of Various Age (kBtu/ft^2/yr)			EUI of NZE Target Goal (kBtu/ft^2/yr)		
Office CBECS Data (peer)	Lab LBL/LBT S.E. U.S. 10th percentile (peer)	Weighted EUI 90% Office CBECS & 10% 10th prcnt. Lab	Office NZE (FL)	Lab NZE	Weighted EUI 90% Office 10% Lab
52.9	169	64.5	23	<100	31

A linear regression analysis was conducted with data from the monthly utility bills which were provided for the Winter Haven Plant Industry site, to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. The detailed description of this methodology can be found in Appendix B.

The model predicts an annual baseload energy use that is about 79,507 kWh/y (60% of total), cooling energy of about 48,758 kWh/y (37%) and heating of about 3,866 kWh/y (3%). These results are presented graphically in Figure 7, with baseload shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond.

The baseload is mostly lighting, budwood lab operations as well as other plug loads. The cooling energy is the single largest use during the summer months. Indicated heating energy use is modest as is normal for central Florida offices. The existing electric heat pumps heating the space are much more efficient than electric strip heat and are already helping to keep heating costs lower.

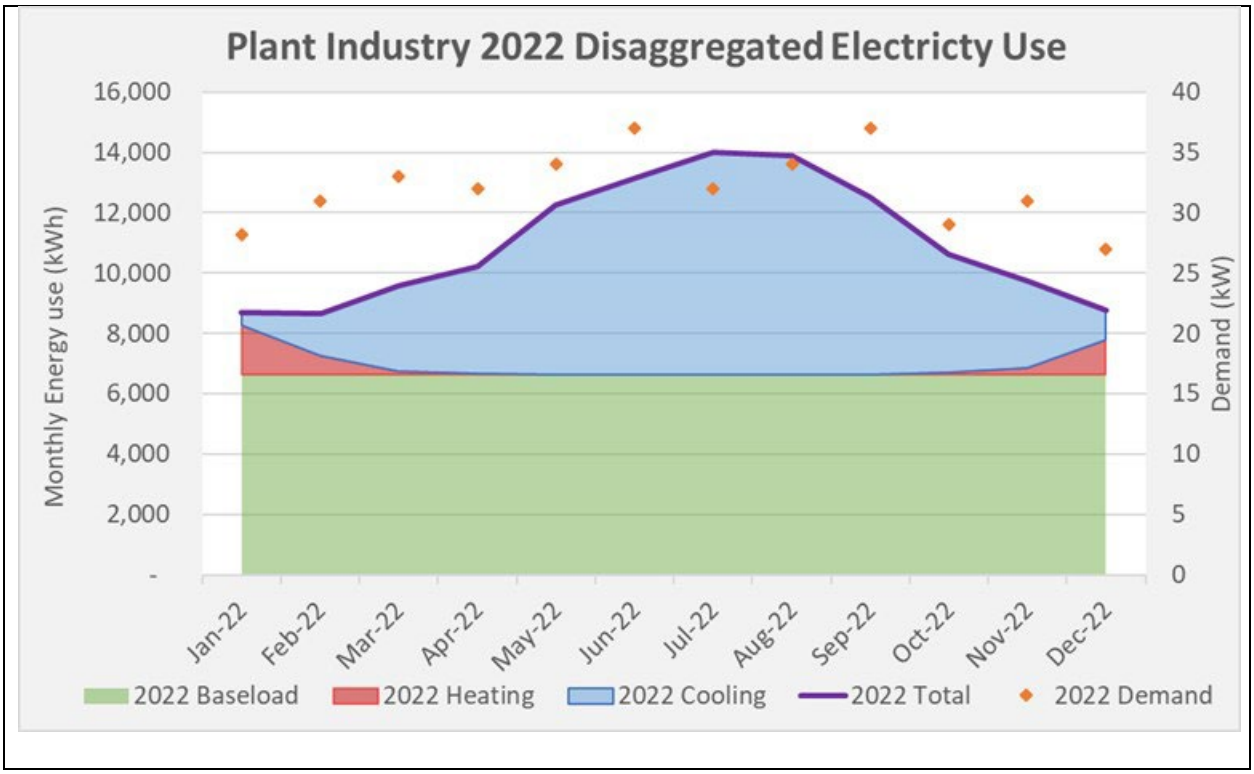

Figure 7. Plant Industry 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, TECO. The peak power charge of $16.53 / kW and energy charge of only $0.04992 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. The very low energy costs for this site diminish rates of return and prolonged simple payback. No assumptions or adjustments were made to predict future cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

5.3 Relevant Findings

Street Lights

There were only two fixtures noted on this account. These fixtures were identified on site as the two lampposts on the entry road. It appeared that the street lighting bill is really a fixed service fee. The energy use was exactly 156 kWh every billing period regardless of the number of days in the billing cycle until April 2022. It appears that a street lighting retrofit may have occurred late March 2022 with the later 2022 billing history indicating a 34.6% drop in energy use (to 102 kWh), however the customer monthly charge remained around $36. The energy use rate was changed to reach the pre-retrofit amount. No recommendations are made for the street lamp account.

Cowperthwaite Building

Figure 8. Left: Front side of buildings facing southwest with west building dominantly shown. Right: Back side facing northeast and northwest side with new power mast and electric meter. Two 5 ton Goodman heat pumps located outside the west building.

This building consists of CMU exterior walls, slab on grade, R19 insulation at the metal roof deck, and new insulated low-e glass windows. There are several offices with exterior windows. Lighting is provided by T832W fluorescent lamps as well as newer LED lamps. Space heat and cooling is provided by electric heat pump central ducted split DX systems that are estimated to be at least 9 years old. The west building had two identical Goodman 5 ton systems serving two different zones. The east building had one ducted 10 ton Daikin with two-stage system connected to two identical Daikin 5 ton heat pumps. All systems appeared to be maintained well and delivered cooling near set-point with exception to the budwood lab. Cooling set-points were reported to be maintained between 68ºF-70ºF and heating at 70ºF-72ºF. Each system was controlled by a single thermostat zone accessible on interior walls. The observed thermostat temperature during visit was 69ºF.

Major Renovations Noted on Cowperthwaite Building

Original construction of the Cowperthwaite building, pictured in Figure 8, was around 1957, but there have been some major renovations within the last 16 years. In 2007 a new trussed metal roof was built over the existing flat built-up roof with R19 insulation added to the metal roof deck noted on plans. HVAC ductwork was replaced with R6 insulated ducts in 2010. Beginning in 2021, three different major renovations occurred to windows, walls and lighting. The renovations spanned from approximately fall 2021 through spring 2022. The electric utility meter was replaced during the same period as the window renovation making energy analysis more challenging. There were four months (Nov. 2021-Feb. 2022) where the utility, TECO, indicated billing use was estimated and does not match prior year profile. The renovations and estimated billing made this period of measured energy unreliable to predict a normal baseline and

disaggregate energy use. Therefore, previous and past use profiles, normalized to weather, were used to create estimated monthly use for Nov. 2021-Feb. 2022.

Recent renovations that occurred during two-year billing analysis period:

- Original single-pane clear jalousie windows replaced with double-pane low-e tinted insulated glass units, thermal blinds added
- Interior block walls had moisture retarder added to control moisture issues, ~R3 wall insulation added and covered by painted drywall
- East building fluorescent T8 lamp and fixture lighting changed to LED lamps and fixtures. The site manager indicated that lighting retrofits to LED are also planned in the future.
- Occupancy lighting control installed in east conference and east and west bathrooms

Indoor Environment- Temperature, Humidity and Illumination

Overall indoor conditions were clean, dry and illuminated well. HVAC systems were in cooling mode during the visit and temperatures were very cool in most locations. Hand-held sample measurements of indoor temperature, RH and illumination levels found readings mostly within generally acceptable levels of comfort during the site walk-through, although some temperatures were low due to low cooling setpoint. Temperatures ranged from as low as 68.7ºF in east building auditorium (no windows and vacant) up to 78.8ºF in the Citrus Budwood Lab. Outdoor conditions during measurements were sunny and about 81ºF between 11am-12pm. This lab space had a significant amount of electric powered equipment that generated internal heat as well as a high exterior wall ratio resulting in higher cooling load than other spaces of the buildings. Relative humidity was under reasonable control throughout the east and west buildings. Most measurements were between 45%-50% RH, however the humidity in the east conference room was slightly elevated at 63% RH.

Indoor illumination was more than adequate with electric lights on. A couple of the offices are pictured in Figure 9. IESNA recommended lighting for offices is at 30-50 footcandles (fc), however less task lighting is needed when working at a computer monitor and reduced lighting can minimize glare issues. Offices with available daylight had desktop illumination with lights off at levels generally between 17-41 footcandles (fc). Most thermal blinds were found drawn down over about ¾ of the upper window area. Daylit offices had illumination with lights on at levels 27-87 fc. The office with lowest illumination (17 fc with light off and 27 fc when light on) appeared to have a preference for lower illumination as only 1 lamp of 4 was lit within the one overhead fixture. Illumination at desktop level was also measured in the east building conference room under the new LED troffer fixtures. Illumination varied from 46 to 71 fc and had occupancy control. This is a good demonstration that 2’x4’ LED panel lighting was effective in replacing pre-existing T8 32 watt linear fluorescent lamp-based troffer lighting.

Figure 9. Left: Desktop illumination in daylit NE middle office was 87 fc with fluorescent lights on and 41 fc with lights off. Right: Desktop illumination in east conference room varied from 46 fc to 71 fc.

5.4 Recommendations

5.4.1 Recommended Energy Efficiency Measures

There are still opportunities for cost-effective energy efficiency measures (EEM) to indoor electric lighting and HVAC. Electric lighting in the west side building is mostly 2'x4' troffer fixtures with T832W lamps and electronic ballasts. These should be replaced with LED equivalents similar to efforts already completed in the east side of building. It is also recommended that offices with natural daylight have occupancy based control with integrated electric light output control (daylighting control). Occupant instruction may be needed to help learn how to maximize natural illumination as much as individual visual and thermal comfort needs will permit.

The interior cooling setpoint is very low. Cooling setpoints maintained continuously below 74ºF have a higher risk of condensation on cold air exterior ductwork or any building surface able to cool to the very low setpoint during warm moist summer conditions. It is assumed this may be needed to maintain comfort in some zones such as exterior offices or the Citrus Budwood Lab in the east building, which has a significant amount of lab appliances. The bud lab had the warmest indoor temperatures during the site visit. One comfort and energy conservation solution for the east building could be to add a ductless minisplit heat pump with the indoor unit attached to an upper portion of accessible wall. This would allow better zone cooling of the lab space without overcooling other east building zone spaces. Although another heat pump would be added, total operational cooling energy costs could decrease substantially. This is because the ductless system would be about 2-3 times more efficient than the central ducted system, and would enable a higher cooling setpoint of the central ducted system. Further detail on savings from higher cooling setpoint is provided below in Recommendation #4.

If a low cooling temperature is what it takes for comfort in the west building office spaces, that is an indication of remaining thermal envelope and/or cooling air distribution inefficiencies that should be addressed. A professional assessment should be made to determine if: the cooling system is delivering expected cooling capacity, there is inadequate airflow to each space, there is duct leakage, or if there is any duct restriction limiting space cooling.

The following recommendations are made, with the first four being the highest priority with the best known financial returns. The remaining recommendations should be considered in efforts to enable cooling setpoints above 70ºF and maintain acceptable comfort in the future. Lastly, mechanical ventilation is discussed since ducted outdoor mechanical ventilation was not evident during the site visit and recent renovations likely decreased natural ventilation. Estimated EEM costs, savings and returns are summarized in Tables 11 and 12.

Summary of Recommended EEM

1. Upgrade all remaining fluorescent lights with LED lamps and fixtures. Offices with exterior windows should have LED lamps or LED fixtures compatible with dimming control.
2. Install lighting control in offices that dim with adequate daylight and turn off when there is no occupancy.
3. Replace existing heat pump systems at end of life with new heat pumps having SEER rating of at least 17 and HSPF of at least 9. Size cooling capacity appropriately for ASHRAE Ventilation Standard 62.1 mechanical ventilation and refer to recommendation #8.
4. Raise occupied cooling set point to no lower than 73ºF. The nighttime cooling temperature setback should be raised to 80ºF. To begin the higher occupied setpoint, try a gradual increase of 1 degree per week from 69ºF to 73ºF over 4 weeks. There is approximately 8% cooling energy decrease for every degree of cooling set point increase. Cooling energy could potentially decrease by 32% from an increase of 4 degrees in setpoint. This is a conservation measure with no implementation cost, however thermal inefficiency of the building may result in local discomfort that could impact productivity thereby rendering this recommendation unacceptable.
5. The supply trunk duct appears constricted on the east Daikin system in the mechanical room (Figure 10). This should be evaluated to ensure that adequate air flow and cooling capacity is distributed.
6. Every air conditioning system should be tested during hot outdoor conditions to verify that it is delivering the designed cooling capacity across the cooling coil. This will require measurement of entering air and supply air conditions as well as the total system airflow. Supply grille airflow should also be measured to verify adequate flowrates. An investigation of duct leakage or other air distribution issues like constricted or undersized flex ducts should be completed if zonal comfort issues remain. Every duct connection should be sealed by duct mastic, not tape.

7. Any leakage in the exterior louvered doors of the east mechanical room should be sealed to improve building airtightness since there is a large continuous open pathway from inside the top of the east mechanical room into the area above the east building ceiling.
8. A mechanical engineer should evaluate if there is adequate mechanical ventilation for the east and west buildings if this has not been done since the new windows and exterior wall renovations.
9. New HVAC equipment sizing should account for future mechanical ventilation loads.
10. Given the daily variable occupancy, demand-based control ventilation should be considered.
11. Replace the original old main electric service panel in the east building with new box and breakers. Confirm breakers are still appropriate amperage for current end uses.

Figure 10. The main supply duct trunk serving the east building is severely constricted.

Table 11. Cowperthwaite EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace T832W Fluorescnt. With LED Lamps; install 8 office occ./daylight controls	2.17	6,098	0	$736	-$4,633	6.3
EEM2	Replace both Goodman 5 ton and Daikin 10 ton heat pumps with new SEER 17 & HSPF 9 heat pumps	5.54	17,138	0	$1,954	-$14,000	7.2
Total Impact of All EEM		7.71 22.4%*	23,236 17.6%*	0	$2,690	-$18,633	6.9
Conservation measure below does not have any cost to implement							
ECM1	Raise thermostat cool setpoint from 69ºF to 73ºF	0	15,669	0	$3,671	$0	0.1

* % of annual average peak of 34.4 kW (2020) and annual total energy of 132,276 kWh (2022 blend disag.).

Table 12. Cowperthwaite EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential TECO Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$14,713	$2,802	$359	-$4,275	16%	$5,503	5.8	20
EEM2	$23,450	$0	$0	-$14,000	9%	$4,173	7.2	12
Total Impact of All EEM	$38,163	$2,802	$359	-$18,275	11%	$9,676	6.8	12-20

5.4.2 On-site Solar Renewable Energy Generation Potential

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 74 kW PV installation are provided in Tables 13, 14, and 15. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 and EEM2 being fully implemented. The efficiency measures are the most economical and should be the first priority. This helps reduced the amount of PV needed to be purchased.

The southeast orientations on rooftop are recommended for the installation. The northwest orientations on the roof were not recommended due to more limited output and the very low cost of utility energy rate. Instead, two separate ground mount locations are also recommended in an effort to increase total power production to offset about 80% of the annual energy used on the site. A 36 kW PV array canopy is suggested to be placed over the north side parking area. This will also provide shaded parking for employees. The second ground mount is proposed just to the southeast of the buildings using a 10 kW array of panels. The illustration in Figure 11 shows the approximate location of the proposed roof and ground mount PV panel arrays. Given the business mission, no trees are suggested to be removed and the PV output accounts for an estimate of modest seasonal shading of existing trees on the south side after several years of growth. The standing seam metal roof is good for PV panel mounts as this is a common type of roof system that handles mechanical and structural loads of PV well. The mounting racks can utilize the standing seam of the roof without the need for roof penetrations.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility peak and energy charges were used based on the most recent utility billing data from the service provider, TECO. The peak power charge of $16.53 / kW and energy charge of $0.04992 / kWh were used in analysis. Standard service charges and

fees not associated with energy use were not included in energy costs analysis. This resulted in a very low energy cost for this site that diminishes rates of return and prolongs payback. Predicting solar PV impact on reducing the peak use charge is very uncertain, therefore a very conservative (minimal) benefit was assumed.

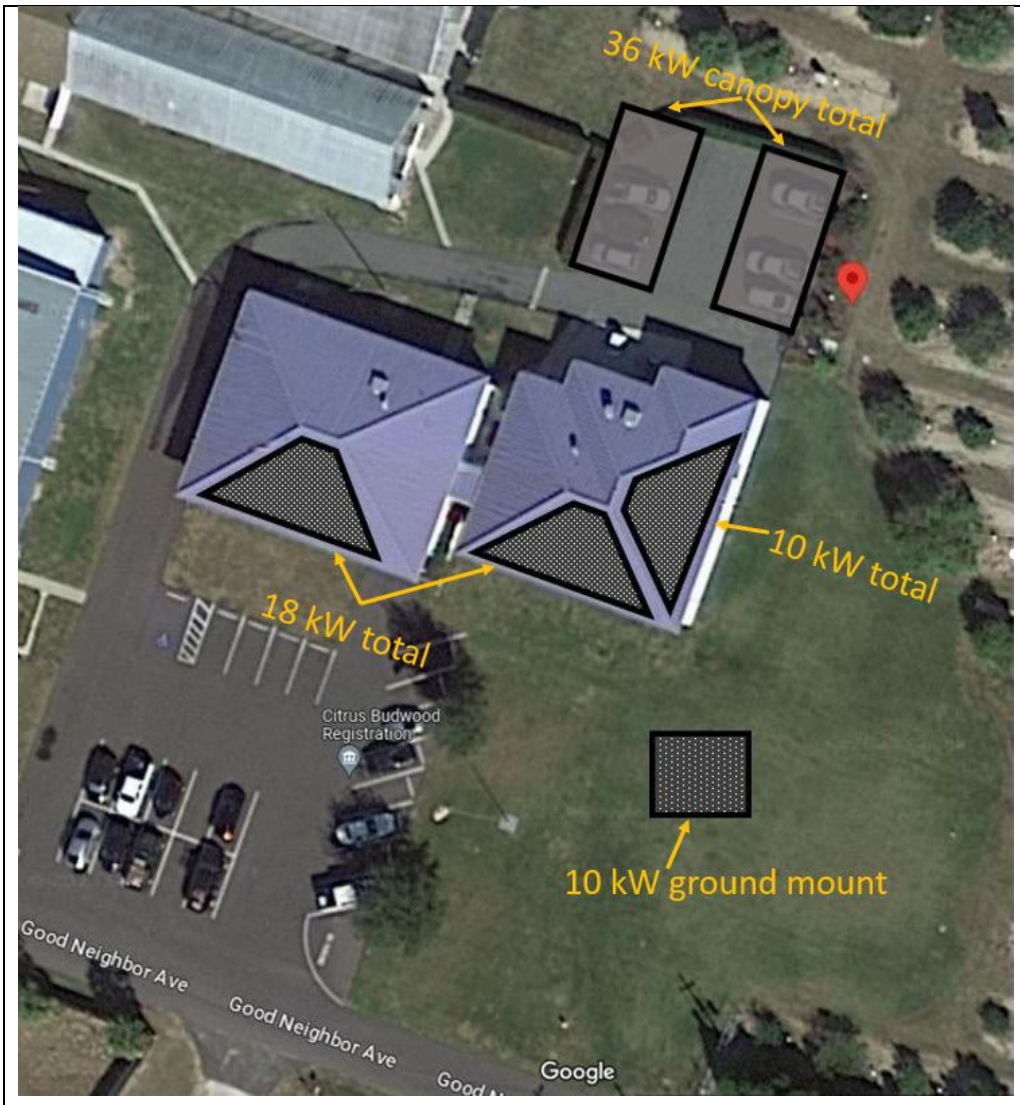

Figure 11. Arial view of potential PV panel arrays. Approximate locations are indicated and are not shown to scale.

Table 13. Cowperthwaite EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1 & EEM2	Total EEM1 & EEM2 Package	7.71 22.4%*	23,236 17.6%*	0	$2,690	-$18,633	6.9
Solar PV	Rooftop & Ground Mount Total 74 kW	1.85 5.4%**	105,556 79.8%*	0	$5,636	-$148,000	26.3
EEM Pkg & PV	Total EEM Package & 74 kW Solar	9.56 27.8%**	128,792 97.4%*	0	$8,326	-$166,633	20.0

* % of annual average peak of 34.4 kW and annual total energy of 132,276 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 74 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 14. Cowperthwaite EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$38,163	$2,802	$359	-$18,275	11%	$9,676	6.8	12-20
Solar PV	$169,090	$0	$0	-$148,000	1%	-$48,593	26.3	30
EEM&PV	$207,252	$20,802	$359	-$166,275	1.6%	-$38,917	20.0	12-30

Table 15. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	132,276	52.2
EEM Pkg	109,040	43.0
EEM Pkg & Solar PV	3,484	1.4

PVWatts® Output Summary Reports

Note that the information and disclaimer below applies to all PVWatts® Results posted herein this report.

