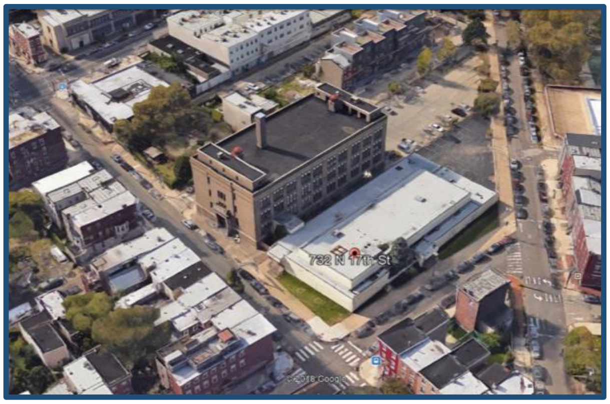

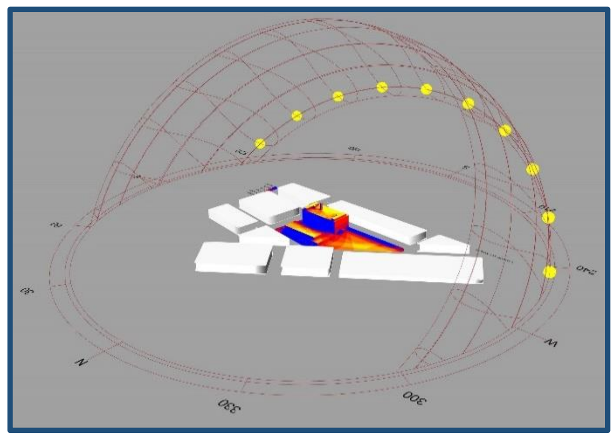

The Samuel D. Cozen Center

Philadelphia Police Athletic League

Prepared by Power Lion Energy

ELECTRI International | Green Energy Challenge 2018

PennState

NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION PENN-DEL-JERSEY CHAPTER

NECA WESTERN PENNSYLVANIA

ELECTRI INTERNATIONAL THE FOUNDATION FOR ELECTRICAL CONSTRUCTION INC.

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Executive Summary

Introduction:

Power Lion Energy is pleased to present its energy efficiency upgrade and Net Zero Building capability proposal for the Cozen Center operated by Philadelphia's Police Athletic League (PAL). This proposal includes a holistic and detailed analysis of the Cozen Center as well as a cost proposal to convert the building into a net zero facility with improved capacity to serve its community as a resilient emergency shelter. Following a detailed energy analysis, we propose an integrated energy retrofit that will allow the PAL to (1) Improve the comfort and functionality of Cozen Center, (2) Save money on energy costs so that more funding can be diverted towards their core mission of youth development throughout Philadelphia, and (3) enable the facility to serve as an emergency shelter through a resiliency component through the introduction of solar-integrated energy storage.

Picture 1: *"WE ARE Power Lion Energy"*

Mission Statement: Power Lion Energy is committed to delivering forward-thinking, creative, and cost-effective energy solutions our clients. We strive to build trust so that our clients can leave their energy challenges and management to us so they can focus what they do best. Our goal is to create lasting relationships through innovative, high quality, and lasting solutions that are highly responsive to client needs.

Summary of Recommendations: We propose a combination of measures to reduce existing energy requirements for annual heating by **68.78%** and electric energy consumption by **45.98%.** The estimated project costs are **$682,244** and are expected to be fully financed with and anticipated payback period of **7.5 years** utilizing available incentive programs. Our proposal reflects a detailed understanding of the Cozen facility, including the existing conditions of the center as well as the variable levels of occupancy and types use of the building. Our comprehensive analysis of the building allows us to propose significant improvements in four main areas:

Lighting in the facility is outdated and can be easily replaced with more efficient and cost-effective options. Efficient lamps combined with modest use of vacancy sensors will dramatically reduce the energy cost of lighting the building.

Mechanical systems in place to heat and cool the center are inefficient and inappropriate for the needs of the building based upon its use and occupancy schedule. Our proposed system is optimized to meet the needs of the building in a more efficient way that is better suited to the occupancy schedule.

High-impact Envelope improvements including adding roof insulation concurrent with a planned roof replacement, and perimeter wall insulation throughout the building.

Solar and Battery Storage: 100 kW solar and 250 kWh storage renewable energy hybrid storage system that will allow the building to operate as a net zero building, but have increased capacity to serve as an emergency shelter in times of crisis. The energy storage system will also operate in the real-time energy market, generating revenue for the Cozen Center by performing multiple grid services.

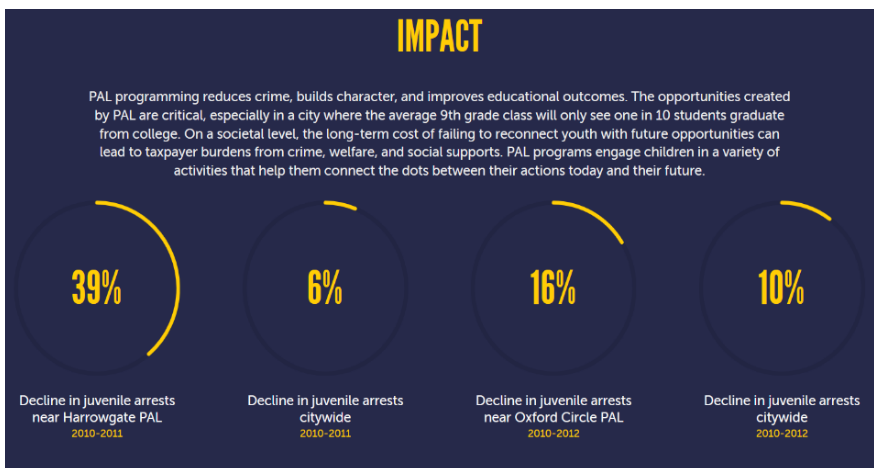
Project Summary

Client and Facility Summary

Introduction to Client: The PAL in Philadelphia has twenty buildings across the city that offer free programs to children ages 6-18. These programs include homework help, computer education, mentoring programs and a wide variety of sports. The mission of the PAL is to keep children safe and occupied after school and during the summer months when student-aged children are statistically at the highest risk of becoming victims of crime in urban areas. For many students, PAL programs offer not only a safe place to be, but programs that challenge them to develop and mature.

Across the City of Philadelphia, the Police Athletic League engages 18,000 students a year, with 10,000 of those students being active members of their respective clubs. The Cozen Center itself has 635 students registered and serves 60 active students on a daily basis. The Cozen Center operates from 1:00 PM to 9:00 PM throughout the school year. During the school year, the center reaches peak occupancy when students arrive at 3:00 and remains at peak occupancy until closing at 9:00. Throughout the summer months, the Cozen Center is occupied from 9:00 AM to 5:00 PM, and is at peak occupancy for the entire day. The school year is dictated by the Philadelphia Public Schools calendar and typically begins in the final week of August and end in the 2nd or 3rd week of June.

It's all about the kids: PAL's slogan is "Cops Helping Kids". Since 1995, the Cozen Center has offered a wide variety of services and activities to the students that they work with. For instance, the Cozen Center provides mentorship programs for young men and women, college and career counseling, a chess club, computer education programs, and they always have a staff member on hand to assist students with their homework during the school year. The PAL also offers a wide variety of sports programs for their students. At the center, the most popular sport is Basketball. These programs are essential to the students and their families because they promote mental and physical well-being, with a focus on character-building. Since the PAL program has been implemented in Philadelphia, there has been a significant decrease in juvenile arrests as well as an increase in the number of young adults pursuing higher education.



Picture 2: Some of the positive impacts PAL centers have had in the Philadelphia area (2010-2012). Photo taken from phillypal.org.

Building Description and Location: The Cozen Center sits in "Francisville" in downtown Philadelphia – an up and coming neighborhood between Fairmount and Girard Streets. We believe that the valuable programs provided by the Cozen Center will eventually evolve to meet the growing potential of this neighborhood. We also believe that achieving a net zero energy profile could serve as vital first step towards this goal, as precious funding used to pay for utilities would be redirected to core programs and activities. We believe that our proposed improvements for the Cozen Center will vastly decrease energy costs and improve the ability of the facility to serve the Francisville community.

Picture 3: An aerial view of the Cozen Center from the North-East. Taken from Google Maps.

Future business development opportunities: The Police Activities League (PAL) in Philadelphia operates 20 facilities across Philadelphia. PAL's primary focus is to provide programs that improve the lives of people living in their communities, particularly the children. As a result, our proposal includes financing strategies that focus on leveraging incentive programs on the local, state, and federal levels so that PAL can improve their facilities while ensuring that the funding remains mostly focused on their core mission of helping communities. Our goal will be to demonstrate the feasibility and value of adding features of this project to the PAL organization and to provide a blueprint for the pursuit of similar projects in the greater Philadelphia region.

Summary: Our proposal includes a complete analysis of all aspects of the building that affect its energy efficiency. After detailed energy analysis and planning, we propose an integrated energy retrofit that will allow the PAL to (1) Improve the comfort and functionality of Cozen Center, (2) Save money on energy costs so that more funding can be diverted towards their core mission of youth development throughout Philadelphia, and (3) enable the facility to serve as an emergency shelter through a resiliency component through the introduction of solar-integrated energy storage.

Picture 4: Power Lion Energy interacting with PAL students during their after-school program.

Project Summary

Team Members

Project Manager

Liam Cummings

B.S. Energy Engineering and B.S. Energy Business Finance
Class of 2020

GEC Responsibilities: Managed all GEC team members. Coordinated relationship with site partner and relationships with external NECA contractors and other professionals. Set goals for the individual teams, and periodically supported all team members and aspects of project.

Relevant Work Experience:

Volunteer Project Coordinator *September 2017- Present*
-Co-Manage recruitment for and facilitation of 30 volunteer service projects engaging 200+ volunteers. Collaborate with executive team to identify and prioritize tasks and projects suitable for volunteer work.

Sustainability Systems Intern *October 2016 – Present*

- Coordinate tours, volunteer service days and sustainability events at the MorningStar Solar Home for 56 events with 850+ guests

Projects:
5 kW PV installation– Birney, Montana
- Planned and led installation of PV Solar Array for a community center on a Native American Reservation.

Current Positions:
Vice President - College of Earth and Mineral Sciences Student Council

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Energy Analysis Team Leader

Nathan Haile

B.S. Energy Engineering and Environmental Engineering Minor
Class of 2019

GEC Responsibilities: Assess current utility bills, building envelop, HVAC and lighting systems. Build and analyze energy model simulations. Provide energy efficient upgrades to electrical systems to reach Net Zero Energy.

Relevant Work Experience:
- Solar Panel Installation Project in Roatan, Honduras (March 2018)
- Burkina Faso FEW Nexus research team, Brownson Solar Group (August 2017 – Present)

Solar Energy System Lead

Corey Crews-Williams

B.S. Energy Engineering
Class of 2019

GEC Responsibilities: Led the design of the solar energy system for competition. Designed a 3D model of the site location. Worked with the Project Manager to performed the site and shading analysis for the location.

Relevant Work Experience:

NECA Service Project **–** Roatan, Honduras — March 2018
-Designed and constructed a 6kW solar array to power a water pump

GREEN Program – Reykavik, Iceland — August 2017
-Studied renewable energy systems at Reykavik University, Iceland

Parks & People Study Abroad – Mang'ula, Tanzania — May 2017
-Performed an economic assessment on traditional and renewable energy methods in rural Tanzania

Race to Zero – Pennsylvania State University — February 2017 – September 2017
-Contributed to the water and energy system design for a green building competition held by the U.S. Department of Energy

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Outreach Team Leader

Nisha Labroo

B.S. Energy Engineering
Class of 2020

GEC Responsibilities:

Coordinated all volunteering efforts by team. Responsible for creation of videos and correspondence with local NECA chapters.

Relevant Work Experience:

The Pennsylvania State University
Learning Assistant, CHEM110 — August 2017 – December 2017
Facilitated student learning of basic Chemistry both in class and during recitation. Required SC 220 in conjunction for basic teaching and demonstrative training.

Oneonta City Hall, 258 Main St. #1, Oneonta, NY 13820
Engineering Aide — June 2017- August 2017
Provided in-depth research and analysis of community environmental planning projects (Clean Energy Community, electric vehicle charging station implementation, composting facility, benchmarking municipal buildings, et cetera).

Projects:

NECA Solar-Water Initiative – Honduras
- Punta Gorda (03/04-11/17)
- West End (03/03-10/18)
  - *Student trip leader*
  - Presented at 2 Electri International meetings (Jan. and Feb. 2018)

Current Position:

Vice President of Penn State NECA Student Chapter

Lighting Retrofit Leader
Taylor Schoch

B.A.E. Architectural Engineering
Class of 2021

GEC Responsibilities: Conducted lighting energy analysis of building, formulated ceiling plan, and determined the best ways to achieve more efficient lighting in the Cozen Center.

Relevant Work Experience:
High Construction Company, LLC.
Construction Management Intern
Worked on developing solutions based on project needs and evaluated contractors' work for accuracy and completion.

Pennsylvania Department of Transportation
Engineering Intern
Carried out construction inspection duties of highway bridge while shadowing project manager. Verified certifications and carried out quantity reports.

Projects:
NECA Solar-Water Initiative
- West End (03/03-10/18)

Construction Management
Anthony Dominick

B.S. Architectural Engineering
Class of 2021

GEC Responsibilities: Lead construction management team, coordinated building upgrade scheduling, calculated project financing, estimated costs, supervised scope reconciliation.

Relevant Work Experience:

Airport Ice Arena
Worked for 3 years at Airport Ice Arena in Pittsburgh, PA. Performed maintenance tasks such as rink glass replacement and Zamboni repair, worked with a team to create a professional-quality ice hockey surface.