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 //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.

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

RESULTS

25,064 kWh/Year*

System output may range from 23,996 to 26,147 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.55	1,560
February	4.15	1,621
March	5.22	2,225
April	6.78	2,689
May	6.69	2,726
June	6.19	2,413
July	5.73	2,310
August	5.70	2,306
September	5.46	2,175
October	4.61	1,958
November	3.93	1,634
December	3.34	1,446
Annual	5.11	25,063

Location and Station Identification

Requested Location	3027 Lake Alfred Road Winter Haven, FL 33881
Weather Data Source	Lat, Lng: 28.05, -81.74 0.5 mi
Latitude	28.05° N
Longitude	81.74° W

PV System Specifications

DC System Size	18 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	14°
Array Azimuth	225°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 15%, Feb 13%, Mar 11%, Apr 0%, May 0%, June 0%; July 0%, Aug 0%, Sept 0%, Oct 11%, Nov 13%, Dec 15%

Performance Metrics

DC Capacity Factor	15.9%

Roof mount 18 kW array on SW roofs

RESULTS

14,282 kWh/Year*

System output may range from 13,674 to 14,899 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.54	866
February	4.18	906
March	5.26	1,248
April	6.84	1,509
May	6.78	1,541
June	6.45	1,402
July	6.05	1,362
August	6.07	1,372
September	5.53	1,227
October	4.66	1,107
November	4.01	928
December	3.39	814
Annual	5.23	14,282

Location and Station Identification

Requested Location	3027 Lake Alfred Road Winter Haven, FL 33881
Weather Data Source	Lat, Lng: 28.05, -81.74 0.5 mi
Latitude	28.05° N
Longitude	81.74° W

PV System Specifications

DC System Size	10 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	14°
Array Azimuth	135°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 15%, Feb 13%, Mar 11%, Apr 0%, May 0%, June 0%; July 0%, Aug 0%, Sept 0%, Oct 11%, Nov 13%, Dec 15%

Performance Metrics

DC Capacity Factor	16.3%

Roof mount 10 kW array on SE roof

RESULTS

51,366 kWh/Year*

System output may range from 49,176 to 53,656 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.58	3,131
February	4.29	3,337
March	5.55	4,739
April	6.68	5,360
May	6.83	5,617
June	6.49	5,111
July	6.01	4,895
August	5.85	4,785
September	5.28	4,242
October	4.73	4,028
November	3.94	3,262
December	3.34	2,858
Annual	5.21	51,365

Location and Station Identification

Requested Location	3027 Lake Alfred Road Winter Haven, FL 33881
Weather Data Source	Lat, Lng: 28.05, -81.74 0.5 mi
Latitude	28.05° N
Longitude	81.74° W

PV System Specifications

DC System Size	35.9 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	0°
Array Azimuth	270°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	16.3%

Ground mount 36 kW parking canopy array

RESULTS

14,846 kWh/Year*

System output may range from 14,214 to 16,487 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	4.49	1,109
February	4.87	1,067
March	5.56	1,330
April	6.63	1,482
May	6.18	1,417
June	5.67	1,248
July	5.33	1,214
August	5.60	1,280
September	5.56	1,248
October	5.21	1,246
November	4.88	1,142
December	4.36	1,063
Annual	5.36	14,846

Location and Station Identification

Requested Location	3027 lake alfred road winter haven, FL
Weather Data Source	Lat, Lng: 28.05, -81.74 0.5 mi
Latitude	28.05° N
Longitude	81.74° W

PV System Specifications

DC System Size	10 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	28°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June
	10%	10%	10%	0%	0%	0%
	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	10%	10%	10%

Performance Metrics

DC Capacity Factor	15.9%

Ground mount 10 kW array on south side of east building

6. Hunt Office Complex

The Hunt Office Complex consists of three primary buildings, The JW Hunt Office, the Polk County Extension/Agriculture Building and Arena, and the W.H. Stuart Conference Center. There is a small campground area on the northeast side of the complex that has its own power meter account, but it had only been used one brief period during the last two years of billing data and so it will not be considered further in this report.

Each of the three buildings, presented in Figure 12, and their associated grounds will be considered separately within this section of the report since they each have their own electric metered accounts and different uses. There was no gas used on site except for an emergency back-up generator installed at the W.H. Stuart Conference Center. The

generator is only used if utility power is lost during local emergencies such as hurricanes as it is utilized as shelter for first-responders and local leaders.

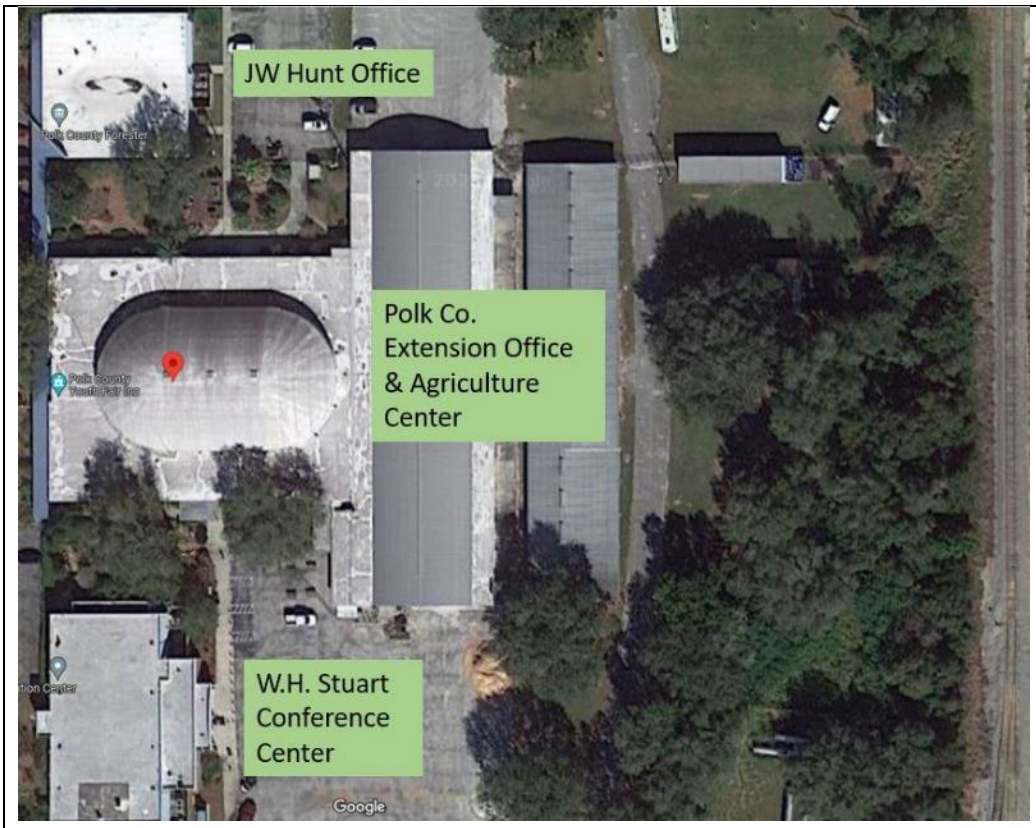

Figure 12. Hunt Office Complex.

6.1 JW Hunt Office

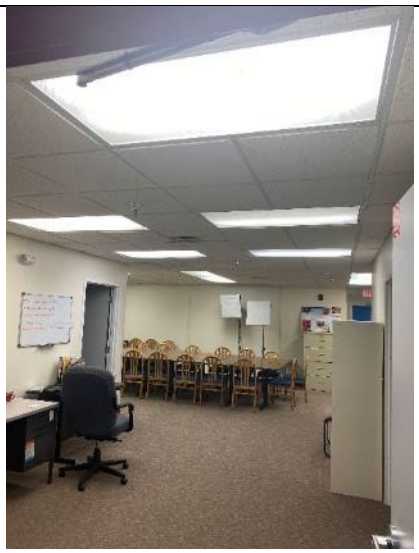

Figure 13. Hunt Office Complex, JW Hunt Office

6.2 JW Hunt Site Description and Findings

This site was visited March 29, 2023. The JW Hunt building, pictured in Figure 13, is a 7,873 ft^2 office space that houses two different departments. Daily operations occur from 8am-5pm 5 days each week. The occupancy was reported to have 12-13 persons overall that varies through the day as inspectors leave offices to go out to perform site visits.

The building was maintained reasonably well and was comfortable, clean, dry, and adequately illuminated. The indoor lighting consisted of linear fluorescent T8 32 watt lamp-based fixtures. Lighting controls were manual switches. Outdoor lighting was controlled by electronic time clock at the lighting panel.

The HVAC systems consisted of two old split-dx air conditioning units manufactured in 2005, and a third newer heat pump manufactured in 2017. AC unit 1 had a rated capacity of 10 tons and AC unit 2 had a capacity of about 6 tons. Each of these systems shows signs of severe degradation and major service needs. They both were R22 based refrigerant systems, although AC2 seems to have had one of its two condensing units replaced with an 410A refrigerant system. It was not determined if the second original R22 condensing unit was still a working part of this system. Images of the systems are provided in Figure 14.

AC1 and AC2 AHU located in outdoor mechanical room.

Mismatch of CU2A (R410-A) and CU2B (taller old R22) serving AC 2

AC1 and AC2 cooling setpoints were at 70F.

AC 2 supply air of 62F is only a 10 deg reduction from the indoor return air of 72F. Should be closer to 54F.

Figure 14. HVAC and Controls.

6.3 Site Energy Billing Data Analysis and EUI

The adjusted 2022 total annual energy use was 69,760 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 30.2 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 16. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption.

Table 16. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	$/kWh	$/peak kW
7,873	69,760	(30 / 21)	30.2	$0.0291	$9.30

Table 17 shows published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for offices. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The JW Hunt Building EUI of 30.2. is less than the existing building CBECS database of 52.9, which indicates that it is more efficient than existing buildings similar in use. It has an EUI about 8% better than buildings built to ASHRAE 90.1-2016 standard. With further energy efficiency improvement, the EUI could be further reduced in efforts to approach the NZE EUI preferred target of 23. This can be difficult to reach for many existing buildings, but provides a stronger efficiency goal to be aimed for.

Table 17. EUI (kBtu/ft2/yr) of Existing Office and of NZE Target Goals

Existing Buildings of Various Age		NZE Target Goal
Office CBECS Data	Office ASHRAE 90.1 2016	Office NZE (FL)
52.9	33	23

A linear regression analysis was conducted with data from the monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. Adjustments were also made for variable days in billing cycles The detailed description of this methodology can be found in Appendix B..

Billing regression analysis predicts an annual baseload energy use of 28,306 kWh (41% of total annual), cooling 39,888 kWh/y (57% of total annual), and heating 1,565 kWh/y (2%). The breakdown in these results are presented graphically in Figure 15, with baseload shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. The highest peak loads are during winter, which are believed to be from inefficient electric strip heat in AC1 and AC2. The very low demand below 15 kW for August, September and November are unusual and the cause is unknown. The baseload is mostly lighting as well as plug loads. The cooling energy is the single largest use (57% of total annual) and is especially noticeable during the summer months. Indicated heating energy use is modest (about 2% of total annual) as is normal for central Florida offices.

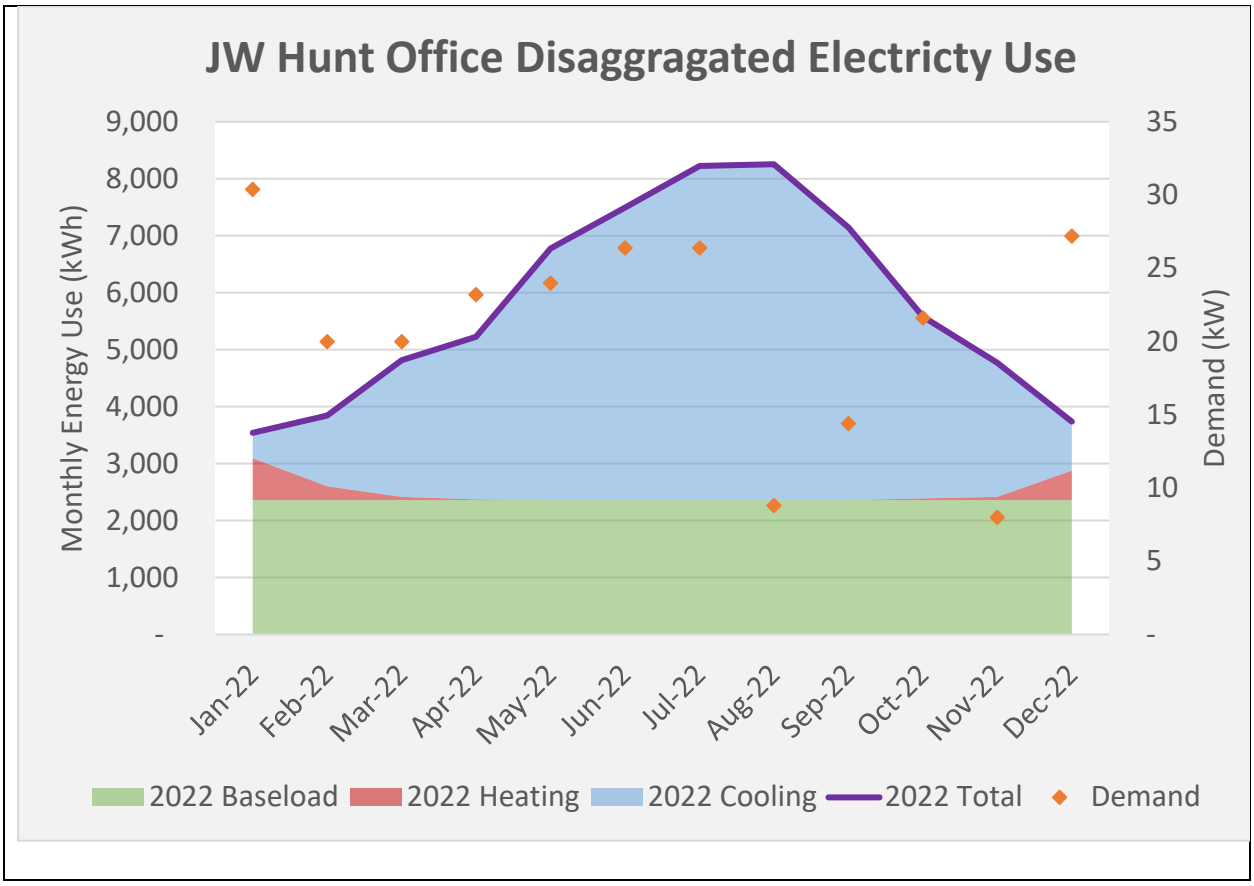

Figure 15. JW Hunt Office Building 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, The City of Bartow. The peak power charge of $9.30 / kW and energy charge of only $0.0291 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. The very low energy costs for this site diminish rates of return and prolonged simple payback. No assumptions or adjustments were made to predict future cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

6.4 JW Hunt Office Recommendations

6.4.1 Recommended Energy Efficiency Measures

There are good opportunities for cost-effective energy efficiency measures (EEM) to indoor electric lighting and HVAC. Electric lighting is mostly 2’x4’ troffer fixtures with T832W lamps and electronic ballasts. These should be replaced with LED equivalents.

The interior cooling setpoints of 70 ºF are very low. Cooling setpoints maintained continuously below 74ºF have a higher risk of condensation on cold air exterior ductwork or any building surface able to cool to the very low setpoint during warm moist summer conditions.

If a low cooling temperature is what it takes for comfort, that is an indication of remaining thermal envelope and/or cooling air distribution inefficiencies that should be addressed. A professional assessment should be made to determine if: the cooling system is delivering expected cooling capacity, there is inadequate airflow to each space, there is duct leakage, or if there is any duct restriction limiting space cooling. It was clear that AC system 2 was not cooling effectively based on supply air temperature of 62ºF when entering air was about 72ºF and setpoint at 70ºF.

The following recommendations are made, with the first four being the highest priority with the best known financial returns. The remaining recommendations should be considered in efforts to enable cooling setpoints above 70ºF and maintain acceptable comfort in the future. Lastly, mechanical ventilation is discussed since ducted outdoor mechanical ventilation was not evident during the site visit and recent renovations likely decreased natural ventilation. Estimated EEM costs, savings and returns are summarized in Tables 18 and 19.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures.
2. AC1 and AC2 (serving east and west zones) should be replaced as soon as possible with new heat pumps having SEER rating equivalent of about 16 and HSPF of about 9.
3. Raise occupied cooling set point to no lower than 73ºF. The nighttime cooling temperature setback should be raised to 80ºF. To begin the higher occupied setpoint, try a gradual increase of 1 degree per week from 69ºF to 73ºF over 4 weeks. There is approximately 8% cooling energy decrease for every degree of cooling set point increase. Cooling energy could potentially decrease by 32% from an increase of 4 degrees in setpoint. This is a conservation measure with no implementation cost, however thermal inefficiency of the building may result in local discomfort that could impact productivity thereby rendering this recommendation unacceptable.
4. Supply grille airflow should also be measured to verify adequate flowrates. An investigation of duct leakage or other air distribution issues like constricted or undersized flex ducts should be completed if zonal comfort issues remain. Every duct connection should be sealed by duct mastic, not tape.

The estimated cost for replacing existing HVAC to systems with efficiencies to an equivalent SEER 16 and HSPF 9 is estimated to be about $12,800 more than the least efficient new air conditioning available. To be clear, this is not the total cost of replacement, but the premium to buy more efficient equipment. Given the old age of equipment, there is likely to be about $2,000 saved in the first year of replacement due to avoided cost of service repairs.

Table 18. W Hunt Office EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM Description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace T832W Fluorescnt. With LED Lamps	4.2	12,057	0	$825	-$6,325	7.7
EEM2	Replace AC1 and AC2 with new SEER 16 & HSPF 9 heat pumps	5.3	16,037	0	$1,062	-$12,800 -$10,800*	12.1 10.2*
Total Impact of All EEM		9.53 45.4%**	28,094 40.3%**	0	$1,887	-$19,125	10.1
Conservation measure below does not have any cost to implement							
ECM1	Raise thermostat cool setpoint from 70ºF to 73ºF	0	9,573	0	$278	$0	0.1

* Measure cost is incremental cost above new min. efficiency minus 1 year avoided $2,000 service repairs of 2 old AC systems.
** % of annual average peak of 21 kW and annual total energy of 69,760 kWh.

Table 19. JW Hunt Office EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$16,500	$7,195	$0	-$6,325	12%	$4,699	7.7	20
EEM2	$12,742	$2,000	$0	-$12,800	6%	$902	10.2	12
Total Impact of All EEM	$29,242	$9,195	$0	-$19,125	9%	$5,601	10.1	12-20

6.4.2 On-site Solar Renewable Energy Generation Potential

Due to the low cost of utility energy, on-site solar PV is not recommended for the Bartow Hunt Office Complex due to poor financial return. The JW Hunt Office site however, is viable for solar PV towards more sustainable operations. The outcome of the solar generation and cost estimates follow.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 28 kW PV installation are provided in Tables 20, 21, and 22, and Figure 16 is an illustration of the approximate location for the proposed installation. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 and EEM2 being fully implemented. The efficiency measures are the most economical and should be the first priority. This helps reduced the amount of PV needed to be purchased.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility peak and energy charges were used based on the most recent utility billing data from the service provider, City of Bartow. The peak power charge of $9.30 / kW and energy charge of $0.0291 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. This resulted in a very low energy cost for this site that diminishes rates of return and prolongs payback. Predicting solar PV impact on reducing the peak use charge is very uncertain, therefore a very conservative (minimal) benefit was assumed.