Building Supervisor August 2017 – Present
As a building supervisor, I am responsible for managing student Facility Attendants, and ensuring that they execute their tasks efficiently and effectively. On a daily basis I assist building patrons and maintenance workers, provide first aid care to patrons, and lock/unlock rooms for clubs and organizations

Technical Analysis 1:

Total Building Energy Efficiency

Project Goal - Economic Net Zero Energy (ENZE): Our approach to this project was to pursue a Net Zero Energy building and in doing so, to demonstrate market leadership in this emerging premium standard of energy efficiency and sustainability. An ENZE building combines high levels of efficiency, mindful operation, and on-site renewable energy production to fully offset annual energy consumption and costs. The Cozen PAL Center represents a unique opportunity to pursue this goal in a manner that is responsive to the market and financing mechanisms. A thorough assessment was undertaken to launch this analysis, including the evaluation of existing building energy performance and utility costs, lighting, electrical, and mechanical systems, as well as occupancy patterns. The goal of this data collection process was to enable energy modeling and the evaluation of multiple scenarios of upgrades leading to net-zero capability. A summary of initial findings is described below.

Existing Conditions:

Utility Bill Analysis: A successful net zero energy retrofit must start with an analysis of the utility bill to understand how and where energy is consumed (*see Appendix 3.1*). The annual energy consumption is gathered from bills regarding electricity and natural gas usage. Electricity accounted for 29.4% (52,720 kWh) of annual consumption while natural gas reported 70.6% (126,800 kWh) of its yearly energy usage. This gives a starting point for the amount of on-site renewable energy production necessary to reach the building's goal of ENZE. Peak months of energy demand include December, January, and February. During the building assessment, attention was paid to supplemental heating sources used by occupants (i.e. space heaters), and occupancy patterns of the facility.

Lighting: The Cozen Center's rooms are currently lit with fluorescent T-12's and a small number of T-8's (Figures 1 and 2). The gymnasium has 20 metal halide 175 W/U fixtures. Currently, the facility has no occupancy sensors, daylight control, or other forms of automated lighting. All these factors account for a significant amount of electricity consumed that can be saved. A detailed analysis of lighting upgrades and the potential addition of lighting controls was performed due to the high likelihood of this aspect of the project being profitable.

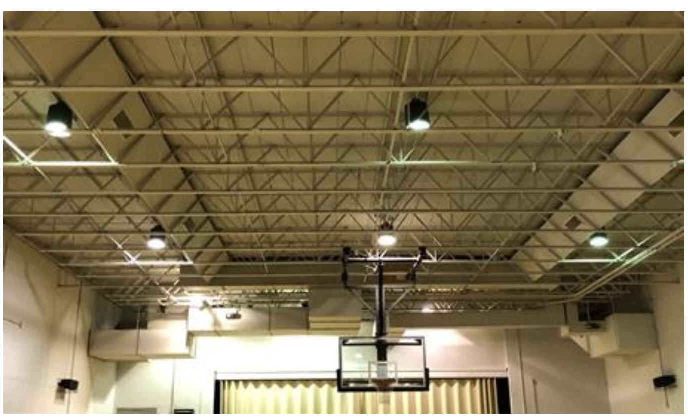


Figure 1: Gymnasium Lighting

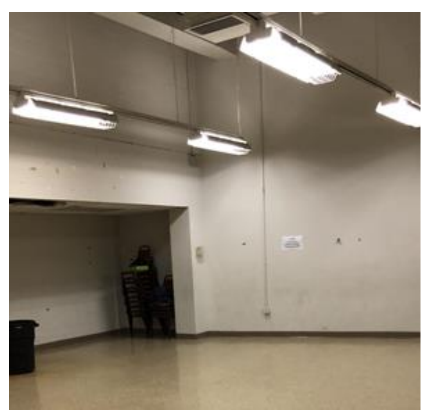


Figure 2: Typical T12 lighting

Existing Building Envelope: The building is approximately 90 feet by 180 feet, with a height of 15 feet. The floor plan of the building is shown in Figure 3. A separate but attached roof for the gym area adds another 12 feet in height for a total building height of 27 feet. The exterior and interior walls of the Cozen Center are composed of double-wythe CMU blocks with little to no insulation. The interior and exterior walls of the building also have a coating of stucco. This locale features single pane windows with no thermal break. Adjacent to this building is the Darrah Apartments, spanning an area of 158 feet by 171 feet, with a height of 56 feet. This building offers additional shading to the Cozen Center. More analysis of this shading is done in the Solar section.

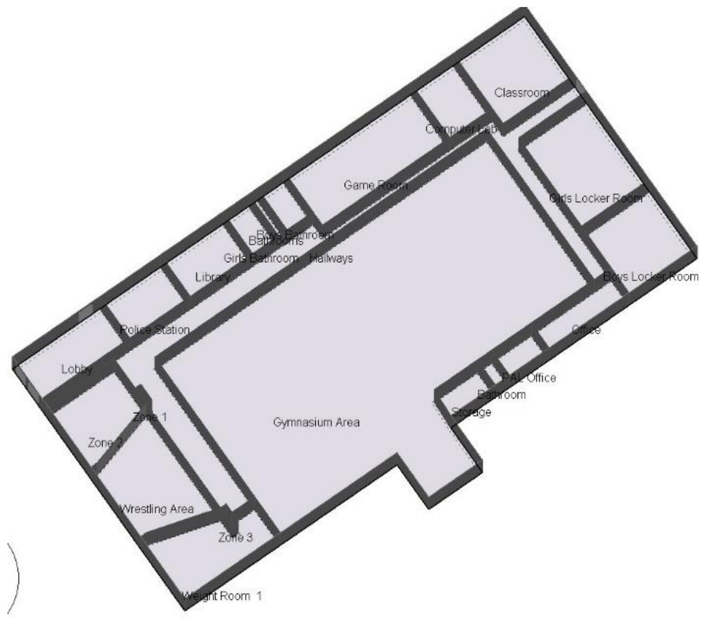


Figure 3: Cozen Center Floor Plan

The roof structure of the building and the gymnasium consists of metal joist and concrete with no existing insulation. There are 17 rooms in the Cozen Center; they include: 1 gymnasium, 2 offices, 2 locker rooms, 2 bathrooms, 2 rooms used primarily for storage, a computer room, a classroom, a game room, a library, an electrical room, a community room, a lobby, and a boiler room. The temperature set point of the gym is 60 degrees Fahrenheit, while the classroom and offices have a set point of 67 degrees Fahrenheit.

Thermal imaging of the Cozen Center shows that both the single paned windows and doors used offer little to no insulation, allowing heat to escape through these cavities (refer to Figures 4 and 5). The use of double wythe cinder-blocks, with no true insulation between blocks, also allows for heat to escape from the building, requiring higher usage of a natural gas heater to compensate for this loss of energy.

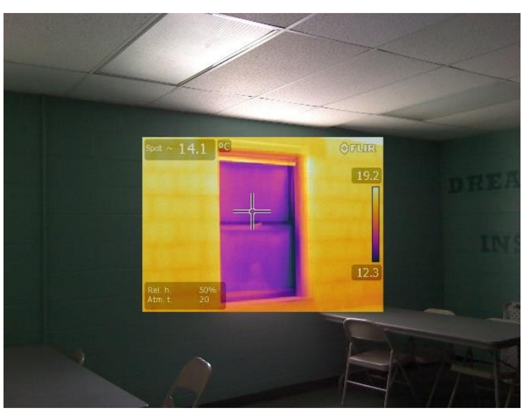


Figure 4: IR image of exterior door

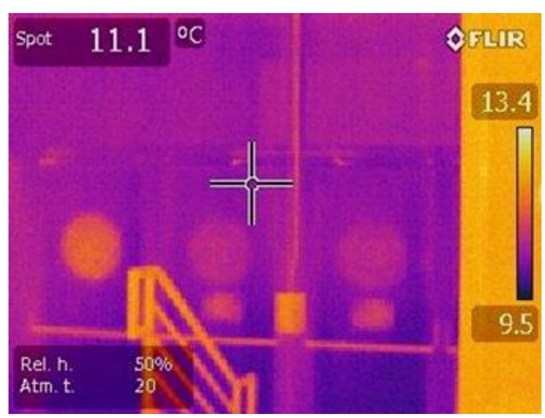


Figure 5: IR image of building envelope

Heating and Cooling: The HVAC system has an AC unit (Figure 6) operated by a packaged rooftop air conditioner while the heating is controlled by a natural gas boiler. HVAC runs on a weekly schedule that begins on Monday at 1PM and ends on Friday at 7PM, thus consisting of 102 hours of operation per week. In addition to the boiler, personal space heaters were found in rooms that contribute to electricity usage during the winter months. There has been little to no maintenance on the system since the Cozen Center's construction. In addition, the system is not being run in a way that maximizes efficiency, and this aids the high electricity and natural gas consumption.

Figure 6: Rooftop AC unit

Occupancy and Use: During the school year (defined as the months of September to June), the Cozen Center operates from 1:00 PM at limited capacity, then reaches maximum capacity (peak hours) between the hours of 5:00 and 9:00 PM. Limited capacity in this case refers to a small group of 4 to 5 staff members in office spaces. Maximum capacity is comprised of roughly 60 students who visit the Cozen Center after school hours, along with staff members that either work in the director's office or supervise students during programs and events.

Throughout summer break, or the months of July to August, the Cozen Center operates from 10:00 AM to 9:00 PM. The rooms most occupied during the peak hours of 5:00 to 9:00 PM include the computer room, the game room, the classroom, the library, the gymnasium, and the community room, where students make up the largest percentage of occupancy. The two offices also exhibit high occupancy after school hours, as staff members make use of these rooms to plan and carry out preparation for incoming students and upcoming events. The lowest occupancies are the north and south locker rooms, the police mini state, and the weight room, which are used most often as storage units.

Solar Potential: The Cozen Center roof is partially shaded and limited in size. To achieve our Net Zero Energy goal, the installation of solar panels on the roof of the Cozen Center and the roof of neighboring Darrah Apartment complex is explored. The inclusion of battery storage system to serve as a back-up power source as well as produce revenue is also examined. This analysis includes the technical requirements as well as the ability of the system to contribute to a reasonable payback for the investment. This complete analysis is offered in the Solar section of our proposal.

Energy Analysis and Simulation:

Having completed a detailed assessment of existing conditions, multiple analysis tools were utilized to determine potential upgrades to energy efficiency as well as the impacts of these upgrade to energy use and utility expenses.

The Asset Score: The analysis utilized the DOE's Asset Score software (Figure 7-1) and the EPA's Energy Star Portfolio Manager (Figure 7-2). Our team developed the model of the Cozen Center in Asset Score to analyze its physical and structural energy efficiency. The Asset Score tool considers a number of aspects including building envelope, lighting, hot water, and HVAC systems, that factor into the building's overall energy usage. The Asset Score generates a simple energy efficiency rating from 1-10 (1 being the worst, 10 the best) that enables comparison among buildings and identifies opportunities to invest in energy efficiency upgrades. The Cozen Center received the score of 6.5 at its existing condition but the building has a potential score of 9 if improvements are made. Some of the recommendations by Asset Score were adding wall, floor and roof insulation, improving the lighting system, and improving the HVAC and hot water system.

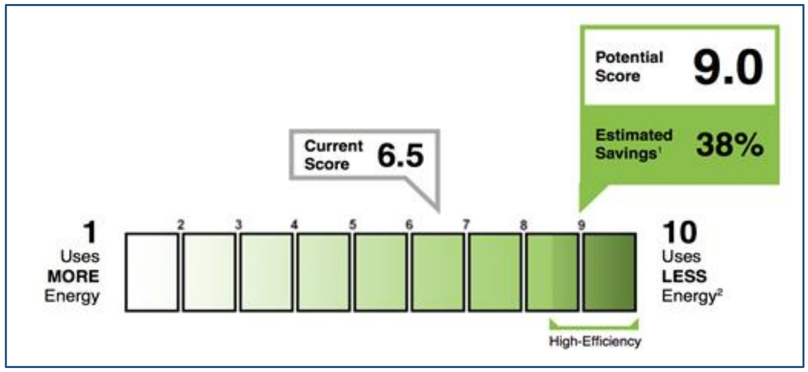


Figure 7-1: DOE Building Asset Score

EPA Energy Star Portfolio Manager: The Cozen PAL Center is a mix-use building consisting of classrooms, offices and a gym area. The EPA's Energy Star Portfolio Manager Tool takes the facility's electricity and natural gas consumption information with regards to heating, cooling, lighting and water usage, along with building details, to provide insights into how the property is performing. It also provides an ENERGY STAR score from 1-100 that compares a property's energy performance to similar properties nationwide. There is no equivalent building type in the Portfolio Manager tool so we assumed the use would be most similar to a K-12 building. The Cozen Center received an Energy Star score of 52 (Figure 7-2), which means that the building is outperforming 52% of its peers. The EUI of this building was 3.8 kBTU/sq. ft. Since the Energy Star score is less than 75, the building is not eligible for an Energy Star certification in its existing condition.

Metrics Summary

Metric	Jul 2017 (Energy Baseline)	Nov 2017 (Energy Current)	Change
ENERGY STAR Score (1-100)	51	52	1.00 (2.00%)
Source EUI (kBtu/ft²)	63.7	62.8	-0.90 (-1.40%)
Site EUI (kBtu/ft²)	37.6	37.6	0.00 (0.00%)
Energy Cost ($)	13,189.72	12,696.34	-493.38 (-3.70%)
Total GHG Emissions Intensity (kgCO2e/ft²)	2.7	2.6	-0.10 (-3.70%)
Water Use (All Water Sources) (kgal)	Not Available	14.2	N/A
Total Waste (Disposed and Diverted) (Tons)	Not Available	Not Available	N/A

Figure 7-2: EPA Portfolio Manager

Building Energy Simulation: Our comprehensive energy analysis culminated in the development of an energy simulation model using the Ladybug and Honeybee software programs. These tools enable the existing conditions to be modeled and calibrated with existing utility bills as a base model. Once a base model is developed and calibrated, multiple scenarios and combinations of energy upgrades can be analyzed to determine an optimum approach for total building energy efficiency. The Ladybug and Honeybee tools were selected due to their open source features and their ability to create the 3D model and visualize the results. This plugin provides the simultaneous execution of illuminance, thermal, and solar analyses. Our specific approach to energy simulation is shown in Figure 8. (1) Rhino and Grasshopper software programs are utilized to generate the 3D model of the building; (2) Weather data is imported through an.epw file; (3) Ladybug is then utilized to conduct solar and radiation analysis; (4) Honeybee is utilized as an interface to DOE Energy Plus and OpenStudio to perform building energy analysis and thermal comfort.