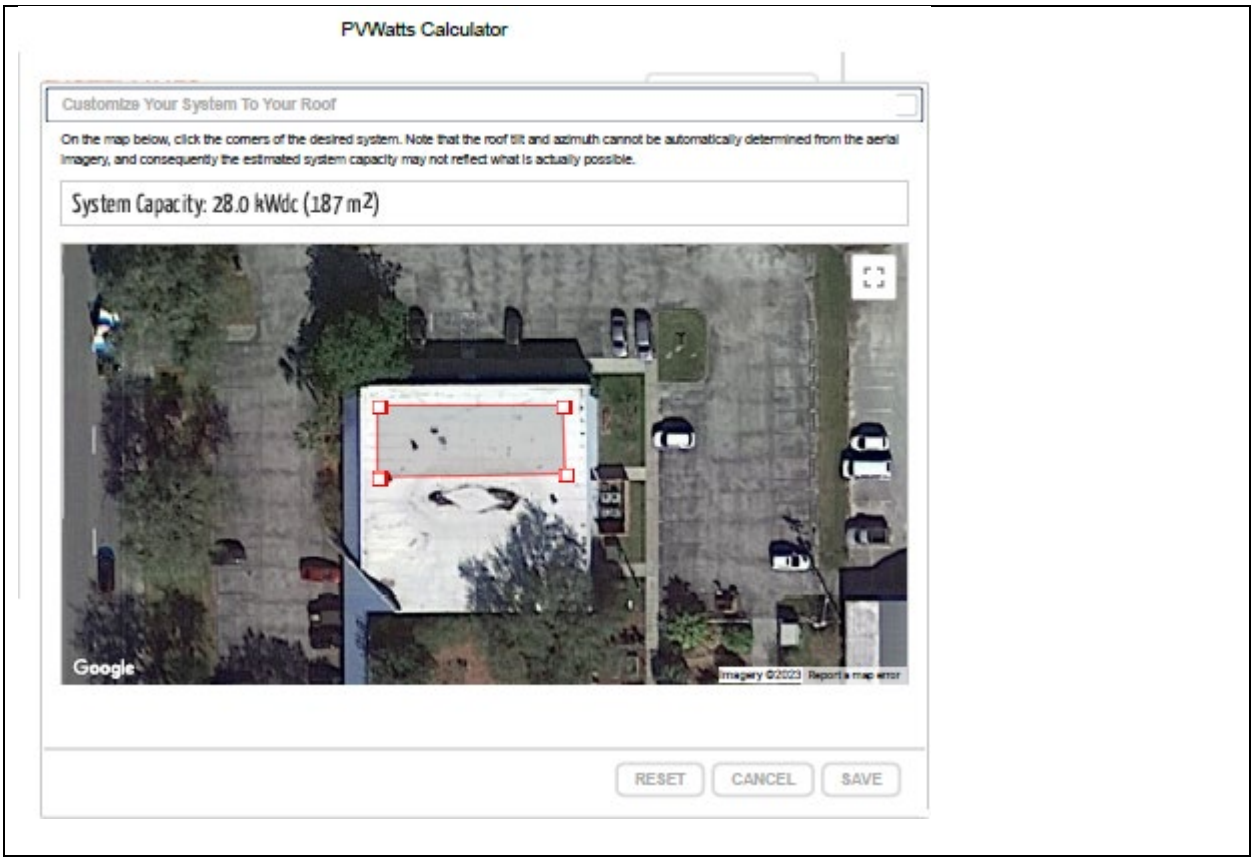

Figure 16. Arial view of potential PV panel arrays. Approximate locations are indicated and are not shown to scale.

Table 20. JW Hunt Office EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1 & EEM2	Total EEM1 & EEM2 Package	9.53 45.4%*	28,094 40.3%*	0	$1,887	-$19,125	10.1
Solar PV	Rooftop & Ground Mount Total 28 kW	0.7 3.3%*	40,639 58.3%*	0	$1,261	-$56,000	44.4
EEM Pkg & PV	Total EEM Package & 28 kW Solar	10.23 48.7%**	68,733 98.5%*	0	$3,142	-$75,125	23.9

* % of annual average peak of 21 kW and annual total energy of 69,760 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 28 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 21. JW Hunt Office EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$29,242	$9,195	$0	-$19,125	9%	$5,601	10.1	12-20
Solar PV	$37,821	$0	$0	-$56,000	-2.4%	-$32,884	44.4	30
EEM&PV	$67,064	$9,195	$0	-$75,125	-0.5%	-$27,284	23.9	12-30

Table 22. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	69,760	30.2
EEM Pkg	41,666	18.1
EEM Pkg & Solar PV	1,027	0.4

PVWatts® Output Summary Report on following page.

NREL

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.

Disclaimer: The PVWatts® Model ("Model") is provided by the National Renewable Energy Laboratory ("NREL"), which is operated by the Alliance for Sustainable Energy, LLC ("Alliance") for the U.S. Department Of Energy ("DOE") and may be used for any purpose whatsoever.

The names DOE/NREL/ALLIANCE shall not be used in any representation, advertising, publicity or other manner whatsoever to endorse or promote any entity that adopts or uses the Model. DOE/NREL/ALLIANCE shall not provide any support, consulting, training or assistance of any kind with regard to the use of the Model or any updates, revisions or new versions of the Model.

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The energy output range is based on analysis of 30 years of historical weather data, 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

40,639 kWh/Year*

System output may range from 38,906 to 42,394 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.92	2,640
February	4.82	2,899
March	5.86	3,868
April	6.57	4,105
May	6.89	4,398
June	6.27	3,786
July	6.04	3,793
August	5.60	3,500
September	5.24	3,228
October	4.93	3,243
November	4.24	2,727
December	3.65	2,452
Annual	5.34	40,639

Location and Station Identification

Requested Location	1702 Highway 17 South Bartow, FL 33830
Weather Data Source	Lat, Lng: 27.89, -81.82 1.0 mi
Latitude	27.89° N
Longitude	81.82° W

PV System Specifications

DC System Size	28.0 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	4°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	16.6%

Roof mount 28 kW array on roof

6.5 Polk County Extension Office and Agriculture Center

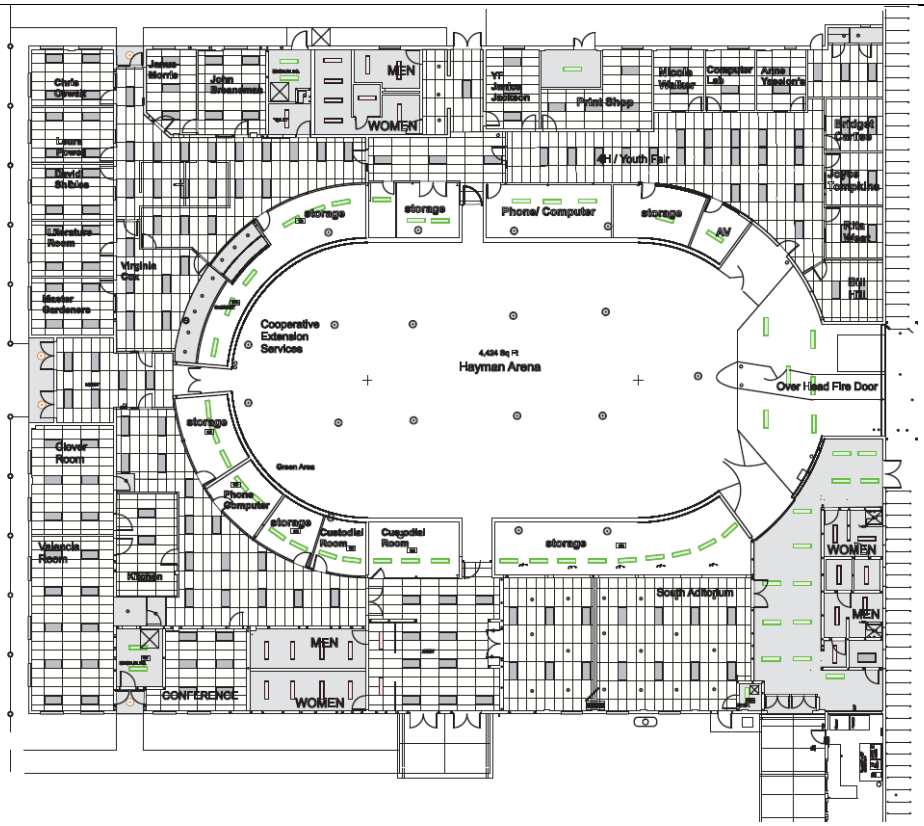


Figure 17. Top: Polk County Extension Office and Agriculture Center. Bottom: Reflected ceiling view of the Polk Co. Ag. Center that consists of an unconditioned livestock arena surrounded by air conditioned offices on the north side, as well as meeting and conference spaces on the south side.

6.6 Polk Co. Ag. Center Site Description and Findings

This site was visited March 29, 2023. The Polk Co. Ag. Center site is used to support UF/IFAS Extension operations for Polk County as well as different agricultural events. The 27,663 ft^2 building, pictured in Figure 17, is unusual having an unconditioned 11,663 ft^2 livestock arena in the middle surrounded by 16,000 ft^2 of conditioned offices and community meeting spaces. Figure 17 also includes the reflected ceiling view of the center, including the unconditioned Hayman Livestock Arena, which uses electric power only for lighting and ventilation fans at the upper level. This space is only used for occasional special events and lights and fans are only operated during events. There is an enclosed barn and a large open air shed on the east side of the arena used for arena functions. These exterior structures only use power for electric lighting during arena events.

The surrounding conditioned space houses Polk County Extension Office operations, as well as youth agriculture events, and other community meeting space needs. The Extension office daily operations occur from 8 am-5 pm 5 days each week, however, the communal meeting spaces around the south side are utilized on a variable schedule as needed. The north side Extension office occupancy was reported to have about 17 employees of which 11-13 persons occupy office space regularly.

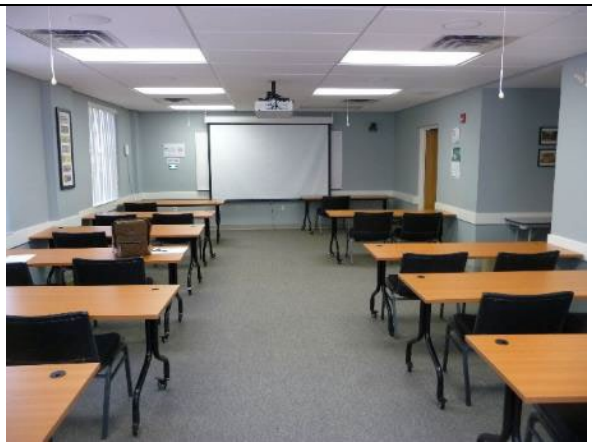
The HVAC maintenance appeared to be more reactive than proactive on very old air conditioning systems. Most conditioned areas were comfortable, except spaces cooled by AC system 3 (AC3). The conditions in one of the meeting rooms cooled by AC3 were measured with a handheld hygrometer. The indoor temperature was about 79°F and humidity 60% resulting in a dewpoint temperature near 64°F. This is warm moist air, particularly for the modest cooling demands during March at a time when this space was unoccupied. AC3 had a measured supply air temperature of 78°F indicating that essentially no cooling was occurring with the setpoint at 76°F and return air at about 78°F. AC3 is a 10 ton Trane air conditioner with heat provided by 25 kW of strip heat. The unit was manufactured in 2000. This system should be replaced as a first priority given its age, need for repair, and terrible efficiency. When the system is replaced, the return air duct distribution should also be assessed to confirm there is adequate return air back to the system. There only appeared to be three main 20”x20” return grilles for this system. One of these returns was located in the Valencia Room having six supply drops. The filter appeared in need of replacement and was found out of correct placement. This may have occurred in part due to increased suction on the filter, and also due to high static pressure from undersized return ducting.

There were two other old Trane air conditioners with 25 kW strip heat (AC1 and AC2) that were also about 23 years old. AC1 serves the northwest extension service office areas that were cool and dry found with a cooling setpoint of 71°F and heating setpoint of 68°F. There was also a humidistat next to the AC1 thermostat set to the lowest humidity setting “on”. It could not be determined the exact level of control this had over the cooling system. This space was cool and dry with measured temperature between 73.8°F in open office area up to 79.8°F at the front extension reception entry area. Humidity was 50% or lower. AC2 serves the northeast Youth 4H service office areas

that were also cool and dry found with a cooling setpoint of 73°F and heating setpoint of 70°F. This space was cool and dry with measured conditions of 73°F and 47% RH. AC4 is only four years old and serves the Auditorium space on the southeast side of the building. This space conditions were measured at 72°F and 45% RH.

The indoor lighting consisted mostly of linear fluorescent T8 32 watt lamp-based fixtures. Interior lighting controls were manual switches. Some outdoor lighting was controlled by electronic time clock at the lighting panel or photocell, however exterior lights on the east side of the enclosed barn and open barns are on manual switch control. The eight exterior flood lights on the east side enclosed barn were found on during the daytime during the site visit. During the site visit, the manager stated that this building was about to have a full lighting retrofit to LED including updated controls as well as some other substantial structural improvements. The lighting retrofit is highly recommended and will result in substantial energy savings.
Images of the interior lighting and HVAC are provided in Figure 18.

Well-illuminated southwest hall outside of areas cooled by AC3. Curved wall encloses storage space that wraps around the unconditioned arena space.



Valencia Room is one of spaces served by AC3 that had one return grille for .

Dirty filter sucked out of place in return grille of Valencia Room. May also be an indication of inadequate return air.

Air handling unit of AC3 serves the southwest area and was running, but not cooling.

Figure 18. Example interior lighting and HVAC images.

6.7 Site Energy Billing Data Analysis and EUI

The adjusted 2022 total annual energy use was 172,800 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. Only the regularly used conditioned space of 16,000 ft^2 was considered in the EUI of 36.9 $kBtu/ft^2/yr$. The summary of site energy use, EUI, and utility cost is shown in Table 23. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption.

Table 23. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI $kBtu/ft^2/yr$	$/kWh	$/peak kW
16,000	172,800	(80 / 63)	36.9	$0.0291	$9.30

Table 24 shows published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for offices. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The most comparable building type for this site in published data would be office buildings, although nearly half of the Ag Center conditioned space is high variability use community meeting space. The Polk Co. Ag. Center Building EUI of 36.9. is less than the existing building CBECS database of 52.9, which indicates that it is more efficient than the mean EUI of existing office buildings in the U.S. It has an EUI about 12% worse than buildings built to ASHRAE 90.1-2016 standard. With further energy efficiency improvement, the EUI could be further reduced in efforts to approach the NZE EUI preferred target of 23. This can be difficult to reach for many existing older buildings, but provides a stronger efficiency goal to be aimed for.

Table 24. EUI (kBtu/ft2/yr) of Existing Office and of NZE Target Goals

Existing Buildings of Various Age		NZE Target Goal
Office CBECS Data	Office ASHRAE 90.1 2016	Office NZE (FL)
52.9	33	23

A linear regression analysis was conducted with data from the monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly

and annually. Adjustments were also made for variable days in billing cycles The detailed description of this methodology can be found in Appendix B.

Billing regression analysis predicts an annual baseload energy use of 28,692 kWh (17% of total annual), cooling 123,314 kWh/y (71% of total annual), and heating 20,489 kWh/y (12%). The breakdown in these results are presented graphically in Figure 19, with baseload shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. The highest peak loads are during winter, which are believed to be from inefficient electric strip heat used for heating in this building. The combined strip capacity of systems AC1, AC2, and AC3 are 75 kW. It is surprise that the maximum peak for the whole year occurs in the winter and was 80 kW. The cooling energy is the single largest use and is especially noticeable during the summer months. Indicated heating energy use is very high for central Florida offices.

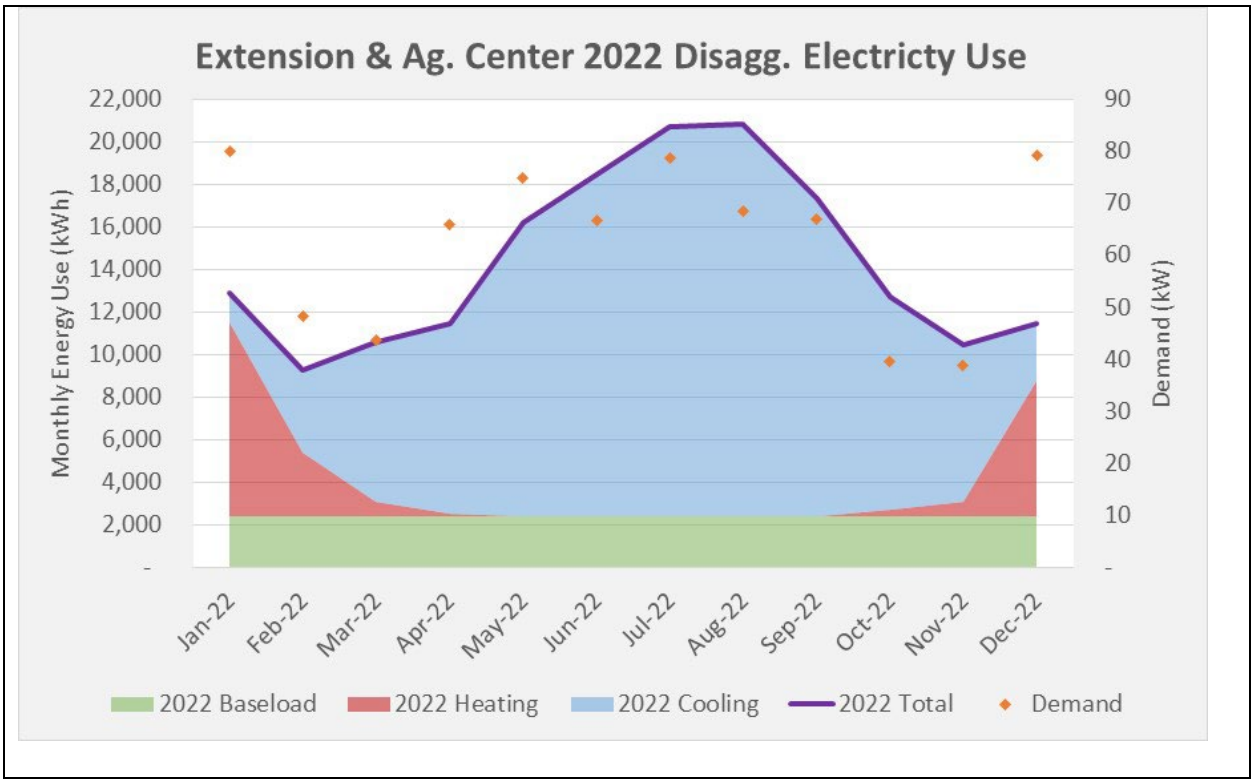


Figure 19.Polk Co. Ag. Center Office Building 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, The City of Bartow. The peak power charge of $9.30 / kW and energy charge of only $0.0291 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. The very low energy costs for this site diminish rates of return and prolonged simple payback. No assumptions or adjustments were made to predict future

cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

6.8 Ext. Office & Ag. Center Recommendations

6.8.1 Recommended Energy Efficiency Measures

There are excellent opportunities for cost-effective energy efficiency measures (EEM) related to indoor electric lighting and HVAC. Electric lighting is mostly 2'x4' troffer fixtures with T832W lamps and electronic ballasts. These should be replaced with LED equivalents, and were already planned to do so before this site energy assessment.

The occupied hours cooling setpoints below 73ºF are low. Cooling setpoints maintained continuously below 74ºF have a higher risk of condensation on cold air exterior ductwork or any building surface able to cool to the very low setpoint during warm moist summer conditions.

If a low cooling temperature is what it takes for comfort, that is an indication of remaining thermal envelope and/or cooling air distribution inefficiencies that should be addressed. A professional assessment should be made to determine if: the cooling system is delivering expected cooling capacity, there is inadequate airflow to each space, there is duct leakage, or if there is any duct restriction limiting space cooling. It was clear that AC system 3 was not cooling effectively based on supply air temperature of 78ºF when entering air was about 78ºF and setpoint at 76ºF.

Recommendations are made below. Estimated EEM costs, savings and returns are summarized in Tables 25-27.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures.
2. AC1, AC2, and AC3 should be replaced as soon as possible with new heat pumps having SEER rating equivalent of about 16 and HSPF of about 9.
3. Raise occupied cooling set point to no lower than 73ºF. The nighttime cooling temperature setback should be raised to 80ºF. To begin the higher occupied setpoint, try a gradual increase of 1 degree per week from 69ºF to 73ºF over 4 weeks. There is approximately 8% cooling energy decrease for every degree of cooling set point increase. Cooling energy could potentially decrease by 24% from an increase of 3 degrees in setpoint. This is a conservation measure with no implementation cost, however thermal inefficiency of the building may result in local discomfort that could impact productivity thereby rendering this recommendation unacceptable.
4. Supply grille airflow should also be measured to verify adequate flowrates. The return air distribution should also be assessed to verify they are adequately sized. An investigation of duct leakage or other air distribution issues like constricted or undersized flex ducts should be completed if zonal comfort issues remain. Every duct connection should be sealed by duct mastic, not tape.

The lighting retrofit shown as EEM1 used the actual awarded bid cost of $111,330. This cost is about three times higher than expected based on researched retail cost of lighting and estimated labor, however the site is older and may require unknown electric work. This contractor bid was the only one that met all requirements. The high cost of the lighting installation and very low cost of electricity make this appear as a low priority EEM, however it remains a good investment given the age of existing equipment.

The second recommended EEM is to replace three air conditioners that are over 20 years old. It is recommended to replace them with heat pumps which will reduce the winter peak kW by approximately 47 kW! The annual average monthly peak reduction for more efficient cooling and heating is estimated to be about 19 kW. The estimated cost for replacing existing HVAC to systems with efficiencies to an equivalent SEER 16 and HSPF 9 is estimated to be about $25,000 more than the least efficient new air conditioning available. To be clear, this is not the total cost of replacement, but the premium to buy more efficient equipment. Given the old age of equipment, and evidence of degradation, there is likely to be about $3,000 saved in the first year of replacement due to avoided cost of service repairs. The very low efficiency of the three air conditioners overcomes the low cost of energy and make this a financially attractive measure.

Table 25. Polk Co. Ag. Center Office EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM Description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace Fluorescnt. With LED Lamps	23.8	34,772	0	$3,668	-$111,330	30.4
EEM2	Replace AC1, AC2 and AC3 with new SEER 16 & HSPF 9 heat pumps	19.2	74,110	0	$4,083	-$25,000*	6.1
Total Impact of All EEM		43.0 68.7%**	108,882 63.0%**	0	$7,751	-$136,330	17.6
Conservation measure below does not have any cost to implement							
ECM1	Raise thermostat cool setpoint from 70ºF to 73ºF	0	29,922	0	$870	$0	0.1

* Measure cost is incremental cost above new min. efficiency.
** % of annual average peak of 62.6 kW and annual total energy of 172,800 kWh.

Table 26. Polk Co. Ag. Center Office EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$65,673	$26,666	$0	-$111,330	-4%	-$59,116	30.4	20
EEM2	$48,993	$3,000	$0	-$25,000	15%	$15,581	6.1	12
Total Impact of All EEM	$114,666	$29,666	$0	-$136,330	-1%	-$43,535	17.6	12-20

Table 27. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	172,800	36.9
EEM Pkg	63,398	13.6

6.8.2 On-site Solar Renewable Energy Generation Potential

Due to the low cost of utility energy, on-site solar PV is not recommended for the Bartow Hunt Office Complex due to poor financial return. Furthermore the Extension Office building, is not suitable for solar PV applied towards more sustainable operations.

6.9 W.H. Stuart Conference Center

Figure 20. W.H. Stuart Conference Center.

6.10 W.H. Stuart Conference Center Site Description and Findings

This site was visited March 29, 2023. The W.H. Stuart Conference Center building, seen in Figure 20, is a 10,547 ft^2 open tall ceiling conference space available for community functions. There is a kitchen space with one commercial food refrigeration unit, commercial ice maker, small dishwasher, an electric oven and range, and commercial exhaust hood ventilation over the oven.

The indoor lighting consisted of linear fluorescent T8 32 watt lamp-based fixtures and can spot downlights. Lighting was controlled by manual switches. Outdoor lighting was controlled automatically by either photocell or electronic time clock at the lighting panel.

The HVAC systems consisted of two Carrier air to air split-dx air conditioning units. AC unit 1 had a rated capacity of 31 tons served by a two stage condensing unit, and AC unit 2 had a total capacity of about 12 tons served by two separate 6 ton condensing units. The AHU and condensing units appeared to be in fair condition, however there were signs of advanced degradation of the refrigerant lines outdoors. Observation of the frothy refrigerant in the site glass during operation indicated that cooling performance may not be optimum. The moisture indicator appears to also indicate some moisture in the system which will further advance ware and aging on the mechanical systems. Select pictures are provided in Figure 21.

Three condensing units serving for AC1 and AC2 are in decent condition.	Refrigerant lines show advanced degradation of insulation and some parts of copper pipe such as near the site glasses.

Frothy appearance of liquid refrigerant and severe corrosion of pipe at a site glass.

Interior lights are controlled manually with friendly reminders to turn off.

Figure 21. Condensing units, degraded refrigerant lines, and manual lighting control.

6.11 Site Energy Billing Data Analysis and EUI

The adjusted 2022 total annual energy use was 141,249 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 45.7 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 28. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption.

Table 28. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	$/kWh	$/peak kW
10,547	141,249	(68 / 58)	45.7	$0.0291	$9.30

Table 29 shows published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for offices. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The conference center EUI of 45.7. is 18.5% less than the existing building CBECS database of 56.1, which indicates that it is more efficient than the median for existing buildings similar in use.

The national median source EUI is a recommended benchmark metric for all buildings. The median value is the middle of the national population – half of buildings use more energy, half use less. The median works better than the mean (arithmetic average) for comparing relative energy performance, because it more accurately reflects the mid-point of energy use for most property types. It is unknown how much the Stuart Conference Center or the other public meeting spaces in the CBECS database are fully utilized. Greater utilization would of course increase energy use and increase the EUI.

With further energy efficiency improvement, the EUI could be further reduced in efforts to approach the NZE EUI preferred target of 27. This can be difficult to reach for many existing buildings, but provides a stronger efficiency goal to be aimed for.

Table 29. EUI (kBtu/ft2/yr) of Existing Office and of NZE Target Goals

Existing Buildings of Various Age		NZE Target Goal
Social/Meeting Hall CBECS Data	Office ASHRAE 90.1 2016	Public Assembly NZE (FL)
56.1	33	27

A linear regression analysis was conducted with data from the monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. Adjustments were also made for variable days in billing cycles The detailed description of this methodology can be found in Appendix B.

Billing regression analysis predicts an annual baseload energy use of 87,784 kWh (62% of total annual), cooling 53,465 kWh/y (38% of total annual). While some heating may occur, the regression analysis did not indicate it was a significant amount (less than 1% of total). The breakdown in these results are presented graphically in Figure 22, with baseload shaded in green, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. It should be noted that this space was used by FEMA operations in response to central Florida hurricane impacts from October 2022 through December 2022.

There is a noticeable increase in the peak loads was October through December 2022 during the FEMA operations occupancy. The highest spike in peak in December is believed to be from a cold weather period late in December 2022 and the use of inefficient electric strip heat in AC1 and AC2. Otherwise the peak load is relatively flat with a small increase during the summer. The baseload is mostly lighting as well as the refrigeration appliance plug loads in the kitchen. The cooling energy is less than the baseload which may be due in part to raised thermostat setpoints during unoccupied periods, and modest occupancy periods. The cooling setpoint during the site visit was low at 70°F, but was the building was occupied as it was being prepared for an event.

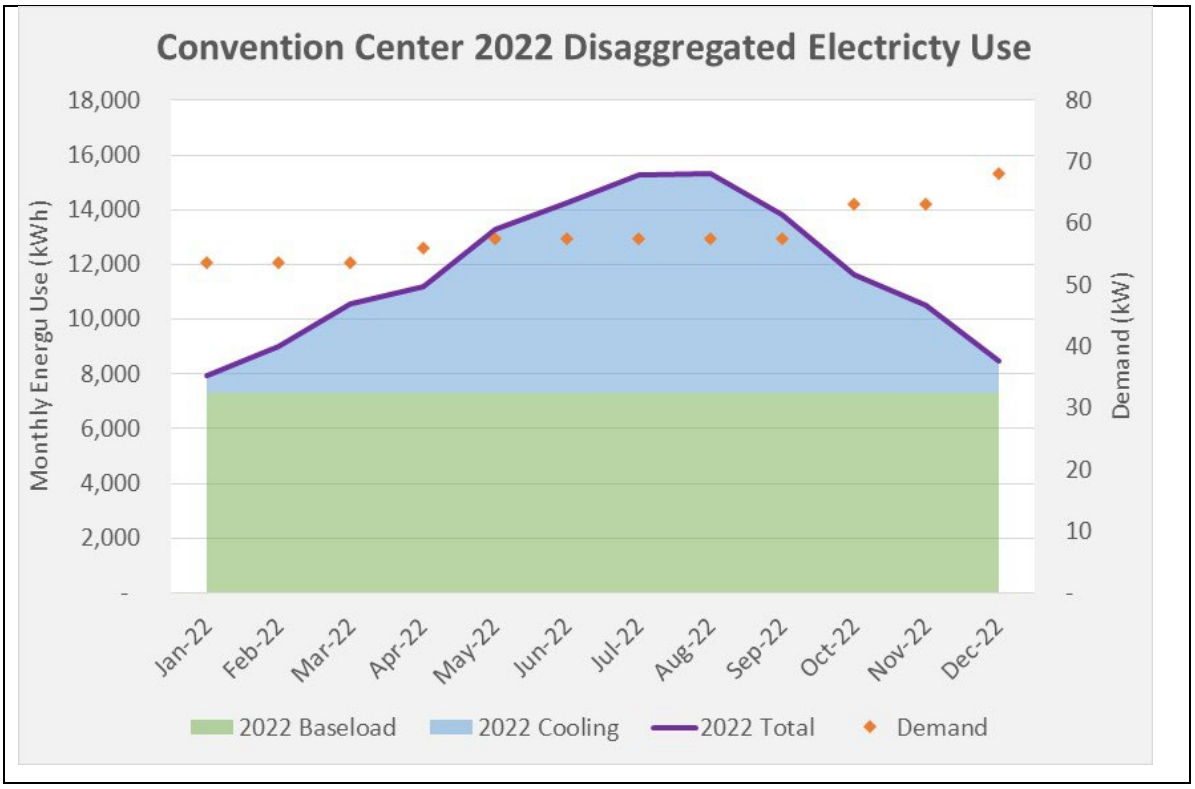


Figure 22. W.H. Stuart Conference Center 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, The City of Bartow. The peak power charge of $9.30 / kW and energy charge of only $0.0291 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. The very low energy costs for this site diminish rates of return and prolonged simple payback. No assumptions or adjustments were made to predict future cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

6.12 Stuart Conference Center Recommendations

6.12.1 Recommended Energy Efficiency Measures

There are good opportunities for cost-effective energy efficiency measures (EEM) to indoor electric lighting and HVAC. Electric lighting is mostly 2’x4’ troffer fixtures with T832W lamps and electronic ballasts and several recessed can lamps. These should be replaced with LED equivalents as is being done in the adjacent Extension Office and Ag Center Building.

It was not determined if the thermostats for AC1 and AC2 have automatic setback of cooling setpoint from temporary lowered holds. It is highly recommended that each system be controlled by thermostats that override any temporary lowered cooling setpoints after 2 hours. The unoccupied setback temperature should be about 80°F. If

the space is not occupied for a few days, the setpoint may need to be lowered for a few hours each day to help dehumidify the space.

The following recommendations are made with estimated EEM costs, savings and returns summarized in Tables 30 and 31. The estimated costs of lighting retrofit assumes a much lower cost compared to the real cost bid at the Extension Office building assuming more competition could be sought after.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures and occupancy controls.
2. Retro-commissioning of HVAC and lighting typically saves at least 13% on total energy bills with a payback typically within a year on buildings with larger systems and more automated controls. This building is simpler with no energy management system or complex controls. It is estimated that perhaps a detailed performance evaluation of two older AC systems could save about 25% of the annual cooling energy. Have AC1 and AC2 cooling performance checked to verify full potential efficiency is delivered. Given the state of refrigerant lines, portions should be considered to be replaced if refrigerant leaks are evident. Retro-commission HVAC systems and controls performance should be done at least every 5 years or sooner as required in addition to regularly scheduled checkups.
3. Ensure thermostat control of AC1 and AC2 have automatic setback of raised cooling setpoint or lower heating setpoint after 2 hours unless the temporary setpoint is reset after 2 hours. This enables comfort for events longer than 2 hours, but ensures that very low cooling setpoints or high heating setpoints do not remain longer than needed.

The lighting savings analysis was based on an average daily scheduled use of 9 hours / day, 5 days per week and outdoor lighting on 12 hours per day, 7 days per week. This may overestimate the potential savings if actual use is less than this.

Table 30. W.H Stuart Conference Center EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM Description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace Fluorescnt. with LED Lamps	6.3	18,388	0	$1,237	-$8,880	7.2
EEM2	ReCx AC1 and AC2 to improve efficiency	6.1	13,366	0	$1,072	-$5,120	4.8
Total Impact of All EEM		12.4 21.3%*	31,754 22.5%*	0	$2,309	-$14,000	6.1

* % of annual average peak of 58 kW and annual total energy of 141,249 kWh.

Table 31. W.H. Stuart Conference Center EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$29,917	$9,359	$0	-$8,880	13%	$7,626	7.2	20
EEM2	$5,359	$0	$0	-$5,120	2%	-$335	4.8	5
Total Impact of All EEM	$35,276	$9,359	$0	-$14,000	11%	$7,291	6.1	5-20

6.12.2 On-site Solar Renewable Energy Generation Potential

Due to the low cost of utility energy, on-site solar PV is not recommended for the Bartow Hunt Office Complex due to poor financial return. The WH Stuart Conference rooftop however, is suitable for solar PV towards more sustainable operations. The outcome of the solar generation and cost estimates follow.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 64 kW PV installation are provided in Tables 32, 33, and 34, and Figure 23 is an illustration of the approximate location for the proposed installation. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 and EEM2 being fully implemented. The efficiency measures are the most economical and should be the first priority. This helps reduced the amount of PV needed to be purchased.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility peak and energy charges were used based on the most recent utility billing data from the service provider, City of Bartow. The peak power charge of $9.30 / kW and energy charge of $0.0291 / kWh were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. This resulted in a very low energy cost for this site that diminishes rates of return and prolongs payback. Predicting solar PV impact on reducing the peak use charge is very uncertain, therefore a very conservative (minimal) benefit was assumed.

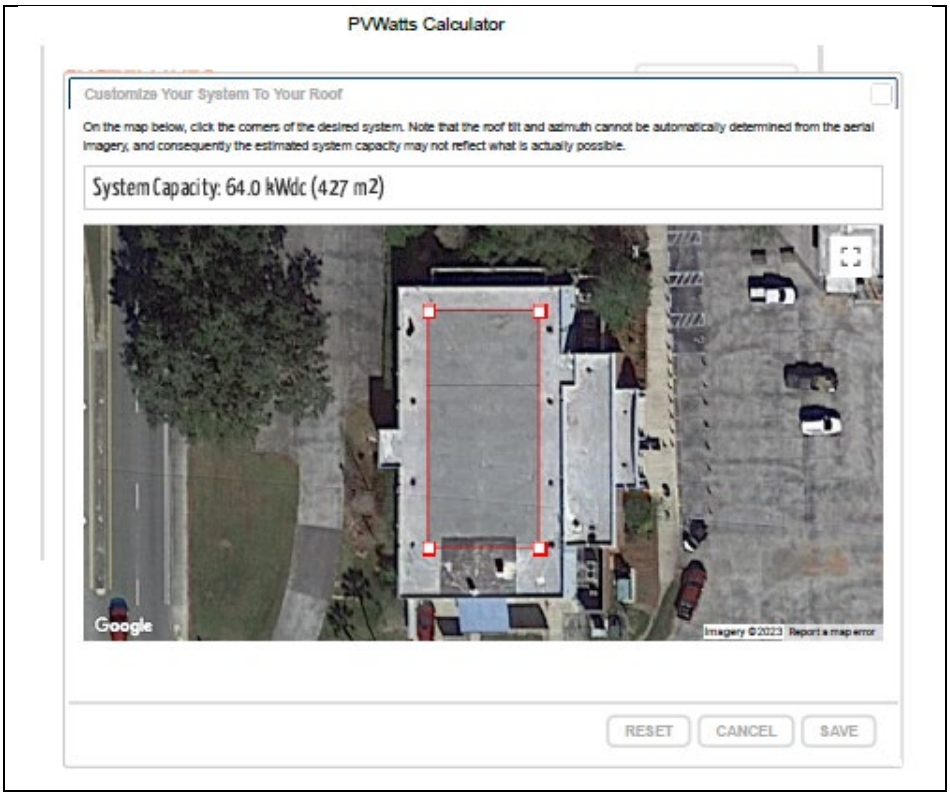


Figure 23. Arial view of potential PV panel array location. Approximate locations are indicated and are not shown to scale.

Table 32. W.H. Stuart Conference Center EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1 & EEM2	Total EEM1 & EEM2 Package	12.4 21.3%*	31,754 22.5%*	0	$2,309	-$14,000	6.1
Solar PV	Rooftop & Ground Mount Total 64 kW	1.6 2.7%*	92,889 65.8%*	0	$2,882	-$128,000	44.4
EEM Pkg & PV	Total EEM Package & 64 kW Solar	14.0 24.0%**	124,643 88.2%*	0	$5,190	-$142,000	27.4

* % of annual average peak of 21 kW and annual total energy of 69,760 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 64 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 33. W.H. Stuart Conference Center EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$35,276	$9,359	$0	-$14,000	11%	$7,291	6.1	5-20
Solar PV	$86,449	$0	$0	-$128,000	-2.4%	-$75,164	44.4	30
EEM&PV	$121,724	$9,359	$0	-$142,000	-1.4%	-$67,873	27.4	12-30

Table 34. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	141,249	45.7
EEM Pkg	109,495	35.4
EEM Pkg & Solar PV	16,606	5.4

PVWatts® Output Summary Report on next page.

NREL

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.

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The energy output range is based on analysis of 30 years of historical weather data, 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

92,889 kWh/Year*

System output may range from 86,932 to 96,902 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	3.92	6,034
February	4.82	6,627
March	5.86	8,842
April	6.57	9,384
May	6.89	10,054
June	6.27	8,653
July	6.04	8,669
August	5.60	7,999
September	5.24	7,378
October	4.93	7,411
November	4.24	6,233
December	3.65	5,604
Annual	5.34	92,888

Location and Station Identification

Requested Location	1702 Highway 17 South Bartow, FL 33830
Weather Data Source	Lat, Lng: 27.89, -81.82 1.0 mi
Latitude	27.89° N
Longitude	81.82° W

PV System Specifications

DC System Size	64.0 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	4°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	16.6%

Roof mount 64 kW array on Stuart Conference Center roof.

7. Conner Complex

The Conner Complex consists of several office buildings, laboratory buildings, facilities buildings, and warehouse spaces that serve the diverse needs of the Florida Department of Agriculture and Consumer Services in Tallahassee. A review of the available energy billing data found fourteen different electric metered accounts and seven gas metered accounts. Figure 24 shows an aerial view of the complex. Identity labels of key facilities are shown on the aerial layout. Table # shows the metered utility accounts and lists the facilities associated with it.

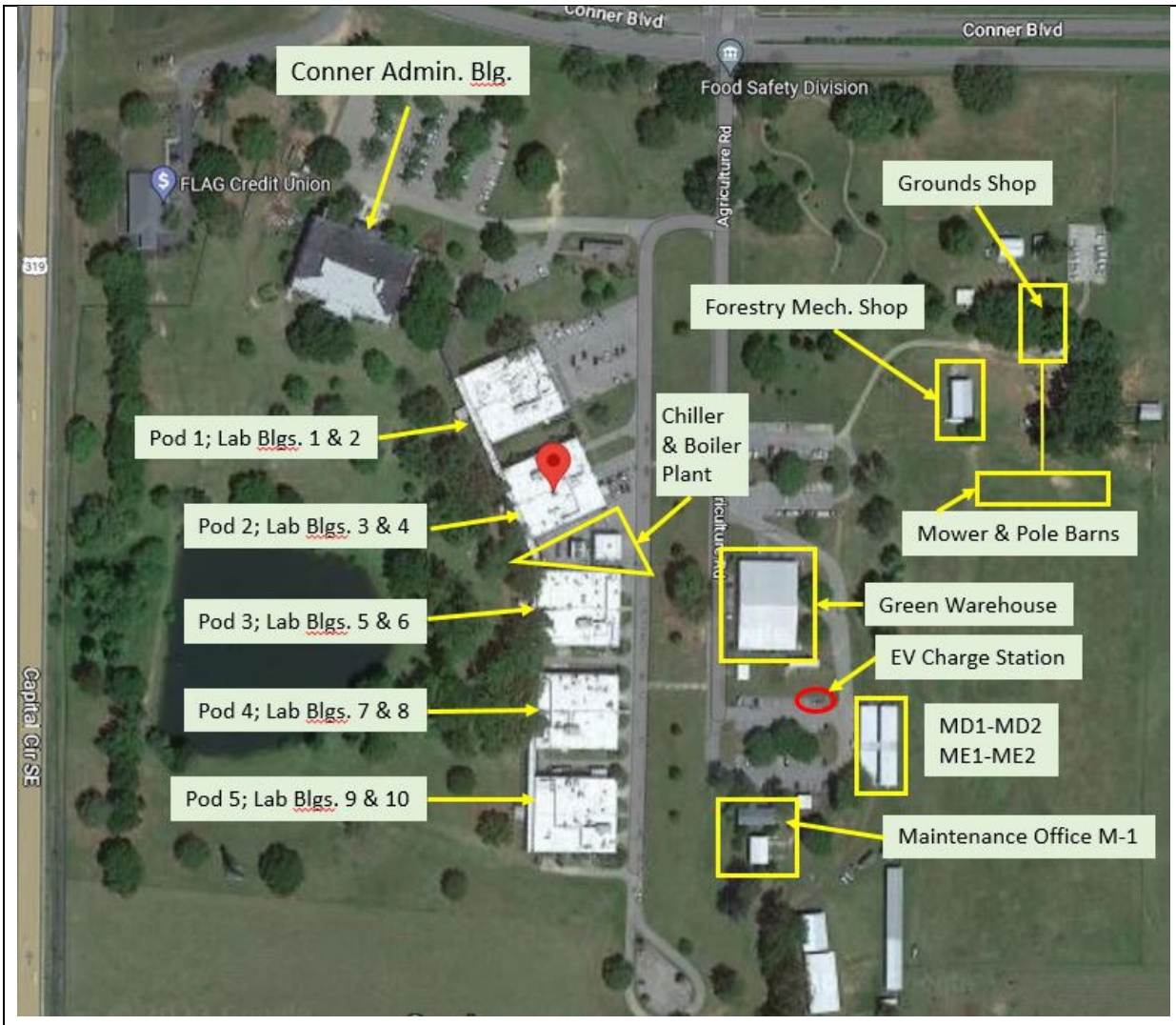

Figure 24.Layout of facilities on the Conner Complex

Table 35 identifies the key facilities and associated energy utility meter accounts.