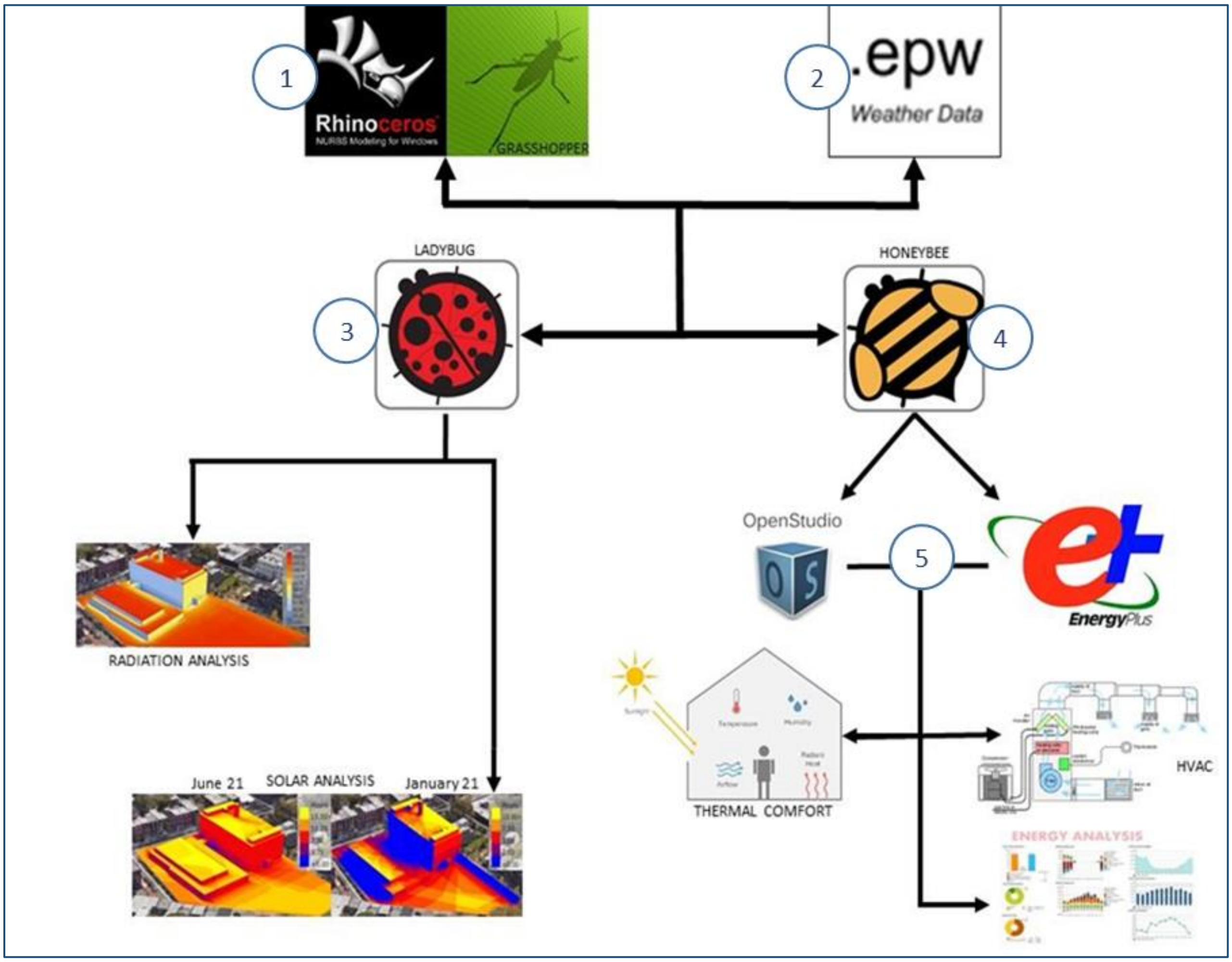


Figure 8: Building Energy Simulation Approach

Based on our asset score model recommendations, we defined various retrofit scenarios to improve building energy performance. Table A shows the list of all the considered retrofit scenarios for the Cozen PAL center.

Scenarios	Strategies
Heating and cooling demand reduction- Demand Side management	Window retrofit (multiple glazing, low-E coatings, Shading systems, etc.)
	Building insulation on roof and walls
	Air sealing
Energy efficient equipment and low energy technologies- Demand side management	LED replacement lamps or fixtures + controls
	Replacement of existing HVAC with split system
	Replacement of boiler with electric heat / fan coil
Human Factors- Energy consumption pattern	Remove personal space heaters Adjust the temperature to provide comfort for occupants Heat and cool only occupied spaces Adjust the temperature based on occupant activity
Renewable Energy technologies- Supply side management	Evaluate Solar PV system Evaluate Geothermal energy system

Table A: Energy Modeling Scenarios and Strategies

Along with the aforementioned retrofit scenarios, the effect of heating and cooling demand reduction, energy efficient equipment, low energy technologies, and human factors on building energy performance were examined through energy simulation. Table A lists all of the considered retrofit scenarios for the Cozen Center, as well as the effect of each of the considered variables on total building energy performance. The energy modeling and simulation tools described above were utilized to evaluate both the individual and combined effects of the scenarios and strategies identified for the Cozen Center. Final recommendations were then made to determine overall energy savings as well as capital costs for upgrades.

Recommendations and Results

Based on analyses of existing conditions and energy simulation modeling we recommend the following set of energy efficiency upgrades and estimate the PAL Cozen Center can potentially save an average of 93,882 kWh each year.

Lighting Retrofit: Replace current T12 fluorescent lighting and metal halide fixtures with LED alternatives to reduce the wattage being used by the lights. Add occupancy/vacancy sensors within the interior lighting controls would reduce energy by eliminating unnecessary lighting in rooms that are over-lit or unoccupied. A detailed analysis of the lighting retrofit is included in the following section of this proposal.

Envelope Upgrades: Addition of insulation to the walls and roofing of the building will cut back on energy consumption due to heating by 34% and cooling by 27%. This results in higher R values that lower energy demand by reducing heat transfer. The Cozen Center has scheduled a roof replacement in the near future, which would provide a low-cost opportunity to add insulation to the roof.

Heating and Cooling System Retrofit / Re-purpose: To eliminate the natural gas heating system, we recommend that the Cozen Center switch their current HVAC system to a mini-split system that has the capability of individually cooling and heating the offices. As for the gym, implementing a radiant heating system under the floors of the bleachers would be a common-sense location for the system, and it would enable conversion to electric heating thereby eliminating natural gas use and service costs.

Net Zero Building + Resiliency Capability: Having achieved significant improvements to building energy efficiency, an analysis was completed (see Solar section for full details) to assess the solar generation capability of the site, including the potential utilization of the adjacent apartment building roof. The exploration of battery energy storage will also be carried out to (1) enhance revenue of a solar system through ancillary services and (2) enable limited use of the building as an emergency shelter in an islanded mode in the event of loss of utility.

Estimated Savings: Figures 9-1 and 9-2 compare the actual monthly heating and electricity energy consumption with simulation results. In these figures, heating represents the heating load and hot water energy consumption while electric represents the cooling load, lighting, and equipment energy consumption. As shown, there is a good agreement between actual energy consumption and simulation results which indicates the accuracy of the energy simulation model. The error was 1.3% and 4.8% for the heating and electric loads, respectively.

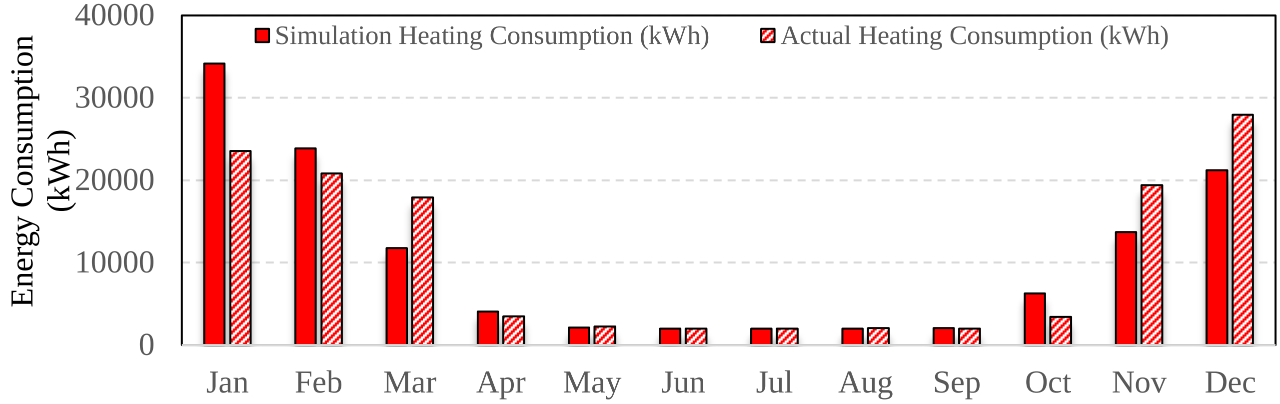


Figure 9-1: Actual Monthly Heating Consumption

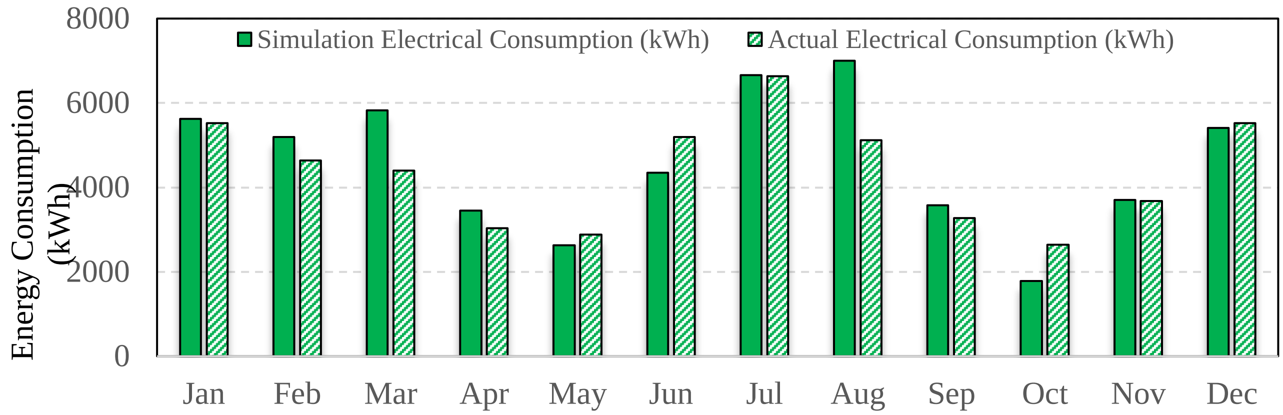


Figure 9-2: Actual Monthly Electricity Consumption

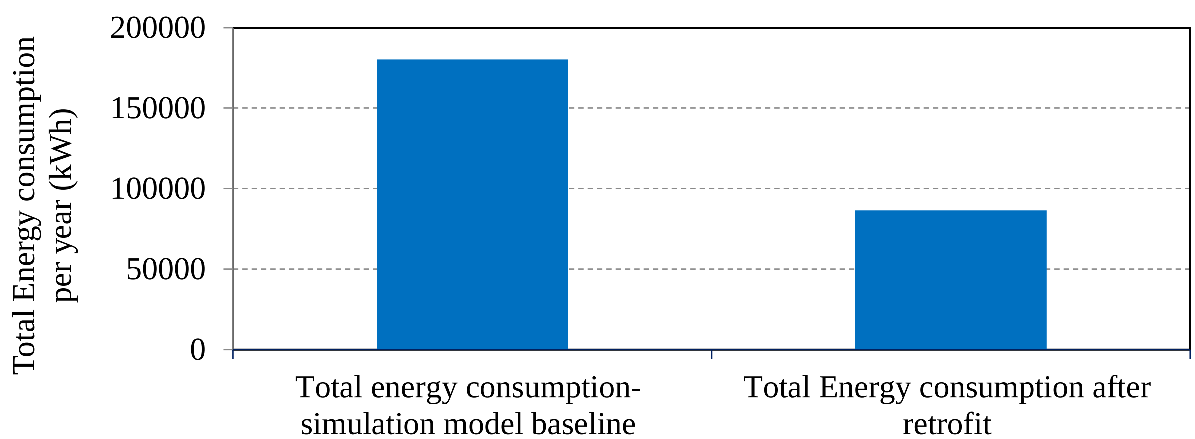


Figure 9-3: Total Energy Consumption Comparison

Figure 9-3 compares the total simulated energy consumption before and after implementing all the retrofit scenarios. It can be seen that the total energy consumption was reduced by 52% or 93,882 kWh.

Technical Analysis 2

Lighting Retrofit

Space Assessment: The Samuel D. Cozen PAL Center houses offices, multi-purpose rooms, and recreational facilities for the community built with the primary purpose of keeping children engaged and safe after school. The majority of the building is illuminated with linear fluorescent fixtures. The dominant lamp type is the fluorescent T-12 and T-8. The fixtures are primarily recessed with some shop fixtures installed in the boiler room as well as on the stage. Based on the qualitative and quantitative criteria, the existing lighting levels are adequate. Corridors are well lit; however, the exit lights are dimly lit which becomes hazardous in the case of an emergency.

A detailed lighting analysis was conducted on the gymnasium and classroom as these rooms are at full capacity between 5:00 PM to 9:00 PM which happen to be the peak hours for the facility. The classroom has nine recessed fixtures with each fixture holding two T-12 bulbs. The gymnasium has 23 metal halide 175 W/U fixtures.