Table 35.Conner Complex Facilities Associated with Each Utility Meter

Meter Acct. #	Facilities on Meter	Primary Function
Electricity		
E401646	Doyle Conner Admin. Blg.	Office
E401640	Pod blg. 1 & 2; (Lab Blgs. 1-4)	Laboratory
E401084	Pod blg. 3 & 4; (Lab Blgs. 5-8)	Laboratory
E401647	Pod blg. 5; (Lab Blgs. 9-10)	Laboratory
E76968	Central Plant	Space heating & cooling Conner Blg. & 5 pod blgs.
E401639	Warehouse	Shipping, receiving, storage
E226042	Maintenance Office and Storage Shed	Office and unconditioned storage
E315833	Maint. Shop, Mow Shed & Pole Barn	Maintenance and unconditioned storage
E226043	Forestry Mechanic Shop	Maintenance
E308140	Blg. MD-1 & MD-2	Storage 2 blgs.; MD-2 demolition planned
E308141	Blg. ME-1 & ME-2	Storage 2blgs.; ME-2 demolition planned
E793404 bill history had 2 meters	Small trailer & EV charging station	EV Charging station
E226049	Blg CS1	unknown
E298339	Pond	Pond water pump
Natural Gas		
G66475	Central Plant	Space heating
G55502	Lab 1 & 2	Lab test process and environment control
G55501	Lab 3 & 4	Lab test process and environment control
G72751	Lab 5 & 6	Lab test process and environment control
G54951	Lab 7 & 8	Lab test process and environment control
G55505	Lab 9 & 10	Lab test process and environment control

All accessible facilities were visited on April 6, 2023 to gather energy site audit information. The audit staff were escorted by the facilities manager. The billing data and site visit information were used to determine the best opportunities for energy retrofits. The Conner Complex assessment will start with general findings and recommendations and then provide greater detail of assessment of four different types of facilities.

Following are some considerations that influenced the level of assessment for some facilities and some general recommendations on the complex.

- It was reported to the energy audit staff that the Covid-19 pandemic resulted in remote work of non-essential office work from 2020 through November 2022. The labs were reported to be fully operational. This means that the billing analysis using the previous two years may be underestimating energy for some

buildings compared to typical occupancy. The impact of lack of occupancy was observable in some energy bills such as the Conner Building.

- The changing occupancy and the addition of new storage buildings created more uncertainty in establishing a baseline energy use and estimating heating and cooling use from monthly billing data in some facilities.
- A major chiller and boiler plant replacement will occur in 2024. This will no doubt result in more efficient operations with newer more efficient equipment and controls. Since equipment was already ordered, the plant operation was not evaluated for further recommendations.
- There are no Btu meters for the individual buildings heated and cooled by the plant. Therefore building heating and cooling energy use could not be determined on such buildings. This limited recommendations to lighting retrofits on the Conner Building, and the ten lab buildings. It is highly recommended to put Btu meters on each building that use chilled and hot water to enable future efforts to track building energy trends.
- The natural gas consumption at the Conner Complex is largely for the plant boiler operation. Much of the energy is necessary to help tightly control lab indoor air environments, which require substantial energy to do so as part of required operations. It was beyond the scope of the Level I energy assessments to evaluate the HVAC complexities of each of the ten lab buildings.
- Given the high energy requirements of the labs, it is recommended that exhaust fans, make-up air units be tested at least annually to verify design air flows are delivered that do not exceed what is required.
- Assessment of the ten lab buildings was limited to lighting retrofits based on plan review and limited access by secured escort through one vacant lab and one occupied lab.
- Two manufactured buildings MD-2 and ME-2 are planned to be demolished. The remaining MD-1 and ME-1 are used for storage and do not appear to be occupied on a regular basis. The package air conditioners should be serviced to verify proper performance. Thermostat cooling settings should be no lower than 80°F when unoccupied.
- Overall, it is recommended to change out fluorescent lights with LED lighting in all facilities on the Conner Complex. The retail cost of LED has dropped substantially over the last several years. The challenge is in finding reasonable installation cost. There are options for linear lamp change-outs without bypassing existing ballast that allow janitorial staff to replace lamps. This may be an approach to consider keeping cost down at least for smaller facilities such as the Mower barn, Forrestry shop, and several other smaller storage buildings.

The Conner Administration Building, Lab buildings, MI-1 Maintenance Office, and the large Green Warehouse have been chosen to provide individual facility assessments in greater detail to demonstrate various savings potential of lighting and HVAC replacement in some cases. The facilities were prioritized for the potential for energy efficiency savings as well as potential for solar PV.

Lighting retrofits have been considered in greater detail with lighting counts of indoor and outdoor lighting considered. The reduction in cooling load of indoor lighting as well as avoided cost of re-lamping fluorescent lights and ballasts over an assumed LED lifetime of 20 years has also been considered.

7.1 Conner Administration Building

Figure 25. Conner Administration Building.

7.2 Site Description

Several buildings were evaluated for energy conservation measures within the Conner Complex, including the Administrative Building. This site, historically known as the Forestry Building, was built in 1975 with about 70,000 ft^2 of conditioned area, including

two stories plus a below grade basement floor, and is of block construction. Reference the areal, front, and back of the building in Figure 25. The building is primarily office space with one large area open to both above ground floors. This building houses the staff or much of the administrative function of the entire Connor Complex campus.

Daily operations at the Administrative Building facility occur from 8am-5pm. Operations were significantly impacted by the COVID pandemic. Telecommuting officially ended December 2022. The building was obviously not fully occupied during the April 6, 2023 site visit. Full occupancy was expected to return by June 1, 2023.

The building was maintained well. It was comfortable clean and dry, adequately illuminated.

7.3 Site Energy Billing Data Analysis and LPD

Electricity is provided to the Conner Complex by the City of Tallahassee. Utility bills covering the period from November 2020 through November 2022 were provided for this site assessment. The Administration Building receives all of its space heating and cooling from the on-campus, central plant, which consists of five boilers and three chillers. No gas accounts were associated with this site. Since occupancy has been effected by the pandemic, the evaluation focused on the most recent year of data.

Since there were no Btu meters on the Conner building heating and cooling use cannot be estimated solely from the facility electric use. Furthermore the central plant is being replaced in 2024. Therefore EEM recommendations are limited to lighting for the Conner building.

Occupancy has had significant impacts on energy use. The utility data received for evaluation precede the termination of the staff telecommute option in December 2022. By early April 2023, occupancy was reported to be at only 65%, with expectations of 100% occupancy by June 2023. Thus, the utility bills available for this evaluation reflect reduced consumption relative to what the current expectations are.

Total annual energy use for the most recent year of utility data was 473,856 kWh. An energy use summary is provided in Table 36.

Table 36. December 2021 – November 2022 Energy Use Summary

Floor Area (ft^2)	Annual energy (kWh)	Annual Peak Demand (kW) (max / avg)	Lighting Power Density (W/ft^2)	$/kWh	$/peak kW
69,273	473,856	123/86.7	1.05	$0.06164	$15.50

A peak power charge of $15.50 / kW and energy charge of $0.0616 / kWh were used for this evaluation. Standard service charges and fees not associated with energy use were excluded from the energy costs presented. No assumptions or adjustments were made to predict future energy costs. As real energy costs increase, real savings would be greater than estimates in this report.

An evaluation of Energy Use Intensity (EUI) is not possible for this site because the space conditioning is provided by the on-campus power plant. In place of this, a lighting power density (LPD) evaluation was conducted. LPD is calculated as the total indoor lighting wattage divided by the total building conditioned area. The LPD for the Administration Building is 1.05 W/ft^2. For reference, the LPD for ASHRAE Standard 90.1-2016 (0.79 W/ft^2) to a more efficient goal of 90.1-2019 (0.64 W/ft^2) are provided in Table 37.

Table 37. Lighting Power Density Code Requirements for Different Periods

ASHRAE Standard 90.1-2016 (W/ft^2)	ASHRAE Standard 90.1-2019 (W/ft^2)
0.79	0.64

Monthly energy use and demand for the two years of supplied utility data are provided in Figure 26 to provide an overview of the energy use trend for the Administration Building. Monthly periods were normalized into calendar months to smooth out some of the difference in billing cycle lengths, which ranged from 27 to 34 days. Total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. The upward trend in both energy use and demand is not surprising, given what was learned about the increasing occupancy. This trend suggests that the energy use and monthly demand charge are continuing to rise as the occupancy increases.

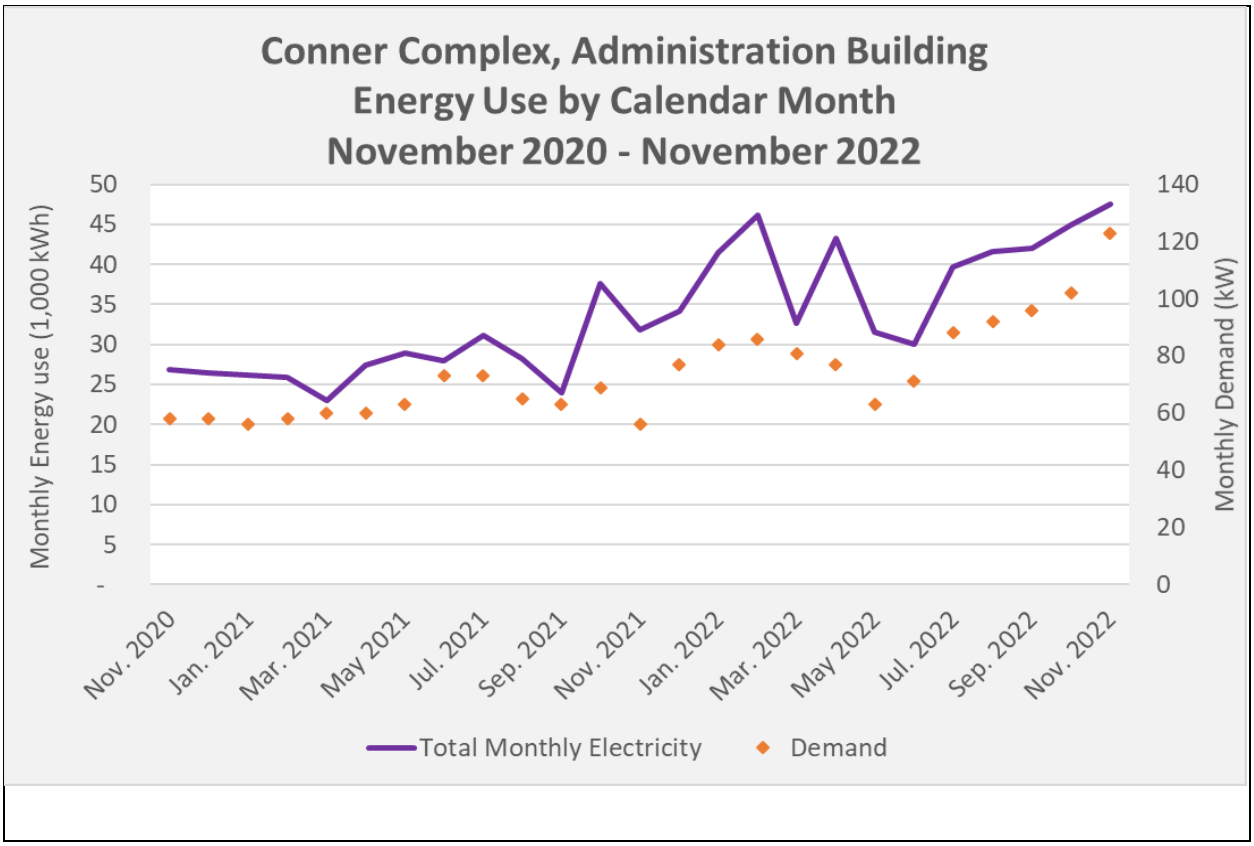

Figure 26. Administration Building energy use, normalized to calendar months, and monthly demand.

7.4 Relevant Findings

Exterior Lighting

There are exterior lights for the Administration Building that were evaluated, including a few wall pack fixtures on the building front and southeast side for which we include LED change out recommendations. However, several other lamps will likely be complete fixture change outs upon failure, given their apparent condition. These include posts and hanging laps in the front and back of the building (most likely sodium halide), as well as the building front and southeast side floodlights and overhead entrance lamps. Lighting images are provided in Figure 27.

Figure 27. Left: Front building courtyard post lamp; Middle: Back building entrance hanging lamp; Right: Southeast side entrance lamp.

Interior Lighting

The interior electric lighting for most of the building, including offices, meeting rooms, and corridors, are provided by 2-lamp ubend T832W fixtures and 2-lamp 4 foot troffer fixtures with T832W lamps, all with electronic ballasts. Pictures of the T832W lamps are provided in Figure 28. There are also several large metal halide laps for the atrium and front entry. There are also a few 6 inch can light fixtures along the front and back entries.

Figure 28. Right: Open areas and corridors under T8 "U" 32 watt lamp fixtures typical throughout building; Left: Desktop illumination in east conference room with natural sidelighting was more than adequate. This is a good application for occupancy and light dimming control.

7.5 Conner Building Recommendations

7.5.1 Recommended Energy Efficiency Measures

Since there were no Btu meters on the Conner building heating and cooling use cannot be estimated solely from the facility electric use. Furthermore the central plant is being replaced in 2024. Therefore EEM recommendations are limited to lighting for the Conner building.

The 2-lamp u bend T832W fixtures, 2-lamp 4 foot troffer fixtures with T832W lamps, and 6 inch can lights should be replaced with LED equivalents. The large metal halide lamps in the front entry and the atrium should also be replaced with LED equivalent replacement.

It is also recommended that offices with natural daylight have occupancy based control with integrated electric light output control (daylighting control). Occupant instruction may be needed to help learn how to maximize natural illumination to the extent that individual visual and thermal comfort needs will permit.

The exterior wall packs should be replaced with LED fixtures. Other older exterior lamps should be replaced with LED fixtures, but are not considered as part of the lighting EEM economics as they are likely to be replaced soon due to end of life.

The following recommendations are made. Estimated EEM costs, savings, and returns are summarized in Tables 38 and 39.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures. Offices with exterior windows should have LED lamps or LED fixtures compatible with dimming control. The interior lighting upgrade will also result in a net space conditioning energy reduction. Upgrade all exterior wall packs to LED.
2. Install lighting control in offices having windows that dim with adequate daylight and turn off when there is no occupancy.

With the implementation of EEM1, the LPD can be reduced from 1.05 to 0.45 W/ft^2 – even exceeding the ASHRAE Standard 90.1-2019 of 0.64 W/ft^2/yr. The economics presented below are based on the most recent year of electricity use provided. However, the trending increase in occupancy will affect the building's future energy use and thus the ability to project ECM economics is hampered.

Table 38. Administrative Building EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace fluorescent T832W and can lights, and exterior wallpacks with LED Lamps	55.305	157,467	n/a	$19,993	-$73,943	3.7

Table 39. Administrative Building EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$399,860	$68,923	$0	-$73,943	27%	$190,162	3.7	20

7.5.2 On-site Solar Renewable Energy Generation Potential

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 are pulled from the weather station closest to the latitude and longitude of each site.

The specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

This baseline is an estimate based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides monthly and annual total energy production. The results below are given a design goal to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 being fully implemented. These efficiency measures are the most economical and should be the first priority. Their implementation will reduce the amount of PV needed.

A 100 kW PV array is recommended, suggesting 75 kW for the south-southwest rooftop section and 25 kW for the north-northeast, front facing section. The illustration below shows the approximate location of the roof mount PV panel arrays. A summary of the economics of the PV installation are presented in Tables 40, 41, and 42, and Figure 29 is an illustration of the approximate location for the proposed installation.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site power generation. A cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher than the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). This higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total PV installed costs have been dropping over the last several years, in contrast to other products.

The peak demand and energy charge rates used for this analysis were based on the most recent utility billing data from the service provider, the City of Talahassee, for a peak power charge of $15.50 / kW and energy charge of $0.0616/ kWh. Standard service charges and fees not associated with energy use were excluded in this costs analysis. This resulted in a very low energy cost for this site that diminishes rates of

return and prolongs payback. Predicting solar PV impact on reducing the peak use charge is very uncertain, therefore a very conservative (minimal) benefit was assumed.

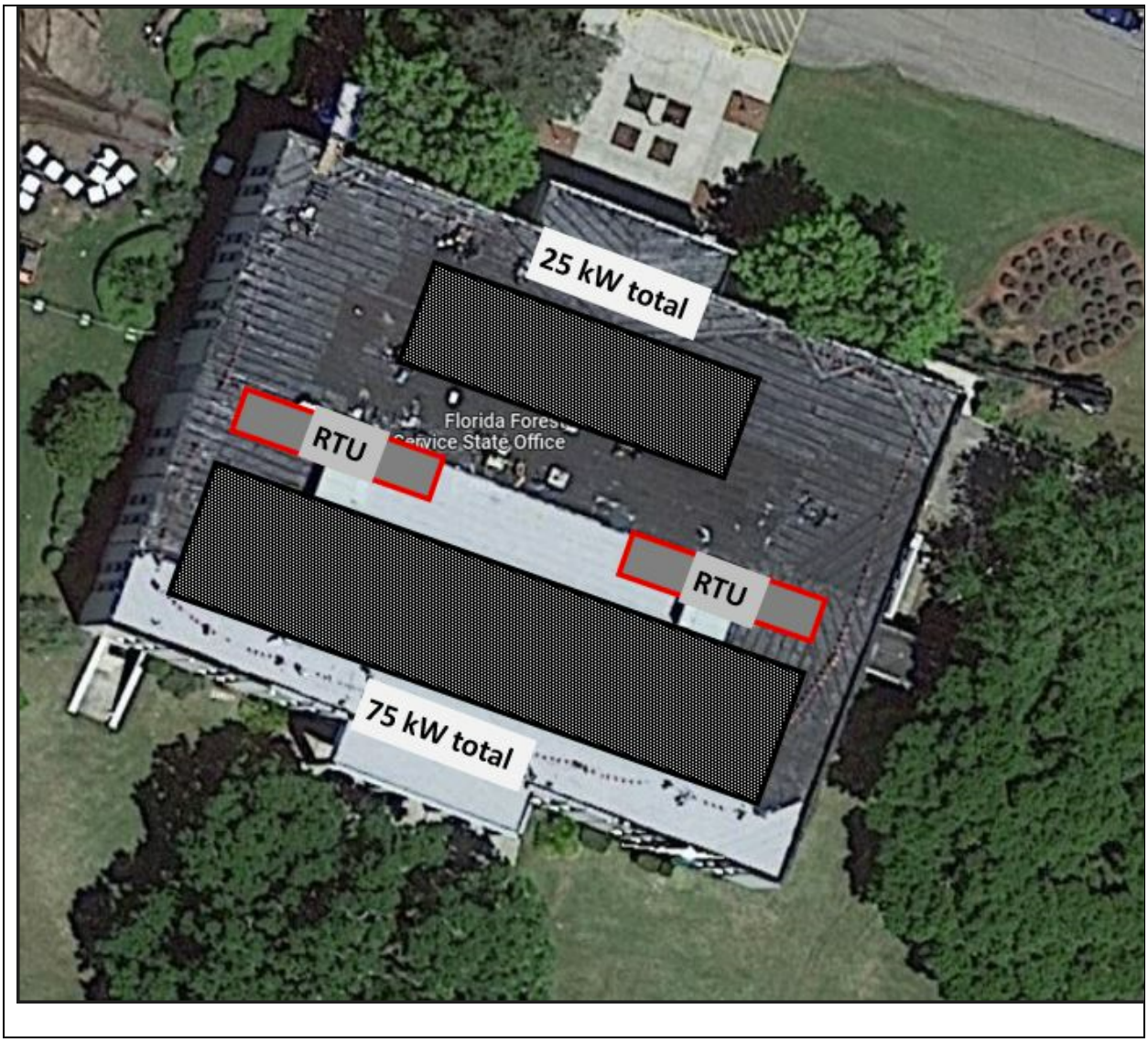

Figure 29. Arial view of potential PV panel arrays. Approximate locations are indicated and are not shown to scale.