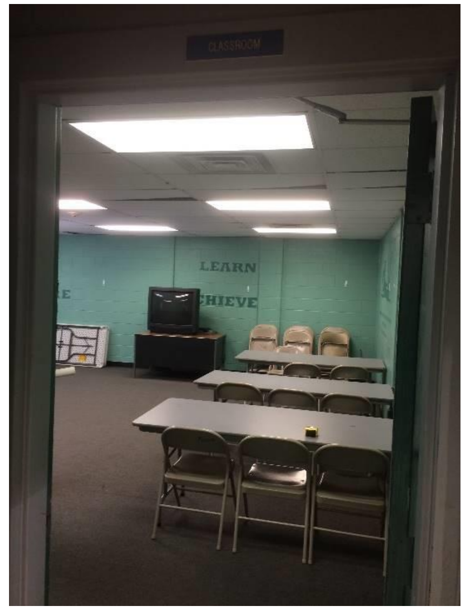


Figure 10: Existing lighting conditions in the Cozen Center

The existing fixtures in the classrooms do not meet the ASHRAE standard 90.1. The lighting fixtures in the gymnasium exceed ASHRAE Standard 90.1 by 25%. The classroom averaged 23 foot-candles (fc) which is below the IES (Illuminating Engineering Society) recommended practice. It states that the minimum amount of light should be around 30-50 fc at desk level. As the building is most often occupied from 5-9 PM, there is minimal effective daylighting, and therefore, it was not factored into the analysis.

Design Options: The current lighting power density of the Cozen center is 0.53 W/SF which is significantly greater than current standards. Two options for lighting upgrades were evaluated including (1) Full fixture replacement and the addition of basic lighting controls and (2) Lamp only replacement and controls. Each option was analyzed for the classroom and gym. Further analyses are described on the following page.

Option 1: Fixture Replacement and lighting controls

Classrooms: Fluorescent fixtures are replaced with an LED equivalent fixture. Economies of scale will be realized by maintaining current locations of fixtures and not changing the layout of fixtures and controls.

Gymnasium: Metal halide lamps will be replaced with LED equivalents. Using LED metal halides will also provide more lumens per wattage. They also don't have time lags when switched on. For the gym in particular we would not be installing new LED fixtures because they cost more than an LED retrofit.

Manufacturer	Fixture Type	Quantity
PLT	LED Corn Bulb	23
Philips	2X4 Recessed LED	53
Lutron	Powerpak 0-10V	11
Lutron	Ceiling-mount dual technology sensor	11
JC Penny Home	Blackout Cordless Cellular Shade	12

Table B-1: Proposed Lighting Replacements

To compare the lighting power density of the existing T-12 fixtures to the proposed LED fixtures, the team used the space-by-space method outlined in ASHRAE Standard 90.1. By switching to the LED's, the total power decreases by 31.5% in the classroom and 43.8% in the gym. Applying the fixture replacement to the whole building would decrease the total lighting density by 37.7%.

Figure 11: Vacancy sensors to be used in the Cozen Center

Dimming switches will be used in all rooms to enable the full advantage of the dimmable LED fixtures. The variable levels of occupancy in the Cozen Center can potentially benefit from basic vacancy sensors that require lights to be turned on manually, but then shut off if rooms are detected to be vacant (Figure 11). Our cost and energy analysis assumes nominal use of vacancy sensors in the classroom and office space.

Option 1 results in the total lighting power use decreasing by 40% when the vacancy sensors and dimming controls are applied throughout the building. The facility will only use 0.32 W/SF for lighting compared to 0.99W/SF, which is what is allowed by the ASHRAE Standard 90.1.

Option 2: Lamp Replacement and lighting controls

In option 2, the lamp replacement would be used only for classrooms, with gymnasium fixtures and lighting controls assumed to be the same as option 1. Table B-2 summarizes the estimated impacts of the proposed lighting upgrades.

The potential to simply replace the lamps in the T12 and T8 fixtures with replacement LED lights was also evaluated. This could potentially reduce the overall cost due to lower material costs, and the less labor-intensive approach method is to apply a lamp replacement rather than a fixture replacement. This option assumes that all of the existing fixtures are standard and in good operating condition.

Location	Area	Existing	Option 1	Option 2
Classroom	6100 SF	4025 W	270 W	261 W
Gymnasium	614.4 SF	720 W	4025 W	4025 W
Entire building	15650 SF	8265 W	6155 W	6084 W

Table B-2: Summary of existing power requirements and impacts of options 1 and 2 and how they can be improved upon.

Recommendations

Our proposal recommends **Option 1** for the Cozen Center because it maximizes energy savings and also reduces the risk of a potential integration problems between fixtures and replacement LED lamps. While incurring higher capital costs, is likely to be a better approach due the age of the existing fixtures and the assurance that the power supply and dimming capabilities could be fully realized. Option 1 has a lower return on investment due to its higher upfront cost for the shades and daylighting controls as well as the complete fixture replacement.

The team also recommends the replacement of the existing 10 exit signs. The signs would be replaced with new LED exit signs. It is an important investment because these are the only lights that are on 24/7 in the center.

Technical Analysis 3

Solar + Energy Storage

Site Analysis: The Cozen Center is located directly North of the multi-story Darrah Apartments building complex, which shades the Cozen roof (Figure 12-1). This fact, coupled with the fact that our overall goal was for both Net Zero Energy and resiliency, we initiated an analysis that would utilize both roof surfaces. Our expectation is that this approach would require a "rental" of roof space on the building and that this cost would be factored into our financial analysis. Both rooftop locations were evaluated using the Ladybug plugin of Grasshopper, a graphical algorithm editor tightly integrated with Rhino's 3-D modeling tools. In the figure below (Figure 12-2), one can see that each roof is expected to experience a favorable amount of solar irradiance throughout the year even with weather conditions taken into consideration.

Figure 12-1: 3D View of Cozen Center (white building) and Darrah Apartments (brown building) (Google Earth)

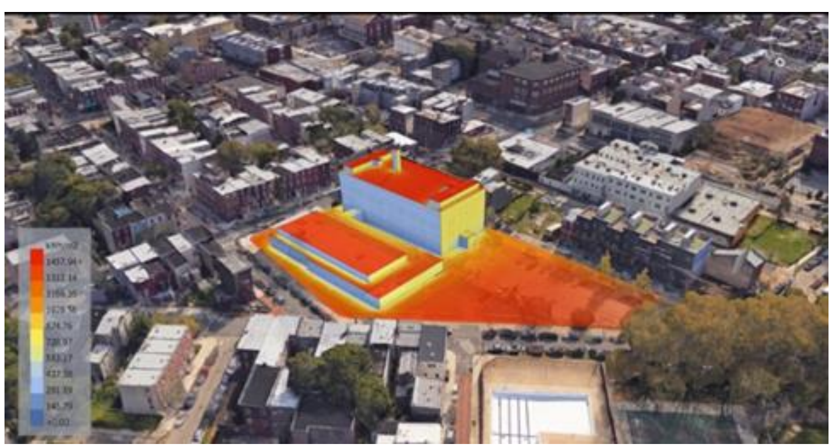


Figure 12-2: 3D View depicting solar irradiance on Cozen Center and Darrah Apartments. Solar irradiance analysis created with Ladybug.

Shading Analysis: The shading analysis enabled us to constrain the size of the array to where it would be most efficient and cost-effective, mitigating shading losses from the buildings as well as roof top equipment and structures. Figure 13-1 below illustrates the worst case of shading and sun path expected on the winter solstice, December 21st. Figure 13-2 illustrates the shading and sun path expected on the summer solstice, June 21st.

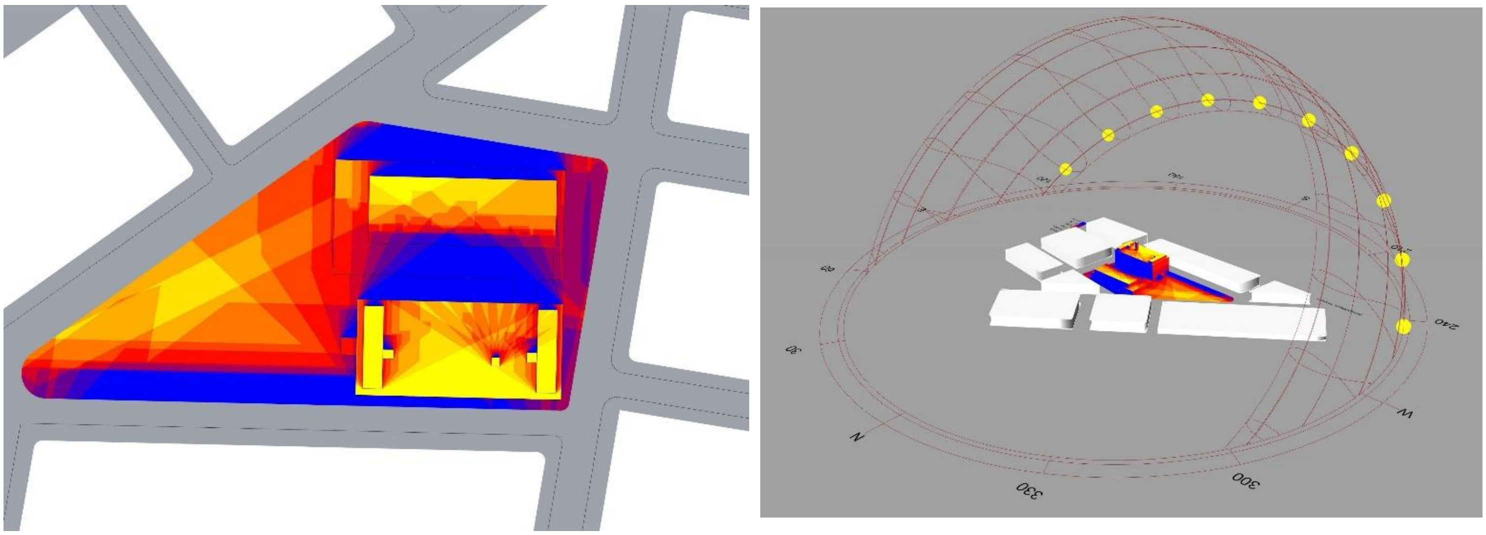


Figure 13-1: December 21st: Shading Analysis and Sun Path

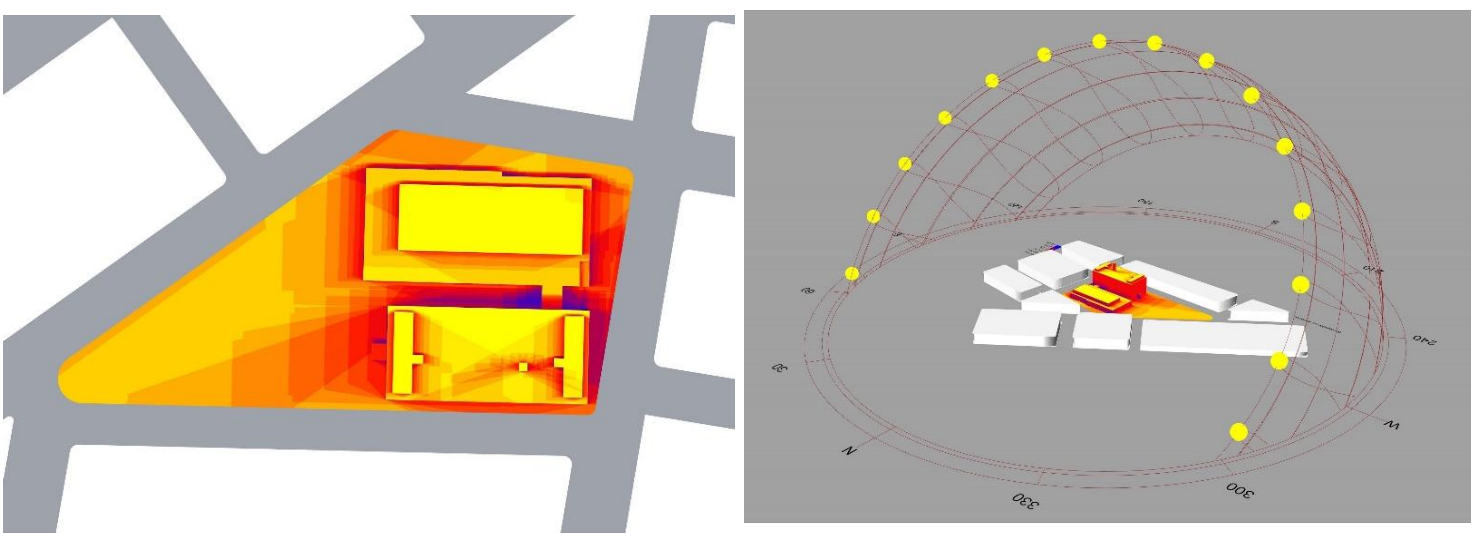


Figure 13-2: June 21st Shading Analysis and Sun Path

Solar System Design: A SketchUp model was utilized to develop a layout of modules on both roof surfaces. To optimize our annual production, we set our tilt angle to 5 degrees. This enabled us to reduce inter-row spacing and include more solar panels physically and thus maximizing overall generation of the array. The array on Cozen Center consists of 119 solar modules and the array on Darrah Apartments consist of 192 solar modules for a total of 311. SunPower327W panels were selected due to their high efficiency as well as the desire to maximize production and resiliency. Four Sunny Tripower 24000TL-US (SMA) inverters were selected due to their versatility for string layouts and operating power. The flat roof mount was designed with IronRidge racking systems. This decision was made because these racks are built to support the strong snow loads that Philadelphia is often susceptible to. The added racking weight for the Cozen Center will be 1262.5 lbs, while the Darrah Apartments will be 1996 lbs. Preliminary structural assessment of both buildings indicated that no structural upgrades would be required to accommodate the additional weight of the PV systems. Utility interconnection of the systems was also evaluated and would likely be achieved in the Cozen Center electrical room. The connection between the two buildings that would be required would be completed through a trench that would not require crossing of public right-of-way.