Table 40. Administrative Building EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace fluorescent T832W and can lights, and exterior wallpacks with LED Lamps	55.31 63.8%*	157,467 33.2%*	n/a	$19,993	-$73,943	3.7
Solar PV	Install 100 kW on roof @30deg tilt; face south 205 deg. (SW)	2.50 2.9%**	137,576 29.0%*	n/a	$8,945	-$200,000	22.4
EEM Pkg & PV	EEM Pkg with 100 kW Solar PV	57.81 66.7%**	295,043 62.3%*	n/a	$28,938	- $273,943	9.5

* % of annual average peak of 86.7 kW and annual total energy of 473,856 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 100 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 41. Administrative Building EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$399,860	$68,923	n/a	-$73,943	27%	$190,162	3.7	20
Solar PV	$268,356	$0	n/a	- $200,000	2%	-$43,577	22.4	30
EEM&PV	$ 668,215	$68,923	n/a	-$273,943	9%	$146,585	9.5	20-30

Table 42. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	LPD (W/Ft^2)
Existing	$473,856	1.05
EEM Pkg	$316,389	0.45
EEM Pkg & Solar PV	$178,813	

PVWatts® Output Summary Report

Note that the information and disclaimer below applies to all PVWatts® Results posted herein this report.

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 //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.

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The energy output range is based on analysis of 30 years of historical weather data, 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

137,577 kWh/Year*

System output may range from 129,914 to 141,526 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	4.41	10,360
February	4.90	10,164
March	5.66	12,757
April	5.90	12,544
May	6.14	13,142
June	5.53	11,571
July	5.52	11,757
August	5.39	11,505
September	5.45	11,411
October	5.47	12,120
November	4.77	10,536
December	4.17	9,709
Annual	5.28	137,576

Location and Station Identification

Requested Location	3125 Conner Blvd, Tallahassee, fl
Weather Data Source	Lat, Lng: 30.45, -84.22 0.9 mi
Latitude	30.45° N
Longitude	84.22° W

PV System Specifications

DC System Size	100 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	30°
Array Azimuth	205°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	15.7%

7.6 Conner Laboratory Buildings

Figure 30. Connor Complex Laboratories.

7.7 Site Description

The Conner Complex has five structures of equal size that house state laboratory operations. These single story masonry structures were built in 1970 and are about 18,744 ft^2 each. Facilities staff refer to each of these structures as a pod that contains two separate laboratory buildings under one roof. Each lab building is separated by a common interior corridor. The laboratories are pictured in Figure 30. The research staff

had limited access to the laboratories, but were able to be escorted through one vacant laboratory (Lab 1) and one occupied laboratory (Lab 6). The laboratory buildings entered demonstrated a mix of laboratory test areas, open cubical office spaces, and closed office spaces.

The following evaluation of the Laboratory Buildings is focused on Lab buildings 1-4 which share one electric meter. This was chosen to investigate the potential for solar PV to be integrated into labs on one metered account. There is not adequate roof top space to mount solar PV, but ground mounted PV could be considered. This approach was explored.

The Laboratory Buildings receive primary space heating and cooling, from the on-campus, central plant. There were no Btu meter on the lab buildings, and heating and cooling use cannot be estimated solely from the facility electric use. Therefore EEM recommendations are limited to lighting for the lab buildings.

The laboratories operate 24 hours per day, and are occupied as needed. No exact occupancy schedule was made clear. Interior lights observed are turned on and off manually.

7.8 Site Energy Billing Data Analysis and LPD

Electricity is provided to the Conner Complex by the City of Tallahassee. Utility bills covering the period from November 2020 through November 2022 were provided for this site assessment. The electric metering for the laboratories consist of three accounts: one account for laboratories 1, 2 ,3 and 4; a second account for laboratories 5, 6, 7, and 8; and a third account for laboratories 9 and 10. Since occupancy may have been effected by the pandemic, the billing energy evaluation focused on the most recent year of data.

Occupancy has significant impacts on energy use. The utility data received for evaluation precede the termination of the staff telecommute option in December 2022. And by early April 2023, campus-wide occupancy was reported to be 65%, with expectations of 100% occupancy by June 2023. Thus, the utility bills available for this evaluation reflect reduced consumption relative to what the current expectations are.

Total annual energy use for the most recent year of utility data was 981,967 kWh. An energy use summary is provided in Table 43.

Table 43. December 2021 – November 2022 Energy Use Summary

Floor Area (ft^2)	Annual energy (kWh)	Annual Peak Demand (kW) (max / avg)	Lighting Power Density ($W/ft^2/yr$)	$/kWh	$/peak kW
37,488	981,967	149/142	0.89	$0.0654	$15.50

A peak power charge of $15.50 / kW and energy charge of $0.0654 / kWh were used for this evaluation. Standard service charges and fees not associated with energy use were excluded from the energy costs presented. No assumptions or adjustments were made to predict future energy costs. As real energy costs increase, real savings would be greater than estimates in this report.

An evaluation of Energy Use Intensity (EUI) is not possible for this site because The primary space conditioning is provided by the on-campus power plant. In place of this, a lighting power density (LPD) evaluation was conducted. LPD is calculated as the total indoor lighting wattage divided by the total building conditioned area. The LPD for the Labs 1-4 is estimated to be 0.89 W/ft^2. This can be compared to older code standards and new more efficient code standards. Table 44 compares the current lab LPD to the ASHRAE 90.1-2007 whole building method LPD for laboratories and to the newest 2021 IECC standard. There is no new code whole building LPD for labs so an assumed proportion of office and lab space was used to create an assumed 2021 space by space determined LPD to compare to. A building space composition of 40% laboratory and 60% office space has been assumed for the Connor Complex laboratories. The assumption used for lab space by space was 0.6 office x 0.67 W/ft^2 + 0.4 lab x 1.24 W/ft^2 = 0.90 W/ft^2 .

Table 44. Interior Lighting Power Density (W/ft2) of Conner Labs Compared to Different Code Eras

Conner Labs with fluorescent light now	Conner Labs with future LED replacement	ASHRAE Standard 90.1-2007: Laboratory (W/ft^2/yr)	2021 IECC Assumed 60% Office Space/ 40% Laboratory (W/ft^2/yr)
0.89	0.55	1.81	0.90

A linear regression analysis was conducted with data from the provided monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. The detailed description of this methodology can be found in Appendix B. It was not surprising to see poor correlation of energy to weather since the whole electric bill did not represent energy used for space heating and cooling.

The energy use is indicative of very steady operations without much variability through the time of year. Variation in demand may be in part due to operational demands and to weather.

The analysis results in a model to predict energy use such that weather or time periods can be normalized for more accurate energy use comparisons. The prediction models for the laboratory buildings is relatively weak because much of the energy use is unchanging with weather given laboratory functions and because much of the space conditioning and water heating – which both have seasonal variation – are not provided

by the buildings themselves but by the on-campus power plant. Still, all laboratory electricity accounts showed some relationship to weather. For labs 1-4, the coefficient of determination (adjusted R-squared) of 0.32, meaning that the model explains about 32% of the variation in energy use.

Through this modeling process a baseline energy use is created for the labs to compare future energy use to, for example, following energy efficiency measures. The model predicts a monthly baseload energy use of 78,498 kWh with a relatively small amount of space cooling; there was no space heating energy detected. Monthly periods were normalized into calendar months to smooth out some of the difference in billing cycle lengths, which ranged from 28 to 33 days. With that adjustment, the range in monthly energy use is 201 kWh to 7,941 kWh for cooling. These results are presented graphically in Figure 31, which is a stacked graph with baseload energy use shaded in green, heating in red, cooling in blue, and total energy use indicated with a purple line. The reported monthly demand is also presented, as an orange diamond. Demand did not vary much by month, ranging from 134 kW to 149 kW, with the highest demand during the warmest months. This is expected as the site energy bills reflect only cooling and no heating.

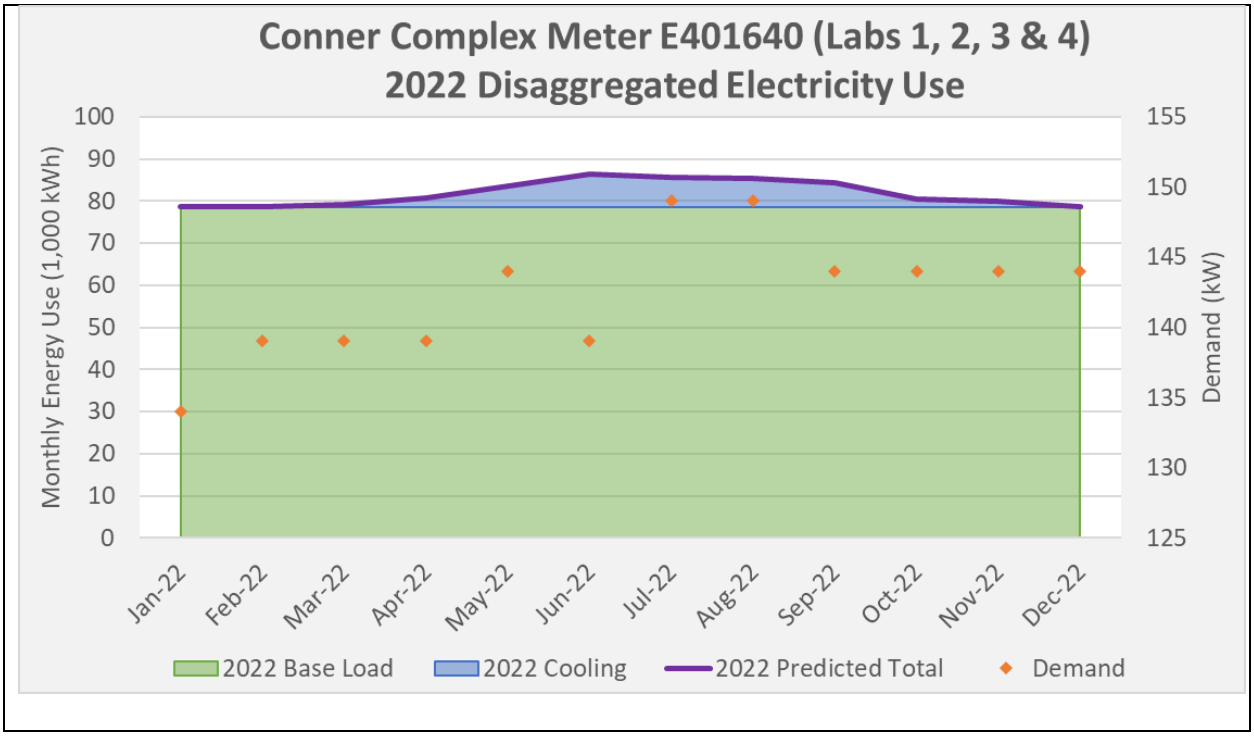

Figure 31. Laboratory buildings 1-4 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand. Very little cooling indicated makes sense since it is not provided through this energy meter, but from a chiller plant instead.

7.9 Relevant Findings

Exterior Lighting

There exterior lights for the Laboratory Buildings are primarily wallpack fixtures on all sides of the building. There is also one overhead entry lamp at the front entrance to each building. Exterior lighting is pictured in Figure 32.

Figure 32. Left: Exterior wallpack; Right: Overhead entry lamp.

Interior Lighting

The evaluation of interior lighting included plan review as well as partial lab space observation. The interior electric lighting for most of the building, including offices, meeting rooms, and corridors, are provided by 2-lamp 4 foot troffer fixtures with T832W lamps with electronic ballasts. There are also a few 6 inch can light fixtures along the front and back entries. The lighting for the walkway connecting the laboratories was controlled by in-line motion sensors. Interior lighting is pictured in Figure 33.

Figure 33. Left: Walkway connecting labs with lights controlled by occupancy sensors; Right: Example of a laboratory work space.

7.10 Conner Lab Recommendations

7.10.1 Recommended Energy Efficiency Measures

The recommendations provided here focus on laboratories 1-4. But are assumed to be able to be apply toward the other labs.

All observed interior lamps, such as 2-lamp 4 foot troffer fixtures with T832W lamps and 6 inch can lights, as well as the exterior wallpack fixtures should be replaced with LED equivalents. The change out of these lamps is included in the economic projections below. The front entrance lighting type, one per building, was undetermined and thus excluded from the economic analysis, though it is recommended that LED lamps be installed here as well.

With the implementation of LED lamping, the LPD may be reduced from 0.89 to 0.55 W/ft^2 – even exceeding the 2021 IECC Standard approximated here to be 0.90 W/ft^2. The economics presented below are based on the most recent year of electricity use provided.

Table 45. Laboratories 1-4 EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace fluorescent T832W and can lights, and exterior wallpacks with LED Lamps	19.392	59,236	n/a	$7,479	-$48,300	6.5

Table 46. Laboratories 1-4 EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$149,583	$32,245	$0	-$48,300	14%	$51,292	6.5	20

7.10.2 On-site Solar Renewable Energy Generation Potential

First we will start off stating that this specific solar assessment will not be recommended, but is presented to demonstrate what potential a large ground mounted PV system could have at the Conner Complex. While it is presented with the Lab buildings, it could be applied towards any facility using similar amounts of energy as the labs.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 are pulled from the weather station closest to the latitude and longitude of each site.

The specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

This baseline is an estimate based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumptions and estimated outputs are

provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides monthly and annual total energy production. The results below are given a design goal to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 being fully implemented. This efficiency measure is the most economical and should be the first priority. Its implementation will reduce the amount of PV needed.

A ground-mounted 100 kW PV array could be considered for to offset energy of laboratories 1-4 (or labs 5-8). The illustration below shows the approximate location of the roof mount PV panel arrays. A summary of the economics of the PV installation are presented in Tables 40, 41, and 42, and Figure 34 is an illustration of the approximate location for the proposed installation.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site power generation. A cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher than the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). This higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total PV installed costs have been dropping over the last several years, in contrast to other products.

The peak demand and energy charge rates used for this analysis were based on the most recent utility billing data from the service provider, the City of Talahassee, for a peak power charge of $15.50 / kW and energy charge of $0.0654 / kWh. Standard service charges and fees not associated with energy use were excluded in this costs analysis. This resulted in a very low energy cost for this site that diminishes rates of return and prolongs payback. Predicting solar PV impact on reducing the peak use charge is very uncertain, therefore a very conservative (minimal) benefit was assumed.

Figure 34. Arial view of potential ground-mount PV panel array. Approximate locations are indicated and are not shown to scale.

Table 47. Laboratories 1-4 EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace fluorescent T832W and can lights, and exterior wallpacks with LED Lamps	19.392 13.6%*	59,236 6.0%*	n/a	$7,479	-$48,300	6.5
Solar PV	Install 100 kW on ground; face south	2.50 1.8%**	145,695 14.8%*	n/a	$9,989	-$218,000	21.8
EEM Pkg & PV	EEM Pkg with 100 kW Solar PV	21.89 15.4%**	204,931 20.9%*	n/a	$17,468	- $266,300	15.2

* % of annual average peak of 142.3 kW and annual total energy of 981,967 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 100 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 48. Laboratories 1-4 EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$149,583	$32,245	n/a	-$48,300	14%	$51,292	6.5	20
Solar PV	$299,672	$0	n/a	-$218,000	2.2%	-$43,527	21.8	30
EEM&PV	$ 449,255	$32,245	n/a	-$266,300	4.3%	$7,765	15.2	20-30

Table 49. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	LPD (W/Ft^2)
Existing	981,967	0.89
EEM Pkg	922,731	0.55
EEM Pkg & Solar PV	777,036	

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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.

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

RESULTS

145,695 kWh/Year*

System output may range from 137,580 to 149,877 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	3.35	8,852
February	4.04	9,430
March	5.22	13,241
April	5.96	14,198
May	6.72	16,079
June	6.25	14,551
July	6.13	14,517
August	5.70	13,579
September	5.22	12,275
October	4.70	11,747
November	3.68	9,174
December	3.08	8,052
Annual	**5.00**	**145,695**

Location and Station Identification

Requested Location	3125 Conner Blvd, Tallahassee, fl
Weather Data Source	Lat, Lng: 30.45, -84.22 0.9 mi
Latitude	30.45° N
Longitude	84.22° W

PV System Specifications

DC System Size	109.6 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	4°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	15.2%

7.11 MI-1 Maintenance Office

Entry of MI-1 Office

Unconditioned warehouse located south of MI-1 office

Interior hall and reception area of office illuminated with T832W linear fluorescent lamps

Interior view of warehouse had an LED fixture on first floor and a few fluorescent fixtures above the mezzanine floor.

Figure 35. MI-1 Maintenance Office.

7.12 Maintenance Office Site Description and Findings

This site was visited April 6, 2023. The Maintenance Office building is a 1,573 ft^2 office space used to oversee the Conner Complex facilities operations. The office is a manufactured building consisting of wood frame, walls and floor. Daily operations occur from 8am-5pm 5 days each week. The typical occupancy of 2-3 persons varies through the day. The MI-1 Maintenance office is pictured in Figure 35.

The building was comfortable, clean, dry, and adequately illuminated. The indoor lighting consisted of linear fluorescent T8 32 watt lamp-based fixtures. Interior lights were controlled by manual switches. Outdoor light was controlled by photocell.

The HVAC system consisted of one package air conditioning unit estimated to be about 10 years old. The nameplate info was too weathered to determine further details about it. The physical appearance of the cabinet looked acceptable with no obvious corrosion or significant panel leaks. The cooling setpoint during site visit was 74°F and the interior space was being maintained at 74°F.

There was one portable dehumidifier located towards the end of the main hallway. It was not operating at the time of site visit. While there was no mention of comfort control issues, the presence of the dehumidifier indicates the central cooling system is, at least at times, unable to control humidity to acceptable levels. This could be from various possibilities such as oversized AC during low cooling loads, poor cooling performance of the package AC unit, or excessive duct leakage. Manufactured buildings with package systems are well-known to have significant duct leakage and often have oversized cooling systems to overcome poorly insulated windows, walls and ceilings during peak summer weather. Select images from this site, including the package unit and thermostat are provided in Figure 36.

Old package air conditioner at MI-1 office.	The AC cooling setpoint was observed at 74F.

Portable dehumidifier in office hallway.

AC filters appeared to be maintained well.

Figure 36. MI-1 office package unit, thermostat, portable dehumidifier, and air distribution filters.

7.13 Site Energy Billing Data Analysis and EUI

The adjusted 2022 total annual energy use was 20,210 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 43.9 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 50. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption. This metered account does not have peak demand charges.

Table 50. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	$/kWh	$/peak kW
1,537	20,210	No Demand	43.9	$0.1007	$0

Table 51 shows published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for offices. Net zero energy is where building energy

efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The Maintenance Office Building EUI of 43.9 is 17% lower than the median EUI of existing office buildings in the CBECS database of 52.9. This indicates that it is more efficient than that group. However, the Maintenance Office site EUI is about 33% higher than buildings built to ASHRAE 90.1-2016 standard. With energy efficiency improvements in LED lighting and HVAC, the EUI could be reduced. The NZE goal can be difficult to reach for many existing buildings, but provides a stronger efficiency goal to strive for over time.

Table 51. EUI (kBtu/ft2/yr) of Existing Office and of NZE Target Goals

Existing Buildings of Various Age		NZE Target Goal
Office CBECS Data	Office ASHRAE 90.1 2016	Office NZE (FL)
52.9	33	23

A linear regression analysis was conducted with data from the monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. Adjustments were also made for variable days in billing cycles The detailed description of this methodology can be found in Appendix B.

Billing regression analysis predicts an annual baseload energy use of 12,067 kWh (60% of total annual), and cooling of 8,144 kWh/y (40% of total annual). Regression analysis was not able to accurately determine the heating portion of the total energy use. The breakdown in these results are presented graphically in Figure 37, with baseload shaded in green, cooling in blue, and total energy use indicated with a purple line. The baseload is mostly lighting as well as plug loads from computers and the dehumidifier.