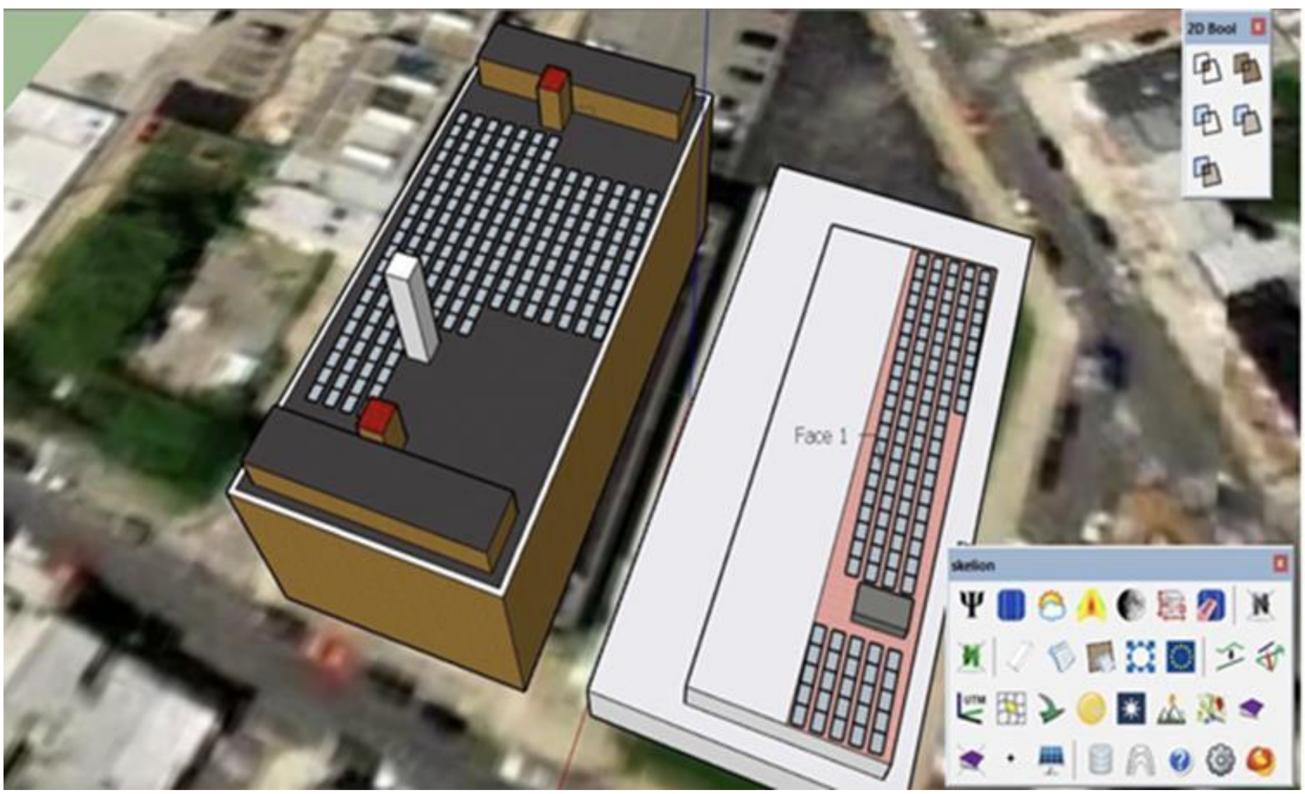


Figure 14: Sketch up model of both buildings with projected arrays

System Production: To estimate the production of the entire system, we used Skelion, an extension of Sketch up used to perform shading analysis in solar estimations. Skelion takes into the account system losses caused by shading and weather conditions of Philadelphia. This program provided us with monthly and yearly estimates of electricity production (see Figures 15-1 and 15-2).

	E_m (kWh/month)											
Group	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	5963.13	6971.97	10280.06	11804.71	13767.75	14262.10	13356.71	13415.15	10435.60	8671.80	6018.91	5072.90
∑	5963.13	6971.97	10280.06	11804.71	13767.75	14262.10	13356.71	13415.15	10435.60	8671.80	6018.91	5072.90

Figure 15-1: Monthly Output Predictions of the combined Cozen and Darrah arrays

	Yearly average			
Group	**Edy (kWh/day)**	**Emy (kWh/month)**	**Hdy (kWh/m^2/day)**	**Hmy (kWh/m^2/month)**
1	328.82	10001.73	4.19	127.36
∑ or Mean	328.82	10001.73	4.19	127.36

Figure 15-2: Projected annual production of Cozen and Darrah arrays

Energy Storage Analysis:

The microgrid market has long focused on specialty projects and pilot studies. Recently, a building-scale microgrid project was developed in the Philadelphia region in a partnership with Penn State, PECO, and IBEW / NECA. This project paves the way for building-scale microgrid systems and provides the technical foundation for our analysis. Further, battery energy storage is rapidly becoming an affordable option for distributed energy systems such as the Cozen Center. A detailed analysis of the inclusion of an energy storage solution was undertaken to assess the value proposition and economic viability. The following criteria and technical capabilities were applied to this analysis:

Net Zero Energy Capability: Energy storage systems can contribute to net zero energy goals by improving the performance of PV systems through smoothing functions and capturing energy produces that would otherwise be lost to curtailment functions.

Peak Capacity and Demand Reduction: The Cozen Center is subject to peak demand charges. Battery dispatch can be utilized during peak times to reduce peak demand and capacity charges.

Frequency Regulation Capability: In the PJM market, where this project is located, battery systems that are 100kW and higher are can participate in frequency regulation and earn FR revenue. This revenue is subject to broad swings and cannot typically be included in project financing. It is best pursued through a revenue-sharing approach with a Curtailment Service Provider (CSP). Our analysis assumes that Navigant would serve this role for our project at a fixed fee and for a percentage of frequency regulation revenue.

Resiliency: The Cozen Center has a perfect location and design to serve as an emergency shelter. In the event of loss of utility, battery systems can provide back-up power supply and be recharged with solar energy generation. This "island" mode of operation required a system with the capability of grid forming.

Economic viability: The overall value of the battery energy storage system needs to be demonstrated with a reasonable rate of return through actual revenue generation from grid services and through modest valuation of the resiliency capabilities offered by the system.

Battery System Design: The grid-interactive battery market is highly aligned with the utility-scale market and the design of unique and custom systems can quickly become too complex for small projects. Our approach to utilize the battery as a back-up power system *and* grid services allows for a utility scale battery system to be used for the project. Based on the assessment of the peak power demand of the building (54kW peak), and a target of three days of islanded condition in poor weather conditions, we recommend the BTM-250 battery from Dynapower, a 250 kWh lithium battery (Samsung). This unit would integrate with the MPS-100 energy storage inverter from Dynapower (100kW) with grid-forming capability. This system would be designed as an AC coupled system to enable the use of standard grid-tied string inverters.

Economic Analysis: Our analysis utilized the HybridFAST, software created by Protogen that has been recently released on Creative Commons. This tool enables life cycle cost analysis and full customization of the energy and economic performance of solar + storage systems including the ability to estimate total system revenue and internal rate of return.

A critical part of our analysis confirmed that in normal operation, the battery will be charged via the solar array 80% of the time and this allows the ***battery to be included in the federal Investment Tax Credit (ITC) worth 24% of the energy storage system cost.*** Under normal operating conditions the battery will discharge energy to the grid when called upon by grid management during times of high demand to help regulate and balance the grid. Using the HybridFAST tool and the GEC minimum energy price of $0.20/kW/h, we estimated this process will generate $2,806 of annual revenue. During the summer months, the battery will discharge energy to be used by the Cozen Center on a daily basis during the hours when the center devotes large amounts of energy towards cooling. This will reduce the Cozen Center's peak usage during the summer months and reduce peak energy charges as a result.

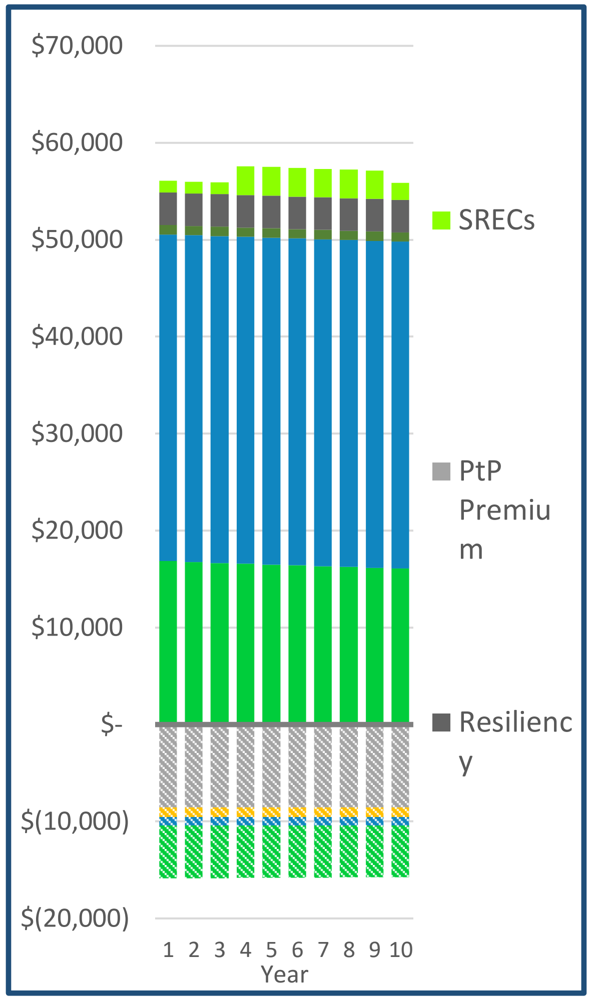


Figure 16-1: Battery revenues, Savings, Expense Years 1-10 (Pre-Tax)

The additional resiliency capabilities are perhaps the most valuable aspect of our integrated energy system as the Cozen Center will have the capability to serve as an emergency shelter and function through periods of loss of utility. The value of energy in times of crisis is unpredictable and often extreme. We conservatively estimated the value of the energy in a potentially life-saving community center during a crisis to be five times as valuable as energy on a daily basis. Using this value and the HybridFAST tool, our analysis shows the resiliency component of the systems carries an annual valuation of $3,360.

3-Line Drawing of System: This 3-line drawing (Figure 17 on the next page) was developed to support schematic and cost estimating of the system. The DC side our three-line diagram features four fused (15 Amp) combiner boxes. Each combiner box has 12 strings of 7-8 SunPower 327 W modules. The combined strings are wired to four Sunny Tripower 30 kW inverters. Then the inverters convert the DC power from the modules to 3 AC lines which are protected by an AC Disconnect. A significant advantage of our design includes the 4 inverters, 2 AC and 2 DC disconnects, and the 2 charge controllers, all of which allow us to easily build an array on each building separately. The AC Disconnect passes the inverter's power through a meter for tracking and grid connected at the Cozen Center's main distribution panel. The storage system is comprised of an AC coupled DynaPower MPS 100 inverter and BTM 250 battery utilizing Samsung lithium ion cells.

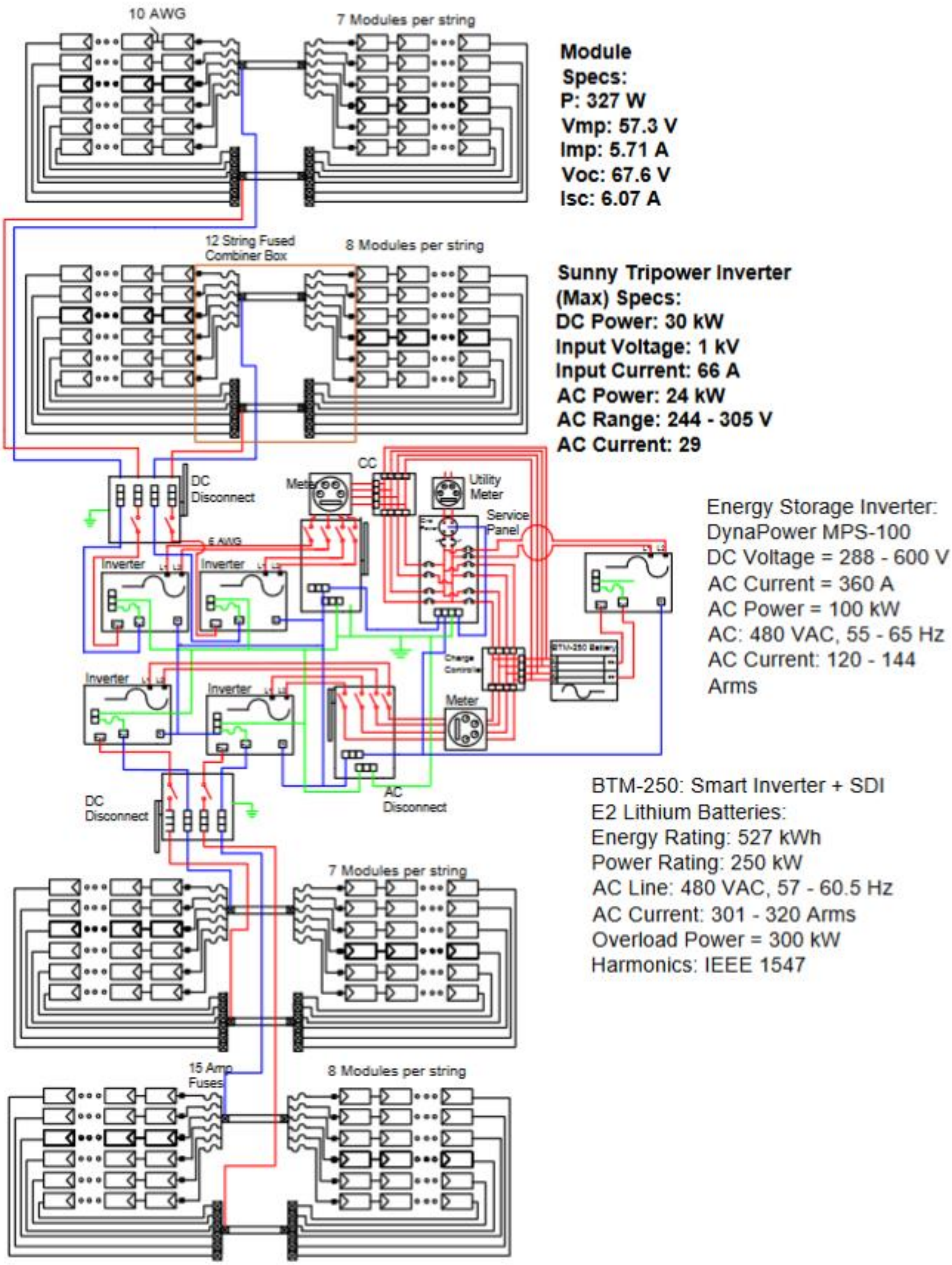


Figure 17: 3-line schematic of solar + storage system

Cost and Revenues of System: To ensure an accurate cost estimate for the entire installation of the photovoltaic system (including materials, labor, balance of system and SCADA program), we sought a peer review quote from Riggs Distler, a fellow NECA electrical contractor who has done extensive solar projects and who also operates in the Philadelphia area. Their quote for a system of this size includes the labor, materials and acquisition costs of all materials. The quoted cost came to a total of $350,000, or $3.40/W$_{DC.}$ This cost is reflected in our total cost estimate and was used to calculate our cost analysis using the Hybrid FAST tool. We estimate the price of the battery and inverter system to come to a total of $147,000. This takes into account a cost of $0.50 per kWh of battery, and $0.22/kWh for the inverter cost. These values were attained through market research of products that typically comprise similar hybrid systems. The Hybrid FAST tool calculates a pay-back period for this hybrid system alone to be **8.42 years**, and as such, would complement the return on energy efficiency investment. Cost analysis data for the hybrid system, as well as standalone PV and Battery systems, are outlined on Figures 17-1 and 17-2.

Period of Analysis		20 years		
		BATTERY	PV	NET
20-Year Discounted ROI		126.4%	4.6%	0.1%
20-Yr. Annualized Mod.IRR		92.0%	88.9%	89.9%
20-Yr. Annualized IRR		24.1%	6.0%	12.5%
20-Year NPV		$ 185,790.56	$ 15,712.42	$201,502.98
Payback		4.50	16.83	8.42

Figure 18-1: The calculated return on investment and payback period for the PV, Battery and Hybrid Systems.

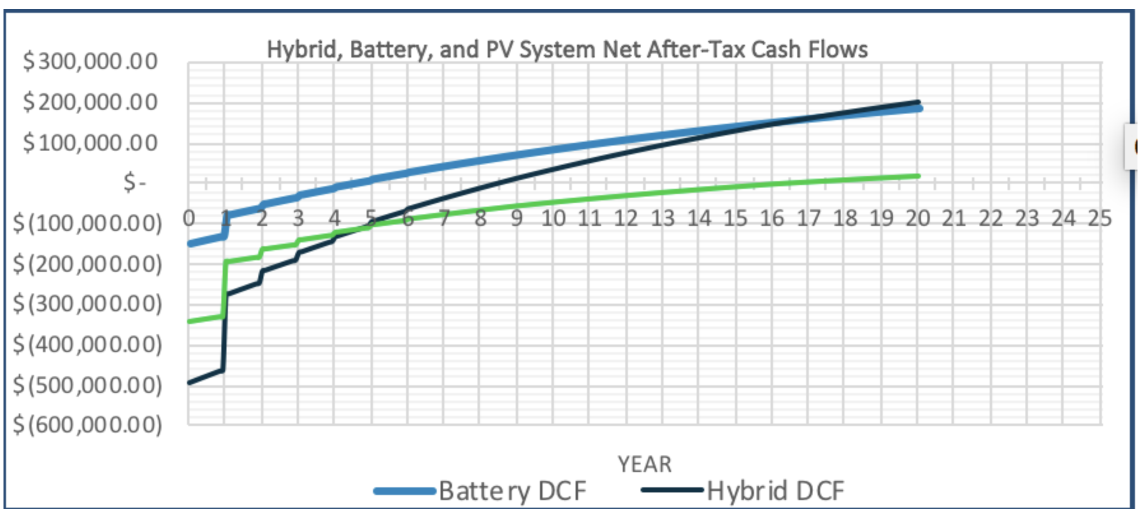


Figure 18-2: A graphical representation of the return on investment and payback period for the PV, Battery and Hybrid Systems.

Construction Management

Estimated Cost of Project

Total Project Costs: The bare project costs for the recommendations in the technical proposal are estimated to be **$682,244.** A full estimate summary is shown below:

Cost Justification: Cost estimating was performed throughout our analysis to inform the payback contribution of both energy efficiency upgrades and the solar + battery energy system. The efficiency upgrade recommendations take into account both payback and long term value to the Cozen Center and PAL. The estimate summary below shows the all-inclusive cost of the retrofit and upgrades to the building as well as potential sources of revenue enhancements. The critical factors contributing to the cost of the project are the solar array and the battery system. The four main categories of the renovation are: Building Envelope, Interior Lighting, Photovoltaic System, and the Mini-Split System. The estimate breaks out wages rates by crew average and was then leveraged with the material costs. Labor rates utilized are based on current rates in the Philadelphia region and include fringe costs. Additional items in the estimate summery include:

Engineering costs: Engineering fee quoted at $55K accounting for use of MEP design engineering and drawings for bid documents.

General Conditions: Calculated at 12% including project management, equipment rental, on-site office (in existing building) and home office overhead.

Profit: Calculated at 2%: This extremely low rate is included to support the viability of this project as a demonstration project and to advance Power Lion Electric's presence in the expanding building-scale microgrid market.

Revenue Enhancements

Investment Tax Credit: As a non-profit organization, PAL is not eligible for the ITC. As an alternative, we have secured a commitment from the Alternative Energy Development Group (AEDG) to serve as the initial owner of the PV-storage system until the project is paid off. Upon payoff of the loan, AEDG will transfer ownership of the system to PAL.

PA Department of Economic Development Solar Program Grant: The timing and details of this project are an excellent candidate for this PA-based program that offers a 30% rebate on solar projects that are completed using prevailing wage rates. The impact of this grant is included in our current analysis due to the very high probability of acquiring of this grant.

PECO energy efficiency incentive program rebate: A modest 5% rebate on energy efficiency and lighting upgrades is included in the overall project cost analysis.

PAL capital contribution: Due to the planned roof replacement, the cost of the new roof and added insulation is currently included in as a capital contribution from PAL. Utilizing the rebates that are available, and assuming no capital contribution from PAL, the financing requirement of the project is **$466,524**.

Estimate Summery Cozen Center Power Lion Electric							
Description	Quantity	Hours	Labor (Crew Average)		Materials		Subtotal
Permitting and Engineering							**$ 72,200**
Permit Costs	688	-	N/A	/hr	$ 25	/$1000	$ 17,200
Engineering							$ 55,000
Building Envelope							**$ 56,674**
Roof							$ 21,372
Install Fiberglass Insulation (6")	16080	160	$ 76.29	/hr	$ 0.57	SF	$ 21,372
Walls							$ 35,302
Install Wall Insulation (2")	5049	96	$ 76.29	/hr	$ 0.30	SF	$ 8,839
2"x2" Furring	5049	96	$ 73.09	/hr	$ 0.28	SF	$ 8,430
Install Gypsum Wallboard	5049	80	$ 62.26	/hr	$ 0.36	SF	$ 6,798
Window Trimout	694	32	$ 73.09	/hr	$ 0.36	SF	$ 2,589
Interior Paint Finish - Walls	5049	64	$ 60.91	/hr	$ 0.40	SF	$ 5,918
Joint Caulking	1736	32	$ 63.55	/hr	$ 0.40	LF	$ 2,728
Interior Lighting							**$ 47,886**
Swap T12 with LED Fixture	108	80	$ 75.25	/hr	$ 238.00	LS	$ 31,724
Swap Metal Halide to LED Gym Lights	26	64	$ 75.25	/hr	$ 149.99	EA	$ 8,716
Install Vancany Sensors / Emerg. Exit	32	64	$ 75.25	/hr	$ 82.19	EA	$ 7,446
Photovoltaic System							**$ 406,605**
SunPower 327W Solar Panel	311	768	$ 75.25	/hr	$ 277.95	EA	$ 144,234
Panel Rack	311	384	$ 75.25	/hr	$ 32.30	EA	$ 38,941
Sunny Tripower 24000TL-US - Inverter	4	64	$ 75.25	/hr	$ 4,314.00	EA	$ 22,072
250k kWh Battery	1	80	$ 75.25	/hr	$ 125,000.00	EA	$ 131,020
250k kWh Battery Inverter	1	32	$ 75.25	/hr	$ 22,000.00	EA	$ 24,408
SCADA control / CSP Contract start-up	1	N/A	N/A	/hr	$ 45,929.00	EA	$ 45,929
Mini-Split System							**$ 23,961**
Demo Boiler/Install Radiant Heater	1	8	$ 79.43	/hr	N/A	EA	$ 635
Piping	120	72	$ 77.98	/hr	$ 2.50	LF	$ 5,915
Wall Penetration & Patching	13	48	$ 51.65	/hr	$ 80.00	EA	$ 3,519
Mini-Split Air Conditioner & Heat Pump	13	80	$ 62.85	/hr	$ 399.00	EA	$ 10,215
Repurpose HVAC Equipment	1	40	$ 79.43	/hr	$ 500.00	LS	$ 3,677
General Conditions							**$ 74,918**
General Conditions	12%						$ 64,215
Fee	2%						$ 10,703
Total Project Cost							**$ 682,244**
Financing and ROI Enhancements							
Investment Tax Credit (26% solar + storage cost)							**$ 105,717**
PA DCED Solar Grant Progem (30% solar + storage cost)							**$ 121,982**
PECO Energy Efficincy Rebate program (5% EE upgrades)							**$ 5,400**
PAL contribution to first cost (planned roof replacement + insulation)							**$ 21,372**
Project capital requrement for financing							**$ 427,773**

Labor Cost (SEPTA Business April 2018)	
Insulator	$ 76.29
Electrian (Journeyman)	$ 94.50
Apprentice	$ 17.50
Carpenter	$ 73.09
Drywall Finisher	$ 62.26
Caulker	$ 63.55
Plumber	$ 77.98
HVAC Demo	$ 79.43

Figure 19: Recommended System Upgrade Estimate

Project Schedule

Project Initiation: If this proposal is accepted, the project could launch as early as August 1st, 2018 and take 65 days to complete. The schedule includes sufficient time for long lead items (battery and inverter), interconnection permits, renovations on the building's envelope, lighting, and HVAC, as well as construction of the solar array and battery storage systems. The Cozen Center is used year-round, primarily in the late afternoon, and children can attend a program that lasts from 9:00 am to 5:00 pm during the summer. The renovations will begin after the school year has begun, taking place between 6:00 am and 2:00 pm every weekday. The project could be completed by October 5th.

Safety: Safety in an active facility is the first apparent challenge during this project. Therefore, all renovation work will take place during off hours to avoid interaction with the Cozen Center patrons. Site logistics and material laydown is a second concern. In addition, at least two members of the on-site team will have completed the ***Energy Storage and Microgrid Training and Certification (ESAMTAC)*** program that is focused on introducing seasoned electrical workers to the hazards and risks of battery construction and high voltage DC systems.

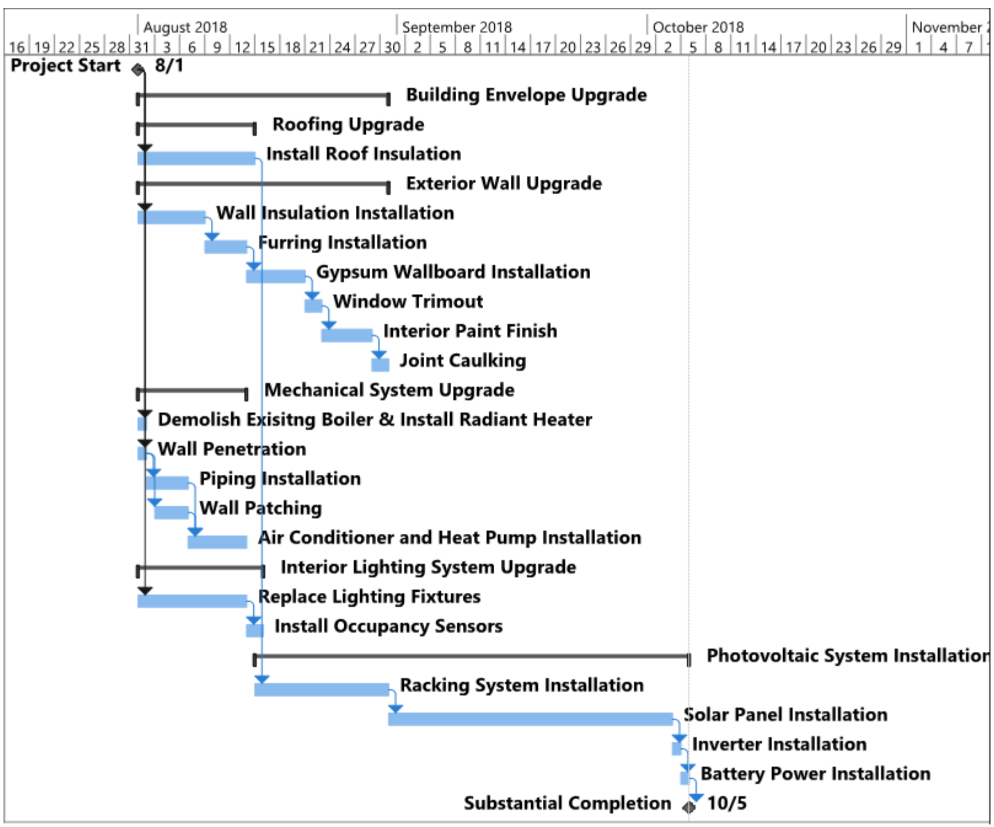


Figure 20: Basic project schedule assuming project approval

Crew Composition: Our estimate includes labor estimates and crew composition for the Philadelphia area. Union crews consist of 1 Apprentice for every 3 Journeymen Wiremen. The project will require two crews for the lighting and solar panel installation. The base pay rate for a Journeyman is $94.50 per hour, and the base pay rate for an apprentice is $17.50 per hour. Scope-specific contractors will perform the building envelope and mechanical improvements. In order to properly manage the renovation, a project manager will be on site throughout the duration of the job, managing submittals, scopes, quality control, and deliveries.

Construction Management

Financing Plan

The feasibility of securing financing for the project was evaluated for the recommended scenario of energy efficiency, solar, and energy storage system investment. NECA's ECAP Platform was utilized to assess these investments and provide financing options for the project. With an overall project cost of $427,773 after rebates and an interest rate of 7.76% per year, the overall project is expected to have a payback period of 7.7 years before the battery revenue.