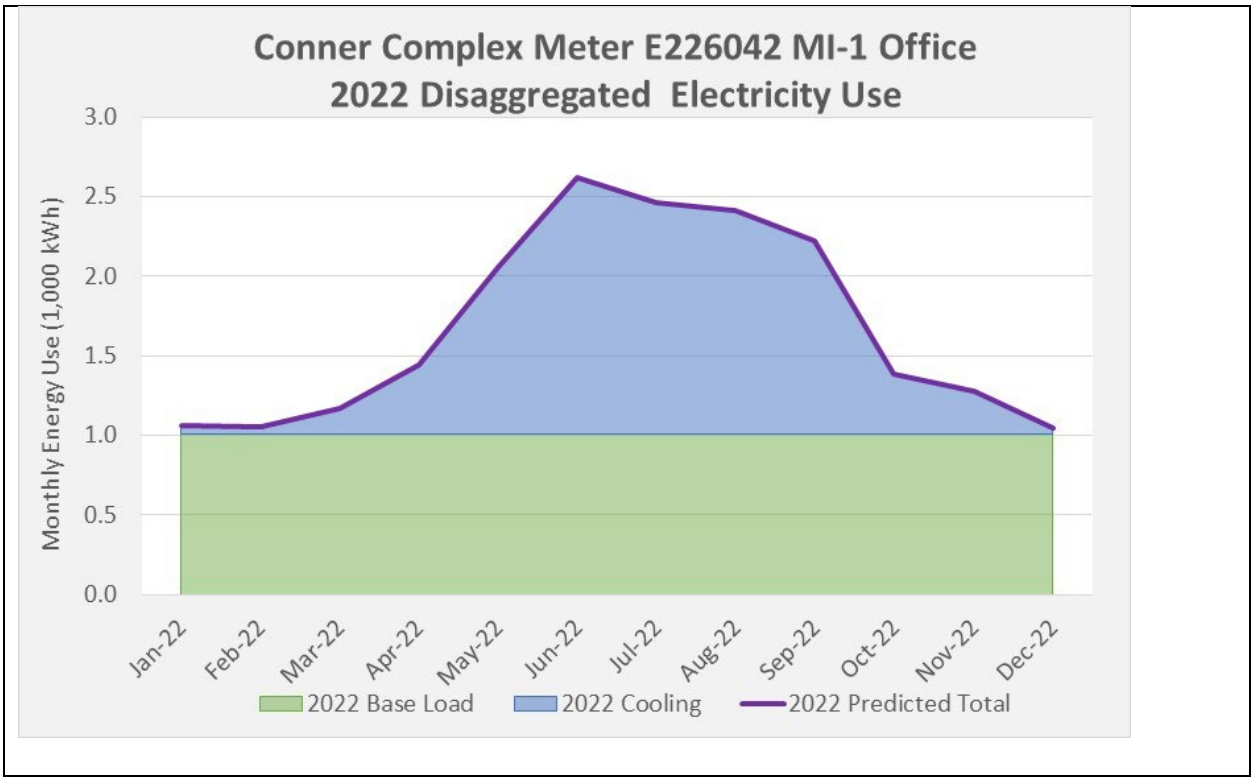

Figure 37. Office Building 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, The City of Tallahassee. The General Service Non-Demand energy charge of $0.1007 / kWh was used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. The relatively higher energy costs for this site make on-site PV financially attractive. No assumptions or adjustments were made to predict future cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

7.14 Maintenance Office Recommendations

7.14.1 Recommended Energy Efficiency Measures

There are good opportunities for cost-effective energy efficiency measures (EEM) to indoor electric lighting and HVAC. Electric lighting consist of T832W lamps and electronic ballasts fixtures. These should be replaced with LED equivalents.

The observed interior cooling setpoint of 74ºF is good during occupied periods. Cooling setpoints maintained continuously below 74ºF have a higher risk of condensation on cold air exterior ductwork or any building surface able to cool to the very low setpoint during warm moist summer conditions.

Recommended improvements are listed below. Estimated EEM costs, savings and returns are summarized in Tables 52 and 53. Peak power reduction is shown, however MI-1 Maintenance office is not charged for peak power use. The cost estimate for lighting retrofit is likely on the low end of costs in the current market without much competition, however LED savings and lifetimes are substantial enough that LED retrofits would be financially sound if the cost was double the costs assumed here.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures. Include occupancy control of offices and reception area.
2. The package air conditioner should be replaced at end of life with a new package heat pump having SEER rating equivalent of at least 15 and HSPF of about 8.
3. Maintain the occupied cooling set point to no lower than 73ºF. The nighttime cooling temperature setback should be raised to 80ºF. There is approximately 8% cooling energy decrease for every degree of cooling set point increase.
4. An investigation of duct leakage or other air distribution issues like constricted or undersized flex ducts should be completed if zonal comfort issues remain. Every duct connection should be sealed by duct mastic, not tape. Ductwork from the package unit into the crawlspace under the building should be off the ground and supported in accordance with ACCA and SMACNA standards.

Table 52. EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM Description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace T832W Fluorescnt. With LED Lamps	0.6	3,188	0	$321	-$1,473	4.6
EEM2	Replace Pkg. AC with new Pkg. SEER 15 & HSPF 8 heat pump	1.3	2,850	0	$287	-$2,000*	7.0
Total Impact of All EEM		1.9	6,038 29.9%**	0	$608	-$3,473	5.7

* Measure cost is incremental cost above new min. efficiency.
** % of annual total energy of 20,210 kWh.

Table 53. EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$6,420	$1,088	$0	-$1,473	21%	$2,778	3.6	20
EEM2	$3,444	$0	$0	-$2,000	10%	$667	7.0	12
Total Impact of All EEM	$9,864	$1,088	$0	-$3,473	16%	$3,445	5.7	12-20

7.14.2 On-site Solar Renewable Energy Generation Potential

The relatively higher commercial cost of energy for The Maintenance Office site makes on-site PV more financially attractive than other sites with much lower cost per kWh. The metal roof of the warehouse located just south of the MI-1 Maintenance Office provides a location for up to 8 kW of solar PV. The outcome of the potential solar generation and cost estimates follow.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 8 kW PV installation are provided in Tables 54, 55, and 56, and Figure 38 is an illustration of the approximate location for the proposed installation. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial

output for the investment. The PV system target size was based on the recommended EEM1 and EEM2 being fully implemented. The efficiency measures are the most economical and should be the first priority. This helps reduced the amount of PV needed to be purchased.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility energy charges were used based on the most recent utility billing data from the service provider, City of Tallahassee. The energy charge of $0.1007 / kWh was used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis.

Figure 38. Arial view of potential PV panel arrays. Approximate locations are indicated and are not shown to scale.

Table 54. EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1 & EEM2	Total EEM1 & EEM2 Package	1.9	6,038 29.9%*	0	$608	-$3,473	5.7
Solar PV	Rooftop & Ground Mount Total 8 kW	0.2**	9,797 48.5%*	0	$986	-$16,000	16.2
EEM Pkg & PV	Total EEM Package & 8 kW Solar	2.1	15,835 78.4%*	0	$1,594	-$19,473	12.2

* % of annual total energy of 20,210 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 8 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 55. EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$9,864	$1,088	$0	-$3,473	16%	$3,445	5.7	12-20
Solar PV	$29,594	$0	$0	-$16,000	4.5%	$1,017	16.2	30
EEM&PV	$39,457	$1,088	$0	-$19,473	6.1%	$4,462	12.2	12-30

Table 56. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	20,210	43.9
EEM Pkg	14,172	30.7
EEM Pkg & Solar PV	4,375	9.5

PVWatts® Output Summary Reports

NREL

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.

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The energy output range is based on analysis of 30 years of historical weather data, 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

4,978 kWh/Year*

System output may range from 4,701 to 5,121 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	2.96	283
February	3.63	305
March	4.92	450
April	5.67	485
May	6.55	564
June	6.18	517
July	6.03	514
August	5.64	483
September	5.03	426
October	4.41	399
November	3.35	300
December	2.69	253
Annual	4.76	4,979

Location and Station Identification

Requested Location	3125 Conner Blvd, Tallahassee, FL 32311
Weather Data Source	Lat, Lng: 30.45, -84.22 0.9 mi
Latitude	30.45° N
Longitude	84.22° W

PV System Specifications

DC System Size	4.0 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	22.6°
Array Azimuth	90°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	14.2%

Roof mount 4 kW array on MI-1 warehouse east facing roof

NREL

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.

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The energy output range is based on analysis of 30 years of historical weather data, 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

4,818 kWh/Year*

System output may range from 4,649 to 4,966 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.08	293
February	3.77	317
March	4.82	438
April	5.60	479
May	6.27	538
June	5.79	484
July	5.69	484
August	5.18	443
September	4.76	401
October	4.24	381
November	3.32	296
December	2.81	264
Annual	**4.61**	**4,818**

Location and Station Identification

Requested Location	3125 Conner Blvd, Tallahassee, FL 32311
Weather Data Source	Lat, Lng: 30.45, -84.22 0.9 mi
Latitude	30.45° N
Longitude	84.22° W

PV System Specifications

DC System Size	4.0 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	22.6°
Array Azimuth	270°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	13.7%

Roof mount 4 kW array on MI-1 warehouse west facing roof

7.15 Large Warehouse

West side entry of the large green warehouse

Unconditioned warehouse storage area under metal roof

Southwest conditioned storage area under acoustic tile ceiling located within warehouse

View into southeast conditioned storage area similar to sw storage area

Figure 39. Large Warehouse

7.16 Warehouse Site Description and Findings

This site was visited April 6, 2023. The Warehouse is a 14,224 ft^2 warehouse space, seen in Figure 39, used to conduct Conner Complex shipping and receiving operations, and is also used for storage. The warehouse is a metal building consisting of iron beam structure, uninsulated sheet metal walls and uninsulated metal roof. There is about 6,300 ft^2 of the total conditioned. It is unknown if there was any insulation on top of ceilings of the conditioned spaces or within walls. Daily operations occur from 8am-5pm 5 days each week.

The indoor lighting consisted of linear fluorescent T8 32 watt lamp-based fixtures controlled by manual switches. Outdoor lighting was controlled by photocell.

The total of all conditioned spaces was cooled by 5 different DX air conditioners with a cumulative total of 20 tons of cooling capacity. Cooling setpoints were between 70°F-73°F. The HVAC systems consisted of three split-DX air conditioners, one heat pump, and one small window unit AC. The office and small shop space were cooled by a newer 5 ton air conditioner. Another newer 5 ton heat pump cooled 2,435ft^2 SW storage space.

An old air conditioner serving the SE storage space was running, but not able to cool the SE space to its 72°F setpoint. Since the SW and SE spaces are open to each other, the unmet cooling load of the SE space was making the SW AC work harder with indoor measured conditions of 79.5°F and 48% RH with the SW AC setpoint at about 70°F.

7.17 Site Energy Billing Data Analysis and EUI

The adjusted 2022 total annual energy use was 96,614 kWh. Normalizing the site energy use by conditioned area established an energy use index (EUI) which can be compared to other buildings of similar use and size. The EUI is 23.2 kBtu/ft^2/yr. The summary of site energy use, EUI, and utility cost is shown in Table 57. Utility cost of energy (kWh) includes non-fuel, fuel, and any other cost that is associated with kWh consumption. This metered account does not have peak demand charges.

Table 57. 2022 Adjusted Energy Use Summary

Floor Area (ft^2)	Annual kWh	Annual Peak kW (max / avg)	EUI kBtu/ft^2/yr	$/kWh	$/peak kW
14,224	96,614	(31/ 23.6)	23.2	$0.06164	$15.50

Table 58 shows published sources of historical existing EUI data as well as EUI target goal of net zero energy (NZE) for offices. Net zero energy is where building energy efficiency and conservation are used along with renewable energy such that the net annual energy consumption is near zero. The NZE target goal EUI reflects the utility energy use without renewable energy accounted for.

The Maintenance Office Building EUI of 23.2 is 2.2% higher than the median EUI of existing non-refrigerated warehouse/storage buildings in the CBECS database (22.7 kBtu/ft^2/y). With energy efficiency improvements in LED lighting and HVAC, the EUI could be reduced. The NZE goal can be difficult to reach for many existing buildings, but provides a stronger efficiency goal to strive for over time.

Table 58. EUI (kBtu/ft2/yr) of Existing Office and of NZE Target Goals

Existing Buildings of Various Age	NZE Target Goal
Office CBECS Data	Warehouse NZE (FL)
22.7	6

A linear regression analysis was conducted with data from the monthly utility bills to estimate the amount of heating, cooling, and baseload energy used at the site monthly and annually. Adjustments were also made for variable days in billing cycles The detailed description of this methodology can be found in Appendix B.

Billing regression analysis predicts an annual baseload energy use of 69,881 kWh (72% of total annual), cooling use of 23,921 kWh/y (25% of total annual), and heating use of 2,812 kWh/y (3%). Regression analysis was not able to accurately determine the heating portion of the total energy use. The breakdown in these results are presented graphically in Figure 40, with baseload shaded in green, cooling in blue, heating in red, and total energy use indicated with a purple line. The baseload is mostly lighting. Based on the high baseload, it would appear that warehouse lighting is operated for very long periods of time each day, or perhaps lights are forgotten to be turned off on several occasions after business hours.

There is a significant spike in peak demand during the winter months. This coincides with the heating season. It is attributed to inefficient electric resistance strip heating.

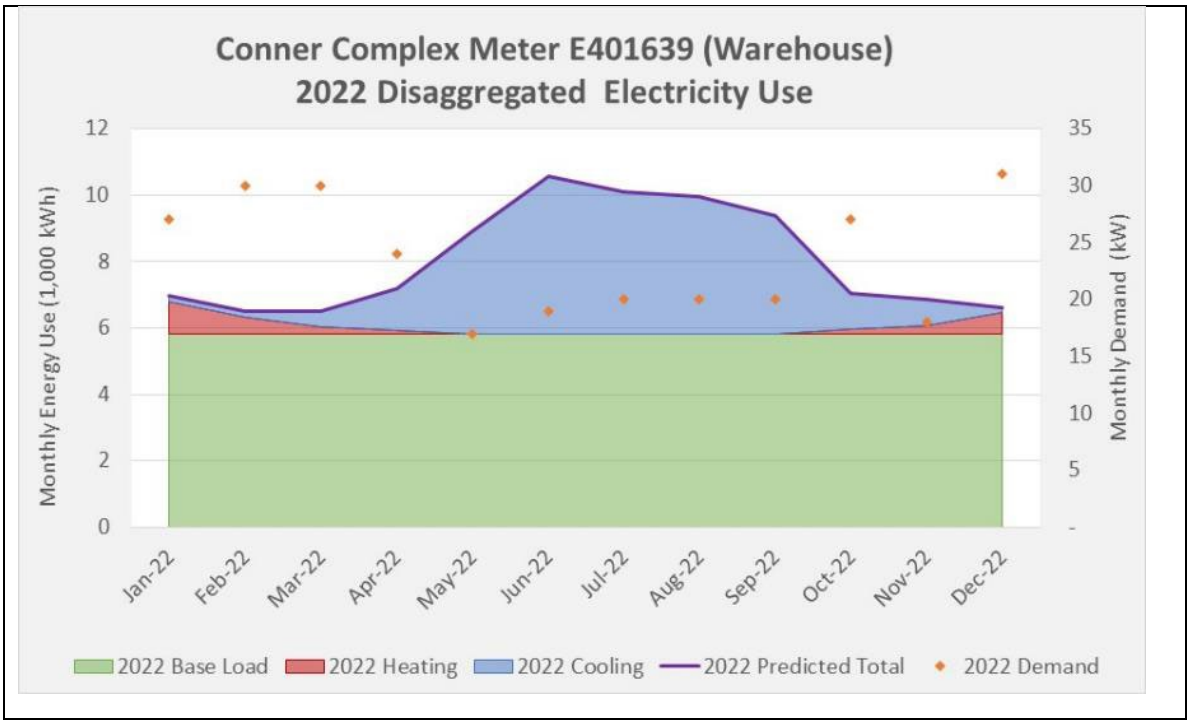

Figure 40. Green Warehouse 2022 monthly disaggregated energy use, normalized to 2022 calendar months, and monthly demand.

The most recent utility peak and energy charges were used based on the most recent utility billing data from the service provider, The City of Tallahassee. The General Service Demand energy charge of $0.06164 / kWh and peak demand charge of $15.50 / kW were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis. No assumptions or adjustments were made to predict future cost of energy in the analysis. As real energy costs increase, real savings would be greater than estimates in this report.

7.18 Warehouse Recommendations

7.18.1 Recommended Energy Efficiency Measures

There are good opportunities for cost-effective energy efficiency measures (EEM) to indoor electric lighting and HVAC. Electric lighting consist of T832W lamps and electronic ballasts fixtures. These should be replaced with LED equivalents as well as occupancy controls.

Recommended improvements are listed below. Estimated EEM costs, savings and returns are summarized in Tables 59 and 60.

Summary of Recommended EEM

1. Upgrade all fluorescent lights with LED lamps and fixtures including occupancy control.
2. Two air conditioners serving the southeast storage area should be replaced with new heat pumps having SEER rating equivalent of at least 16 and HSPF of about 9. The high cost of peak energy makes heat pumps more attractive even though the winter heating season in Tallahassee is limited to a few months. The thermal inefficiency of the warehouse envelope is likely to have some mild winter mornings needing heat and afternoons needing cooling for a few hours.
3. The conditioned spaces within the warehouse are not constructed with good thermal and air barriers. The acoustical tile ceilings air not a barrier to air movement. The conditioned spaces would benefit from measures of air tightening and adding insulation on ceilings and in walls, however these measures are expensive and recommended to be deferred for a time when major renovation is planned.

Table 59. EEM and ECM Recommendation Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM Description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1	Replace T832W Fluorescnt. With LED Lamps and controls	4.8	27,748	0	$2,604	-$16,337	6.3
EEM2	Replace 2 old AC with SEER 16 & HSPF 9 heat pumps	2.7	6,876	0	$920	-$6,000*	6.5
Total Impact of All EEM		7.5 31.7%**	34,624 35.8%**	0	$3,525	-$22,337	6.3

* Measure cost is incremental cost above new min. efficiency.
** % of annual average peak 23.6 kW and annual total energy of 96,614 kWh.

Table 60.EEM Recommendation IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net EEM Cost	IRR EEM Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
EEM1	$45,495	$10,132	$0	-$16,337	15%	$18,323	6.3	20
EEM2	$11,045	$2,000	$0	-$6,000	27%	$6,164	6.5	12
Total Impact of All EEM	$56,540	$12,132	$0	-$22,337	17%	$24,488	6.3	12-20

7.18.2 On-site Solar Renewable Energy Generation Potential

The large amount of unshaded metal roof of the warehouse provides ample room for large PV array installation, however, the relatively low cost of energy results a low IRR and a negative NPV. The outcome of the potential solar generation and cost estimates follow.

Potential for solar power production was calculated using PVWatts®, a software tool developed by the U.S. Department of Energy and available free online from the National Renewable Energy Laboratory (NREL) 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 specific characteristics of the buildings and grounds around the building were considered for installing solar photovoltaic (PV) renewable electric power to offset energy consumption. The power and energy use of the electric utility meter associated with this site was used to establish a current baseline from which to size the PV system.

Economic summaries of a 43 kW PV installation are provided in Tables 61, 62, and 63, and Figure 41 is an illustration of the approximate location for the proposed installation. The estimate provided is based upon assumed site locations, rated panel output, PV system efficiency, PV panel orientations, and long-term historical weather data for this site location. Real PV performance will vary from this estimate depending upon how different installed equipment varies from assumptions. Best efforts were made to include typical published industry efficiency as well as consider potential shading impacts from growth of nearby trees. The assumed assumptions and estimated outputs are provided at the end of this subsection in the PVWatts® output summary reports. The potential variability of annual energy output is also provided in the output summaries.

The PVWatts® Calculator provides a monthly and annual total energy production. The goal was to use the most suitable locations for PV panels that could provide substantial output for the investment. The PV system target size was based on the recommended EEM1 and EEM2 being fully implemented. The efficiency measures are the most economical and should be the first priority. This helps reduced the amount of PV needed to be purchased.

Estimates were made on the installed PV cost and cost savings from reduced electric utility consumption offset by on-site generation. An assumed cost of $2.00 per installed PV Watt was assumed. This is almost 9% higher compared to the current national estimate of $1.84 / W used by NREL for estimation purposes (Ramasamy et al 2022). A higher value was used since some estimates covering the Florida region cite costs between $2-$3 / W. The NREL value is based on more substantial research and considered more reliable. It should be noted that total installed costs have been dropping over the last several years instead of steadily rising like other products.

The utility energy charges were used based on the most recent utility billing data from the service provider, City of Tallahassee. The energy charge of $0.06164 / kWh and peak demand charge of $15.50 / kW were used in analysis. Standard service charges and fees not associated with energy use were not included in energy costs analysis.

Figure 41. Arial view of potential PV panel array on the large warehouse. Approximate locations are indicated and are not shown to scale.

Table 61. EEM Package and Solar Cost Savings and Payback

		Annual Energy and Cost Savings				Simple Payback	
Measure ID	EEM description	Peak (kW)	Electric (kWh)	Gas (therms)	Total Cost Savings	Measure Cost	Simple Payback (years)
EEM1 & EEM2	Total EEM1 & EEM2 Package	7.5 31.7%*	34,624 35.8%*	0	$3,525	-$22,337	6.3
Solar PV	Rooftop 43 kW	1.1** 4.6%*	60,615 62.7%*	0	$3,936	-$86,000	21.8
EEM Pkg & PV	Total EEM Package & 43 kW Solar	8.6 36.2%*	95,239 98.6%*	0	$7,461	-$108,337	14.5

* % of annual average peak 23.6 kW and annual total energy of 96,614 kWh.
** Peak savings of solar PV is conservative estimate of only 2.5% kW annual average reduction (2.5% of 43 kW installed PV) (*SOURCE: NREL/FS-6A20-69016 • September 2017*)

Table 62. EEM Package and Solar IRR and Lifecycle Benefits

Measure ID	EEM Financial Benefits							
	Lifecycle Gross Savings	Avoided Costs	Potential Utility Incentives	Net Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Total EEM Package	$56,540	$12,132	$0	-$22,337	17%	$24,488	6.3	12-20
Solar PV	$118,088	$0	$0	-$86,000	2.2%	-$17,244	16.2	30
EEM&PV	$174,628	$12,132	$0	-$108,337	4.7%	$7,243	14.5	12-30

Table 63. Reduction of Site Utility Energy Use With EEM Package and Solar PV

	Annual Utility (kWh)	EUI (kBtu/ft^2/yr)
Existing	96,614	23.2
EEM Pkg	61,990	14.9
EEM Pkg & Solar PV	5,899	0.3

PVWatts® Output Summary Report

NREL

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 ./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 the NREL report: The Error Report.