In addition to this ECAP proposal, the twenty-two year forecast was created to show the future cash flow of the building upon completion. The forecast shows enough earnings to pay for a replacement system outright at year twenty, with $610,444 left over. This constant stream of income can help fund other capital investments. A cash flow diagram representing this trend can be found in Figure 21.

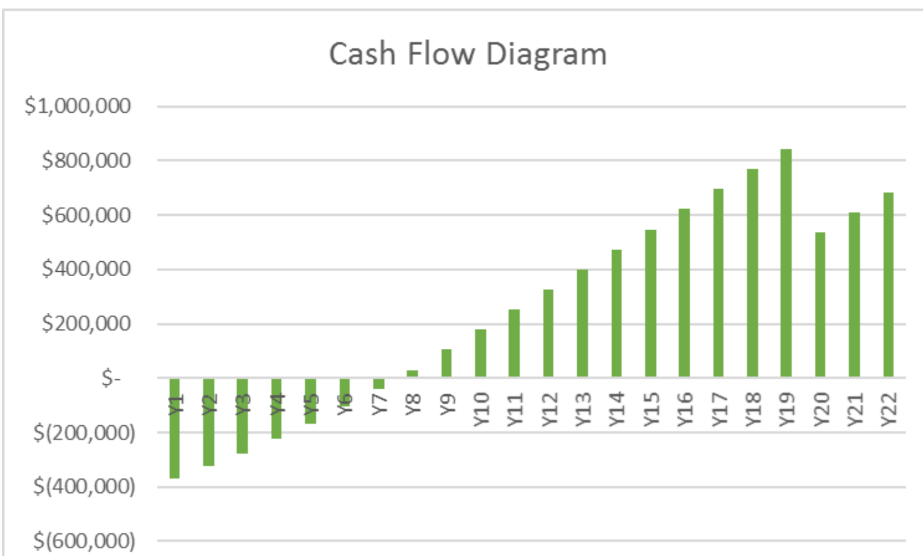


Figure 21: Cozen PAL Center Cash Flow Diagram

Finance Summary		
Total Project Cost	$	686,779
Total Rebate (DCED + PECO+Solar Rebate)	$	275,143
PAL Initial Investment	$	-
Total Finance Amount	$	411,635
Loan Interest (Per Year)		7.76%
ROI (Return on Investment)		7.7 Years
Savings from Loan Completion to System Replacement	$	843,243
System Replacement Cost (20 yrs)	$	306,681
Available Funds After Replacement (20 yrs)	$	536,562
Net Positive Income (PV Panels) + Energy Shaving	$	73,879

Figure 22: Finance Summary

Figure 23: E-CAP Analysis

PROJECT FINANCIAL SUMMARY

The total financed project cost is $466,524 and it will generate $46,581 in annual savings before factoring in any utility rate escalations.

The project's simple payback without financing would be 10 Years and the project would generate an annualized return on investment of 4.9% over 20 Years.

Total Financed Project Cost	Annual Cashflow	Payback	20 Year Annualized ROI
$466,524	$46,581	10 Years	4.9%

LEASE FINANCNIG OPTION

We are recommending a lease financing structure with the following terms for the project.

Lease Term	Lease Interest Rate	Annual Lease Payment	Net Annual Cashflow	20 Year Free Cashflow
7 Years	7.76%	-$88,757	-$43,023	$310,316

PACE FINANCING OPTION

A Property Assessed Clean Energy (PACE) Financing structure would allow for the project to be paid back through the property's tax bill. Unfortunately, PACE is not available at this time in Pennsylvania. However, if PACE is required to implement the project, then we will work with you to expedite the establishment of a Pennsylvania PACE Program.

PROJECT PERFORMANCE INSURANCE OPTION

If needed, we can arrange for a third-party investment grade insurer to guarantee the performance of the project. However, please note that this insurance could materially affect the financial performance of the project due to its costs.

Summary

An Energy and Economic Business Opportunity

The Cozen PAL Center is currently experiencing high energy costs due to the combined effects of the lack of building insulation, inefficient lighting and aging mechanical systems. These inefficiencies are compounded by a lack of controls and resulting heating and cooling of unoccupied spaces for extended periods of time. ***These conditions accumulate to create an excellent opportunity for energy efficiency upgrades through a whole-building approach.***

Market conditions and the advancement of battery technology further add to this opportunity at the Cozen Center. With large floor spaces, kitchen amenities, and locker rooms, the Cozen center is uniquely positioned to serve as an emergency shelter in the neighborhood. Through the addition of a battery storage and on-site solar generation, the Cozen Center could feasibly operate for extended periods of time in the event of loss of utility. Further, based on the location of this system in the PJM market, the solar and battery systems are capable of generating revenue through grid services, and contributing to the overall payback of the project investment.

The goal of this proposal was to examine both the technical and financial feasibility of a net-zero-energy building in a manner that responded to existing conditions and available technologies. Our approach to a technical solution for this proposal included an aggressive examination of energy efficiency and solar-storage investments in the building as well as the full utilization of available incentives and financing instruments yielding and overall payback period of the project to be 7-10 years depending on the type of financial vehicle selected by the project team.

Key decisions and assumptions made in the recommended scenario that require further analysis should this project be pursued further include:

Solar vs. Natural Gas Heating: Choosing between the over-production of solar vs. the retainage of natural gas heating is a close call. The natural gas system is cost effective as current rates and would free up some solar energy production for other purposes.

Use of Adjacent Building Roof: The technical and business feasibility of using the adjacent apartment building roof was explored in this proposal but would require further negotiation and coordination with the building owner.

Third party financing of solar + storage and ITC: The Cozen Center and PAL are non-profit entity that are not eligible for the Investment Tax Credit. This credit can potentially make a dramatic effect on the project's rate of return. We have identified a partner (Alternative Energy Development Partners) to provide interim ownership and management of the system in exchange for a revenue share. This business model would need to be developed further and secured through a service contract.

Estimate: Our estimate includes a diligent review of required labor and equipment costs, however the scale and nature of this project, and the volatility of solar and battery prices will warrant closer scrutiny of the estimate prior to contracting and procurement phases.

Long-lead items: Our schedule is aggressive and laden with assumptions making is an absolute best-case scenario. Moving forward, efforts to secure interconnection permits and long lead items will need to be evaluated for their impact on the construction start date.

Outreach

Interaction with Client

After School Programs: Working with the Cozen Police Athletic League gave Power Lion the opportunity to educate kids about energy awareness and renewable energy through existing programs. The PAL center currently offers after school programs for local kids, focusing on their character development, physical fitness, and education. Our team enjoyed three trips to the Cozen Center during which volunteer activities were combined with data collection and site analysis.

Picture 5: Lion Power members interacting with PAL students

Promoting Energy Awareness: Our team felt that we could reach a wider audience with regards to volunteering and energy awareness by creating two educational videos on the importance of energy efficiency and renewable energies. These were designed to be integrated with the after-school programs at 20 Police Athletic League centers across Philadelphia. The first video was directed at children ages six through eleven and focused on why we need energy, why renewable energy is important, and how anyone can make a difference. The second video was similar to the first but was aimed at an older audience of twelve through eighteen-year-olds, and went into more depth with these topics, as well as energy efficiency in buildings. Not only will our videos reach the 10,000 active student participants across Philadelphia PAL centers, but they may very well reach students across the world as well.

Testing the Videos: Lion Power joined PAL's after-school program on April 13th, 2018. At this time, we decided to volunteer with the kids by helping out with their regular activities, so that we could have a better idea of how the PAL program works. We got to know the students for the afternoon and found out that they are very willing to learn, but they have a lot of energy after school. Therefore, we modified our educational videos to be no longer than 3 minutes each so as to keep the attention of the kids. Additionally, we received feedback from advisors, PAL and NECA contacts, and modified the videos to improve their effectiveness.

Implementation: The links to the videos (below) have been sent out to the 20 Philadelphia PAL centers and will be shown periodically into the future.

Link for Elementary-Age Students: https://www.youtube.com/watch?v=67fyTyvJTpU&t=15s

Link for Middle and High School-Age Students: https://www.youtube.com/watch?v=l3WnmambDAI

Volunteer hours: The in-person volunteering aspect consisted of three site visits by a total of 13 team members. This presence totaled to 42 in-person hours not including travel time. The majority of our volunteering hours were done remotely including the organization of outreach events and the development of the energy efficiency videos for PAL to share with its users and guests at all of its locations. We cannot know exactly how large of an audience will be reached by our videos, but we do know that there are 10,000 active participants in PAL programs across Philadelphia, and the videos will reach them at least once. Therefore, we can estimate that, at a minimum, our videos will provide 500 hours of volunteering (10,000 people * 3 mins/ video = 30,000 mins, **or 500 hours**).

Site Visit 1	Site Visit 2	Site Visit 3	Organization / Videos	Total Hours
4 hours	28 hours	10 hours	85 hours	**127**

Figure 25: Volunteer hours

Feedback Letter from Client: We have been delighted to interact with the Cozen Center staff and PAL leadership in the devleopment of this project. We were honored to receive the attached letter of appreciation from Pat Winner, the Chief Development Officer of the Philadelphia Police Athletic League.

Police Athletic League of Philadelphia

April 25, 2018

The Penn State University NECA Student Chapter
c/o Ms. Nisha Rae Labroo
The Pennsylvania State University
104 Engineering Unit A
State College, PA 16801

Re: Green Energy Challenge PAL Partnership

Dear Penn State NECA Chapter Members,

PAL is very grateful to have been selected as the recipient of your generosity – for the comprehensive energy audit, in your generous time with our kids at Southwest PAL, and in the two educational videos you put together for use throughout our 20 PAL Centers across the city for our 10,000 active youth from age 6 to 18.

Your project at the Samuel D. Cozen PAL Center at 732 N. 17th Street to potentially identify ways in which PAL might use energy more efficiently was very welcome. Our PAL Officers and civilian support staff want to be good stewards of natural resources and to model that behavior for the 685 registered youth at the Center. Additionally, as a non-profit that must fundraise 100% of its operating budget on an annual basis, any savings we are able to realize through smarter and more efficient use of energy means we can redirect those savings for youth programming.

Over the past three months, your team was professional to deal with, and knowledgeable. I personally appreciated the time several of you took on the Saturday I spent at Cozen with you to answer my questions about the various equipment you were using, and the measurements you were taking. I was impressed by the seriousness with which you undertook the process of uncovering the details of the Cozen Center in the absence of floor plans or mechanical drawings. I know it wasn't an easy job.

I also appreciate the seriousness with which you planned the time you spent at a PAL Center on April 13th. The kids loved having you there, as you certainly could tell from their invitations to watch them practice their cartwheels and splits, and to play dodgeball, limbo, jump rope and high water with them. As you know, our PAL Centers are located in high-crime and low-income areas and many of our kids face challenges that can be hard to fathom. Knowing that there are adults who care about them is so important. Having college-age students spend time with them in fun activities was something that they just loved.

Cops Helping Kids Since 1947

3068 Belgrade Street, Philadelphia, PA 19134 • 215-291-9000 • 215-426-3263 FAX

WWW.PHILLYPAL.ORG

PAL will be able to use the educational videos you created not only at the PAL Centers you visited, but throughout our network of 20 centers. That reach will be significant; we have 10,000 kids who are actively involved in our programs. We will provide the links to our officers, as well as our homework club and computer club instructors, all of whom will introduce the videos in their groups. The energy education videos were done well – not too long, or technical for a young audience, and interesting to watch while providing an awareness to the audience of the importance of the topic. What is great is that they will have a shelf life and that we will be able to use them over time.

I enjoyed meeting your team members and truly appreciate the proposed recommendations you offered. I look forward to meeting with our Executive Director and our Facilities Manager, Kevin Frayne, with whom you met, to fully review to determine what recommendations PAL will be able to implement in the near-term to make an impact on our energy use, while we evaluate the more costly recommendations and develop a timeline for implementing others.

I hope you and your team enjoyed your experience with PAL as much as all of us enjoyed having you in our centers! Thank you for the professionalism, thoughtful analysis, and financial savvy you brought to the project. Most importantly, thanks for your interest in our mission, and the children we serve, and your goal of helping to provide the best possible environment for them.

I wish you the best in the competition! Please keep me posted!

Warm regards,

Pat

Patricia A. Winner
Chief Development Officer

Police Athletic League of Philadelphia

3068 Belgrade Street, Philadelphia, PA 19134 · 215-291-9000 · 215-426-3263 FAX

WWW.PHILLYPAL.ORG

Outreach

Articles

"Penn State Students Help Cops Help Kids"
The Daily Collegian (Penn State Newspaper - to be published)
Stall Stories at the College of Earth and Mineral Sciences – published (***see Appendix 4.1***)

As school winds down, the Penn State National Electrical Contractors Association (NECA) student chapter is gearing up for the 2018 Electri International Green Energy Challenge (GEC). The GEC is an annual competition in which NECA student chapters across the country combine their university training and industry knowledge to help a local organization improve energy efficiency in their building. "A lot of people think of energy efficiency as an afterthought", said sophomore Nisha Labroo, "but making an inefficient building efficient will cut costs and greenhouse gas emissions in vast amounts." The competition focuses on working with community partners in 5 areas: energy efficiency, lighting, construction management, solar, and outreach. It is the goal of the first 4 teams to assess the building for areas of improvement, while the outreach team manages the volunteering and communicative aspects of the project.

Penn State students chose the Samuel D. Cozen Police Athletic League (PAL) center in Philadelphia as their building for assessment. The Cozen Center is a safe place for kids from ages 6 through 18 to learn and be active after school on a daily basis. PAL centers also provide tutoring services and character development instruction for students of all ages, mentoring programs for young children, and college scholarships for young adults. Upon initial inspection, "The building itself was wholly inefficient and stood in stark contrast to the services offered there", said project manager Liam Cummings. Through this competition, the team hopes to raise awareness for the importance of energy efficiency, as well as to shine a spotlight on the incredible work done at PAL centers across the United States. "These officers are committed to providing real opportunities for children living in inner city environments", said junior Ricky Alvarez. Since the PAL program has been implemented in Philadelphia, there has been a significant decrease in juvenile arrests as well as an increase in the number of young adults pursuing higher education.