Disclaimer: The PVWatts® Model ("Model") is provided by the National Renewable Energy Laboratory ("NREL"), which is operated by the Alliance for Sustainable Energy, LLC ("Alliance") for the U.S. Department Of Energy ("DOE") and may be used for any purpose whatsoever.

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The energy output range is based on analysis of 30 years of historical weather data, 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

60,615 kWh/Year*

System output may range from 57,239 to 62,355 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	4.13	4,275
February	4.69	4,281
March	5.63	5,587
April	6.02	5,616
May	6.45	6,059
June	5.88	5,384
July	5.83	5,431
August	5.64	5,279
September	5.52	5,080
October	5.36	5,240
November	4.52	4,404
December	3.88	3,980
Annual	5.30	60,616

Location and Station Identification

Requested Location	3125 conner blvd, tallahassee, fl
Weather Data Source	Lat, Lng: 30.45, -84.22 0.9 mi
Latitude	30.45° N
Longitude	84.22° W

PV System Specifications

DC System Size	43 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	20°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 0%, Feb 0%, Mar 0%, Apr 0%, May 0%, June 0%; July 0%, Aug 0%, Sept 0%, Oct 0%, Nov 0%, Dec 0%

Performance Metrics

DC Capacity Factor	15.9%

Roof mount 43 kW array on Large green warehouse south facing roof.

8. Conclusions

The first goal in completing the site assessments was to prioritize facilities in which to begin energy efficiency measures and use the experience to help generate case studies and educational outreach for other small local governments. The site energy assessments were based on basic Level I energy audits at each site and some research to establish estimated costs and savings of the most likely to be recommended retrofits. Lighting and some limited HVAC cost data was updated and spreadsheets were developed to generate estimates on recommended upgrades.

One of the unique challenges with this portfolio of buildings is that they serve several different important facets for the State of Florida Department of Agriculture and Community Services responsibilities. This included sites with not only offices and community centers and storage spaces, but also a livestock arena, greenhouses, and laboratories for petroleum testing, designing and testing new plants, and seed, food safety labs, and crop disease testing laboratories.

This project enabled the opportunity to develop EEM savings spreadsheets that with more refinement may be able to be shared with other site managers to enable a quick assessment of potential lighting retrofits. It also offered an opportunity to further outline the types of resources local governments need.

The Most Cost-Effective Types of EEM of the Five FDACS Sites

Cost-effectiveness within this project was based upon simple payback, IRR, and positive NPV. Priority for improvements should be set towards buildings with EUI higher than similar peer type of building that have positive financial outcomes for the investment. Simple payback is not the best metric for buildings with high EUI and long future ownership periods.

The most commonly recommended cost-effective EEM was replacing florescent lamps and fixtures with LED equivalents. The retail costs have come down substantially for several different LED lamp types, and the long lifespan avoids re-lamping costs of shorter lifetime fluorescent lamps. LED lamps are particularly beneficial in high mount locations.

Depending upon installation cost and utility cost of energy, the payback may be possible within the 5 year warrantee period of the most common LED products. The LED retrofit costs were all based on FSEC estimates, except for the Hunt Extension Office, which had a real bid for LED change out. The lack of competitive bids may have resulted in much higher costs than otherwise expected. This one site was the only site to demonstrate poor economic benefit of LED retrofit based on the awarded bid cost and very low utility cost of energy.

The FSEC estimated LED installation costs may be undervalued in an uncompetitive market. The cost benefit of the Hunt office LED retrofit was re-evaluated using three times the FSEC estimated costs with a more-typical utility cost of $0.06/kWh and $15.00/ kW. Based on these different parameters, it demonstrated it was still possible to have a simple payback 10-11 years (half of LED rated life), an IRR around 6%, and positive NPV around $3,500.

The second most common recommended EEM was to replace old air conditioners and replace with heat pumps more efficient than the current Federal minimum efficiency standard. The estimated cost indicated in this report does not use an estimate of the total installed cost of more efficient heat pumps. The cost used is the estimated additional cost of the recommendation compared to the current minimum efficiency allowed.

Summary of Prioritized Energy Reduction

In an effort to prioritize improvements, the results of EEM are shown in Table 64. Next the combined result of recommended EEM packages along with solar PV are shown separately in Table 65. The rationale of combining EEM with PV results is that it is more cost-effective to reduce energy consumption and then size the PV for the reduced use. Table 64 can be used to prioritize EEM efforts and Table ES 65 can be used to prioritize greater sustainability efforts wherever solar PV is feasible. For the larger complex sites having several utility metered accounts, some low-use accounts were not prioritized and are not shown as they have low savings potential compared to some of the very high energy use facilities.

Table ES-1 compares the energy savings-related financial benefits for highest priority facilities from each of the five FDAC locations. Costs are based upon assumed estimates from research of readily available resources. Tables ES-1 and ES-2 have not prioritized by chosen FDACS sites. Specific facilities within an FDACS site are prioritized higher to lower for specific sites. The priority was established by the authors primarily based on IRR as long as there was a positive NPV. It is recognized that availability of funds and timing the potential disruption of retrofits may supersede recommendations.

Table 64. Packaged EEM Recommendations Based on IRR and Lifecycle Benefits

	EEM Financial Benefits						
EEM Locations and Description	Lifecycle Gross Savings	Avoided Costs	Net EEM Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Lifetime (years)
Winter Haven Plant Industry Site							
Cowperthwaite Blgs. LED and HVAC	$38,163	$2,802	-$18,275	11%	$9,676	6.8	12-20
Hunt Office Complex							
Stuart Conf. Center* LED and ReCx HVAC	$35,276	$9,359	-$14,000	11%	$7,291	6.1	5-20
JW Hunt Office LED retrofit and HVAC	$29,242	$9,195	-$19,125	9%	$5,601	10.1	12-20
Extension Office & Ag. Center LED and HVAC	$114,666	$29,666	-$81,636 -$136,330**	6% -1%	$9,055 -$43,535	10.5 17.6	12-20
Conner Complex							
Conner Admin. Blg. LED	$399,860	$68,923	-$73,943	27%	$190,162	3.7	20
MI-1 Maint. Office LED and HVAC	$9,864	$1,088	-$3,473	16%	$3,445	5.7	12-20
Large Green Warehouse LED and HVAC	$56,540	$12,132	-$22,337	17%	$24,488	6.3	12-20
Labs 1-4 (Pods 1&2) LED	$149,583	$32,245	-$48,300	14%	$51,292	6.5	20
Labs 5-8 (Pods 3&4) LED	$149,583	$32,245	-$48,300	14%	$51,292	6.5	20
Lab Blg. 9-10 (Pod 5) LED	$89,293	$17,498	-$29,373	14%	$30,099	6.6	20
State Farmers Market Pompano Beach							
Myrick SFM Blg.6 Petroleum Lab Newer blg.	No major recommendations; has LED lights and controls; EUI of 92 kBtu/ft^2/y qualifies for "best practice" compared to Lab LBL/LBT S.E. U.S.10th percentile of peer lab blgs. Continue regular maintenance and periodic retro-commissioning.						
Myrick SFM Blg.7 Newer blg.	No major recommendations, but unoccupied space needs AC repair, Blg. meets current code with LED lights and controls. Low priority since tenant space use remains unknown.						

* Serves as FEMA operation center during declared emergencies.
** Based on real lighting retrofit bid and estimated HVAC change-out costs; only one qualified bidding contractor; lighting retrofit already funded and underway.

Table 65 shows a prioritized table based on the most cost-effective package of EEM with on-site solar PV. Low cost of utility energy as well as unsuitable site locations were the primary causes of poor solar financial benefits. Packages with negative NPV or with payback longer than 25 years were not considered. Some sites have suitable location for solar, but perhaps very low energy costs. Such sites should still be considered for demonstration of long-term sustainability efforts. The individual results may still be found within the main report body.

Table 65 EEM With Solar PV Economic Analysis Estimates

	EEM Financial Benefits						
Measure Locations and Description	Lifecycle Gross Savings	Avoided Costs	Net EEM Cost	IRR Lifetime	NPV	Simple Payback (years)	EEM Assumed Lifetime (years)
Winter Haven Plant Industry Site							
Poor PV economics due to low utility cost of energy $0.049/kWh and less than ideal available PV orientation.							
Cowperthwaite Blgs. EEM & PV	$207,252	$20,802	-$166,275	1.6%	-$38,917	20.0	12-30
Hunt Office Complex							
Low utility cost of energy results in poor PV financial benefit. ($0.029/kWh & $9.30/kW)							
Stuart Conf. Center* EEM+PV	$121,724	$9,359	-$142,000	-1.4%	-$67,873	27.4	12-30
JW Hunt Office EEM+PV	$67,064	$9,195	-$75,125	-0.5%	-$27,284	23.9	12-30
Ext. Office & Ag. Cntr. EEM & PV	Lighting retrofit already underway; Site not ideal for solar PV						
Conner Complex							
(Different rates on site; GSD $0.062/kWh & $15.50/kW; GSND $0.101/kWh)							
Conner Admin. Blg. EEM & PV	$668,215	$68,923	-$273,943	9%	$146,585	9.5	20-30
MI-1 Maint. Office EEM & PV ($0.101/kWh)	$39,457	$1,088	-$19,473	6.1%	$4,462	12.2	12-30
Large Warehouse EEM & PV	$174,628	$12,132	-$108,337	4.7%	$7,243	14.5	12-30
Labs 1-4 (Pods 1&2) EEM & ground PV	$449,255	$32,245	-$266,300	4.3%	$7,765	15.2	20-30
State Farmers Market Pompano Beach							
Myrick SFM Blg.6 Petroleum Lab Newer blg.	Solar PV not feasible due to inadequate space.						
Myrick Blg.7 Solar PV ($0.120/kWh)	$180,185	$0	-$72,000	7.3%	$30,634	12.0	30

* Serves as FEMA operation center during declared emergencies.

The EEM and PV package at three facilities at the Conner Complex stand out as the best options. The Conner Lab package involves a large ground mount PV array that may be aesthetically undesirable and have more unpredictable costs and is considered a low priority.

The top priorities for implementing EEM with solar PV are:
1) Conner Admin. Building
2) MI-1 Maintenance Office and
3) the Large Green Warehouse.

These selections are largely due to the higher utility cost at the Conner Complex compared to Winter Haven and Bartow sites. While the Myrick Blg. 7 site in Pompano Beach had the highest cost of energy and is relatively efficient, it is only partially occupied and there is potential for much greater energy use in the tenant space that creates much more uncertainty about that specific location. The Conner Building has the best estimated financial returns with all things considered, but at highest first costs. The Maintenance Office offers the lowest first cost with expected positive returns. The large Warehouse could also be considered as a project with somewhat more moderate costs and substantial payback.

End of main body of report.

Appendix A – EEM Data Resources and Assumptions

This appendix is intended to provide supplemental information that may be useful in making decisions about HVAC and lighting improvements in buildings. It varies from very general to technical. These two energy use categories were found to be the best targets for recommended cost-effective EEM during the assessments of the five FDACS sites.

HVAC Energy Savings

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

1. Increasing Equipment Efficiency and Improving System Performance
2. Reducing Conditioning Loads, Predominantly Heat and Humidity Gain (includes raising cooling setpoints and lowering heating setpoints)

HVAC Equipment

Recommendations for HVAC Equipment More than Nine Years Old

FSEC recommends replacing HVAC equipment over nine years old. Table A-1 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 Return on Investment (ROI). Estimates for ROI are shown below in Table A-2.

Table A-1. 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 replacement cost benefit analysis, the savings must be determined based upon the current legal minimum SEER 14 (systems under 5 tons), rather than a less efficient system being replaced since the less efficient system is not currently an option. Table A-2 provides example cost benefit estimates for two capacities at 3 and 5 tons. 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 insufficient cost data.

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

Table A-2. 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 if the costs were $1000 more than indicated. Payback would be about 3-4 years and average annual ROI about 10% and 17% for 3 ton and 5 ton, respectively.

The heat pump cost and benefit was disaggregated from Table A-2 to evaluate replacing electric strip heat COP 1 to heat pump HSPF 8.5. The results shown in Table A-3 indicate that most of the benefits shown in Table A-2 can be attributed to the heat pump. 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 A-3. 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 if the costs were $1000 more than estimated. Payback would be about 3-4 years and average 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 (Central and North Florida).
- Make 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

- 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.
- Survey building managers annually and investigate areas with consistent comfort complaints; comfort issues often indicate areas where HVAC energy use is higher than needed. 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.

HVAC Load Reduction

The cooling load is impacted from several sources, both outside and inside a building. Solar heat gain, particularly through the roof assembly and windows, generally has more impact on smaller buildings than very large ones. The external cooling load impacts are 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 (OA) 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 runtimes and sometimes chronically high indoor humidity levels, as the system tries to reach comfortable conditions. 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 excess air is enough for about 33 people and would require about 3 tons air conditioning capacity to remove 16.7 pounds (2 gallons) of water from the air every hour. Condition the excess air would use about 3.1 kW of power and could represent an increased energy use of 6,434 kWh/y (~$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 have an occupancy schedule. 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. The savings potential for more predictable occupancy, like office spaces that vary little from schedule, are limited. A schedule-based control is best in this type of circumstance where the OA damper closes off ventilation after business hours.

The ASHRAE 62.1-2019 standard sets the ventilation rates for commercial spaces with different uses. This standard has a history of some significantly big changes over serval decades – allowing different ventilation rates for buildings of different ages. 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 best 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 the 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.

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. 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.
- Installing hurricane rated Bahama style shutters over windows provides substantial shading and improves building resiliency. These should be considered for 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.

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.

Lighting

Interior lighting configurations vary widely from space to space and must be effective for specific types of task. Illumination recommendations are general and individual needs may vary. Following is information intended to demonstrate that LED lighting is cost-effective as well as provide other considerations regarding lighting retrofits. Buildings with windows should also consider light dimming controls in addition to occupancy control.

Table A-4. Example 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

*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.

General Recommendations for Lighting Replacement

- Replace fluorescent fixtures with LED as budget permits.
- Measure illumination samples to identify places where levels are higher than Illuminating Engineering Society recommendations to identify potential areas to reduce lighting. 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 A-5 shows recommended illumination levels for some common types of spaces. There are free applications for smartphones that can measure light levels.

Table A-5. 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. LPD is calculated as the total indoor lighting wattage divided by the total building conditioned area. The LPD allowances for sample spaces under the 2021 IECC code are shown in Table A-6. New light retrofits should strive for the very efficient LPD target. Specific space lighting needs may require higher LPD.

Table A-6. Sample Spaces of New Construction LPD Allowances

General Space Type	2021 IECC LPD (W/ft^2)
Audience seating, auditorium	0.44
Audience seating, convention center	0.23
Audience seating, religious building	0.65
Classroom, lecture hall, training room	0.65
Computer room	0.85
Dining area, family	0.54
Electrical/mechanical room	0.39
Laboratory, classroom	1.04
Laboratory, other	1.24
Lobby, general	0.76
Office, ≤250 ft^2	0.67
Office, >250 ft^2	0.60
Office, open plan	0.55
Restroom, general	0.57
Sales area	0.95
Stairwell	0.45
Workshop	1.09
Gymnasium, exercise area	0.50
Library, reading area	0.77
Manufacturing, high bay	0.58

Reference 2021 IECC Table 701.4.6.1B, Lighting power density (LPD) allowances and room cavity ratio (RCR) thresholds using the space-by-space method.

- 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 a Color Rendering Index (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 A-7 is an example of a cost benefit analysis for a light control installation at a fire station. The estimated ROI is high given the expected long life of controllers.

Table A-7. Example Estimated Lifecycle Benefit, Simple Payback, and Cost Differential from Lighting Control Installation in a Fire Station

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

Table A-7 footnotes continued:
Occupancy Assumptions
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.).

Assumptions for lamp analysis

- *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*

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.

Retro Commissioning (RxC)

Based upon study and analysis by Parrish et al. 2013, retro commissioning typically saves 16% 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 for buildings with energy management systems and HVAC and lighting systems with several controls and sensors.

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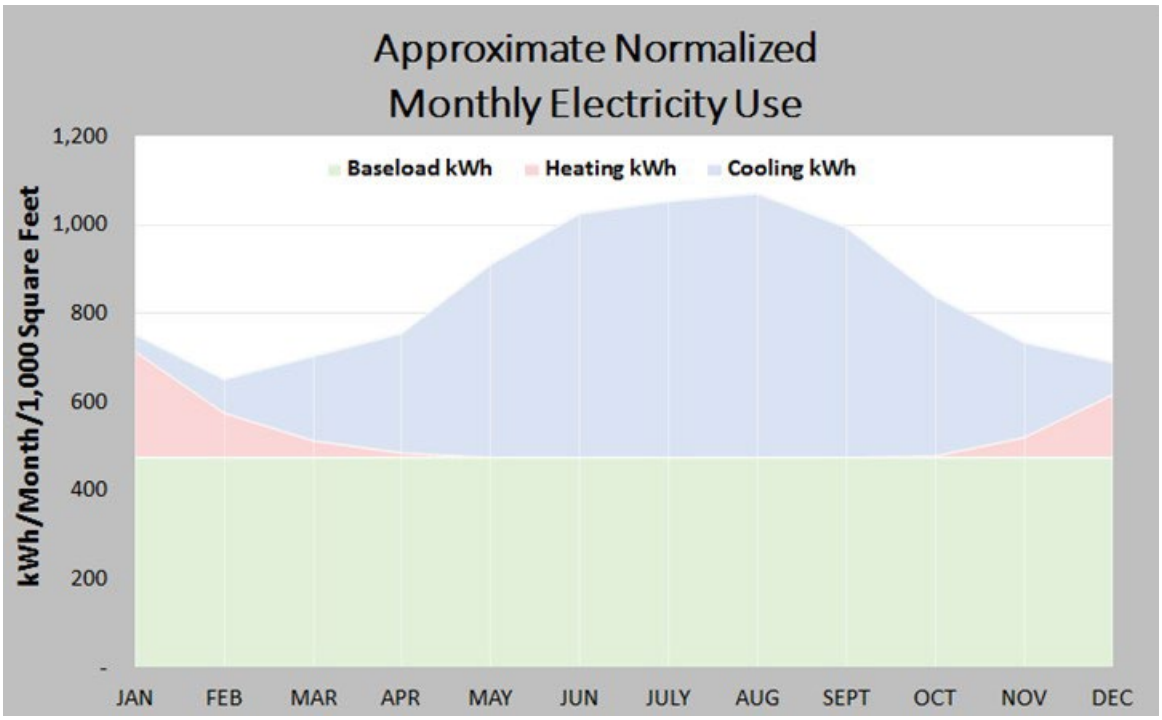
Appendix B – Utility Bill Analysis Methodology

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.

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.


Approximate Normalized
Monthly Electricity Use
Baseload kWh
Heating kWh
Cooling kWh
kWh/Month/1,000 Square Feet
1,200
1,000
800
600
400
200
-
JAN
FEB
MAR
APR
MAY
JUN
JULY
AUG
SEPT
OCT
NOV
DEC

Appendix C – Supplemental Information About Solar PV

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 at the end of each facility assessment section in the main report. They provide a photo of the footprint approximate area 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.

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.

In some cases the roof area could accommodate solar panels capable of producing far more power than the annual energy use of the building. 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 site 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.

FSEC would recommend installing only the number of PV panels needed to offset predicted annual energy use after EEM are adopted, limited to resulting in a net zero energy (NZE) building. The top capacity recommended for buildings in this report did not exceed 109 kW DC generation.

Installed Output Capacity Considerations

The local electric utility requirements must be considered for on-site generation of any type. There are typically requirements for insurance or proof of self-insurance for different capacities of generation. An example may look something like this below.

Tier 1 system <= 10 kW generation

Insurance not required

Tier 2 system > 10 kW to <= 100 kW
Insurance of at least $1 million; may self-insure
Tier 3 system >100 kW to < 2 megawatts
Insurance of $2 million; may self-insure.

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 settings typically ranges between $1.75 and $2.00 per watt, but can be more in some cases. The PV installed estimated costs used in this 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.

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.

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 a site, the contractor selected for installation should provide a minimum period of service and maintenance. Many solar companies now routinely offer this service. However, when possible, it is recommended that plant or maintenance personnel be trained by the equipment providers on routine maintenance and troubleshooting.

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. 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 on flat roofs; 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.

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