Penn State NECA would like to give a special thanks to Pat Winner, Chief Development Officer at the Police Athletic League of Philadelphia and Officer Cedric Jones of Southwest PAL for making this partnership possible. Thanks to Helen Levins of NECA Penn-Del-Jersey and Joelle Salerno of the Western PA NECA chapter, as well as Mark Stutman of Penn State University, Gabrielle Reese of Sprig Electric, Jeff Simpson of Riggs Distler, Andy Mackey of Protogen Energy, and Ryan Holleran of H. B. Frazer Co. for their professional assistance in this endeavor. The team eagerly awaits the reception of their 2018 Green Energy Challenge proposal and hopes to present their findings at the conference in Philadelphia this fall.

Outreach

Interaction With NECA

This proposal would not have been possible without the time and expertise afforded to us by our local NECA contacts. The Penn-Del-Jersey NECA chapter generously made themselves available to the Lion Power team whenever we had questions or needed advice. We were able to therefore correspond weekly with Penn-Del-Jersey NECA via e-mail and/or phone calls. They provided assistance with our energy audits by supplying tools and offering expertise on the readings, they gave us feedback on our proposed ideas, and they provided contacts for us to work with in nearly every aspect of our project. Additionally, a Penn-Del-Jersey representative (Helen Levins) was present at all group visits to the center to assist the team and ensure that we had all of the supplies and provisions we needed.

NECA Penn-Del-Jersey put us in contact with the ***H.B. Frazer Company*** and ***Riggs Distler and Company Inc***. These contacts answered some of our in-depth technical questions and provided us with feedback on our plan from an electrical contracting perspective. Riggs Distler also assisted us with our solar portion by confirming the size of the solar array and offering us a professional quote of the labor and materials that would go into the installation. Ryan Holleran of H.B Frazer Co. attended our in-person volunteering day (April 13th, 2018) at the Southwest PAL center. Ryan was instrumental in the drafting portion of our proposal and gave us feedback on early drafts to assist us in creating a more professional final product. The energy efficiency team also received feedback from a former GEC team veteran and current ***Sprigg Electric Employee***, Gabrielle Reese.

The Western PA NECA Chapter also aided our group in the early stages of the competition by offering feedback on the plan itself and by making suggestions that would better suit our group.

Sponsors and Acknowledgments

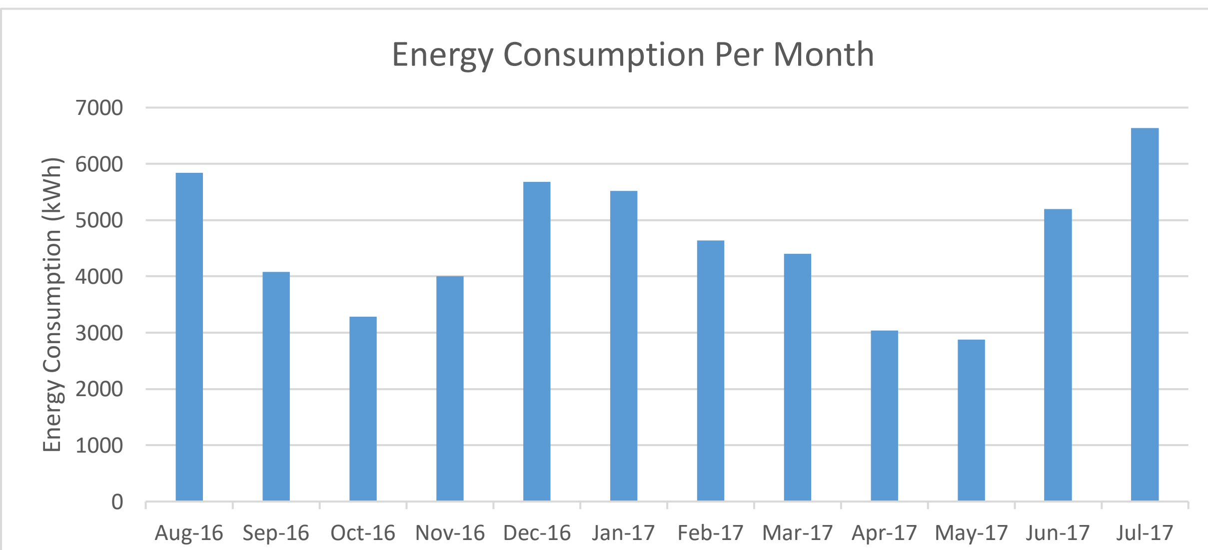
Helen Levins, Government Affairs Manager at Penn-Del-Jersey NECA
Ken McDougall, Business Development Manager, Penn-Del-Jersey NECA
Mark Stutman, Assistant Research Professor at Pennsylvania State University
Joelle Salerno, Government Affairs Director at Western PA NECA
Pat Winner, Chief Development Officer at the Police Athletic League of Philadelphia
Officer Cedric Jones, PAL Southwest Center
Ryan Holleran, Project Manager at H. B. Frazer Co.
Gabrielle Reese, Project Engineer at Sprig Electric
Jeff Simpson, Operations Manager at Riggs Distler and Co., Inc.
Andy Mackey, ProtoGen Energy Co-founder and Executive Vice President
Somayeh Asadi, Penn State NECA Chapter Co-advisor
David Riley, Penn State NECA Chapter Co-advisor

Appendix

1. Energy Efficiency

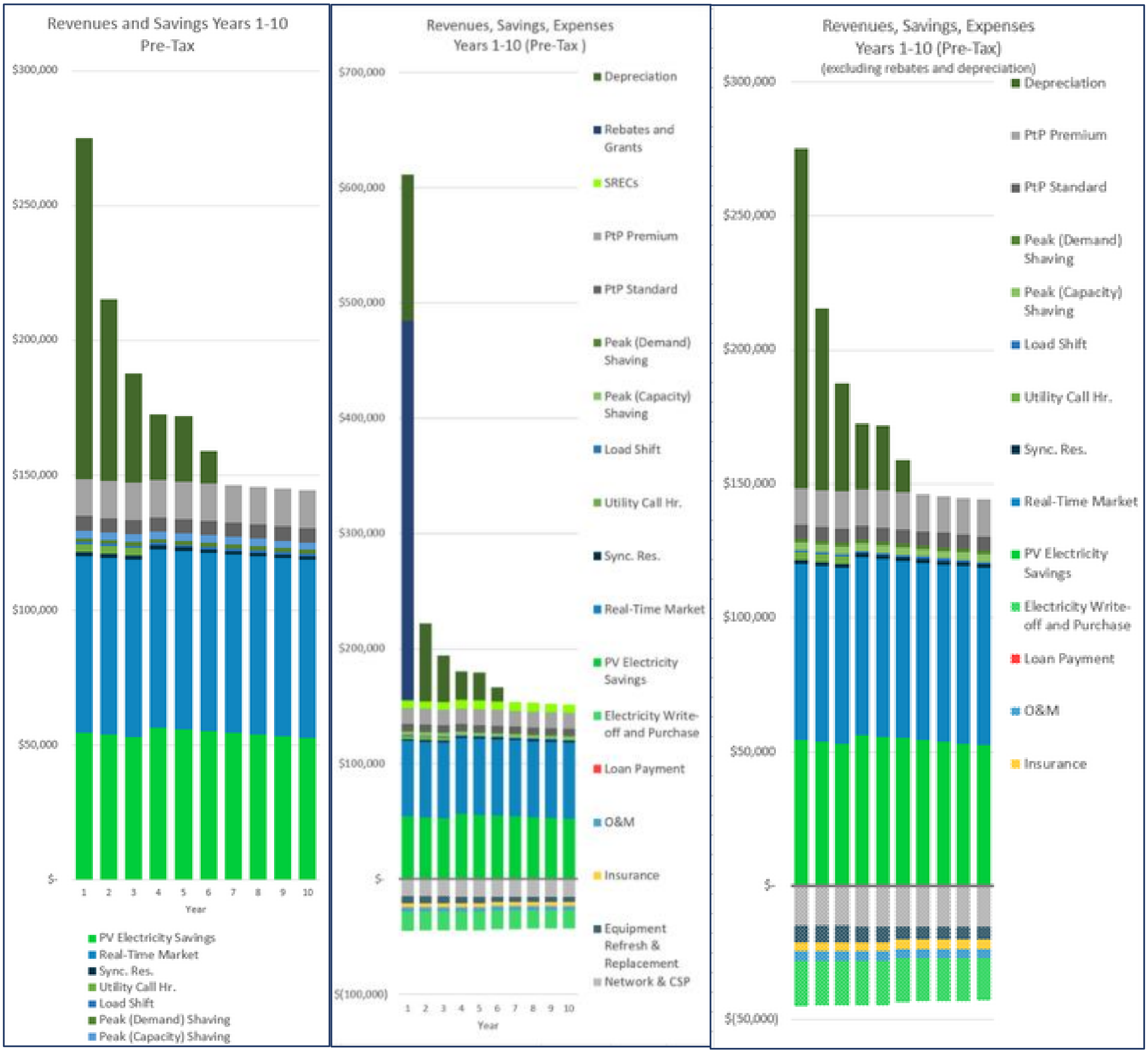
1.1 Monthly Energy Consumption

Month	Energy Consumption (kWh)
Aug-16	5840
Sep-16	4080
Oct-16	3280
Nov-16	4000
Dec-16	5680
Jan-17	5520
Feb-17	4640
Mar-17	4400
Apr-17	3040
May-17	2880
Jun-17	5200
Jul-17	6640



2. Solar

2.1 ProtoGen HybridFAST- *Revenues, Savings, and Expenses*



	Revenues									Incentives			Expenses					
Year	PV Electricity Savings	Real-Time Market	Sync. Res.	Utility Call Hr.	Load Shift	Peak (Demand) Shaving	Peak (Capacity) Shaving	PtP Standard	PtP Premium	SRECs	Rebates and Grants	Depreciation	Electricity Write-off and Purchase	Loan Payment	O&M	Insurance	Equipment Refresh & Replacement	Network & CSP
1	$ 54,386.16	$ 65,650.56	$ 1,466.53	$ 2,850.00	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 6,476.22	$ 329,850.00	$ 126,639.45	$ (16,920.75)	$ -	$ (3,500.00)	$ (3,500.00)	$ (6,000.00)	$ (14,930.11)
2	$ 53,704.26	$ 65,650.56	$ 1,466.53	$ 2,850.00	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 6,424.60	$ -	$ 67,541.04	$ (16,777.55)	$ -	$ (3,500.00)	$ (3,500.00)	$ (6,000.00)	$ (14,930.11)
3	$ 53,027.79	$ 65,650.56	$ 1,466.53	$ 2,850.00	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 6,373.39	$ -	$ 40,524.62	$ (16,635.49)	$ -	$ (3,500.00)	$ (3,500.00)	$ (6,000.00)	$ (14,930.11)
4	$ 56,398.97	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,587.11	$ -	$ 24,314.77	$ (16,630.10)	$ -	$ (3,500.00)	$ (3,500.00)	$ (6,000.00)	$ (15,026.11)
5	$ 55,733.25	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,526.63	$ -	$ 24,314.77	$ (16,490.29)	$ -	$ (3,500.00)	$ (3,500.00)	$ (6,000.00)	$ (15,026.11)
6	$ 55,072.82	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,466.64	$ -	$ 12,157.39	$ (16,351.61)	$ -	$ (3,500.00)	$ (3,500.00)	$ (5,000.00)	$ (15,026.11)
7	$ 54,417.67	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,407.13	$ -		$ (16,214.02)	$ -	$ (3,500.00)	$ (3,500.00)	$ (5,000.00)	$ (15,026.11)
8	$ 53,767.73	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,348.09	$ -		$ (16,077.54)	$ -	$ (3,500.00)	$ (3,500.00)	$ (5,000.00)	$ (15,026.11)
9	$ 53,122.98	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,289.52	$ -		$ (15,942.14)	$ -	$ (3,500.00)	$ (3,500.00)	$ (5,000.00)	$ (15,026.11)
10	$ 52,483.37	$ 66,130.56	$ 1,466.53	$ -	$ 912.50	$ 1,433.35	$ 2,772.00	$ 5,250.00	$ 13,750.00	$ 7,231.41	$ -		$ (15,807.82)	$ -	$ (3,500.00)	$ (3,500.00)	$ (5,000.00)	$ (15,026.11)
11	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

2.2 Riggs Distler- *Solar Installation Quote*

RIGGS DISTLER

April 25, 2018 **Page 1**

Green Energy Challenge
Penn State University

Attention: Mr. Liam Cummings

Green Energy Challenge
103kw DC PV System Installation
Our Reference No. 1804-xx

Gentlemen:

We are pleased to submit our lump sum proposal for the Engineering, Procurement and Construction (EPC) work on the above referenced project. Our proposal is based upon document set listed below and the following Scope of Supply.

Drawing Set included in Base Bid

Email	Rev. 0	4/23/2018

Project Understanding

Riggs Distler and Company, Inc. (RD) understands that Green Energy Challenge (GEC) is seeking a quotation for providing engineering, procurement, and construction (EPC) services for the installation of a 103.04kwdc Photovoltaic System (PVS) located at 1701 Folsom Street, Philadelphia, PA.

RD's proposal is based on the email, dated April 23, 2018. RD is proposing to provide electrical and structural engineering services.

RIGGS DISTLER

April 25, 2018 **Page 2**

Scope of Supply – Base Bid

1. **Electrical & Structural Engineering Design**

A. Provide power distribution design for the PVS
B. Provide power distribution design for auxiliary equipment
C. Design utility interconnection in conformance to NEC, IEEE 1547, NFPA, PECO and interconnection standards.
Provide documentation as required for
Submission to PECO for approval. Coordinate with PECO; interconnect voltage is expected to be 480vac
D. Provide one-line diagrams, and as-built design drawings, including the engineering design Package to include the following items for review by local code/utility compliance:

1. Site plan and layout plan.
2. Structural plans
3. Electrical single-line diagrams
4. Electrical wiring details.
5. Grounding plans and details. Design grounding in accordance with NEC, IEEE, NFPA, and applicable utility requirements.
6. Electrical design for all miscellaneous loads
7. Signed and sealed drawings for permits.

E.

N. Submission to Local Township for permits.
O. Conference calls as needed.
P. Attend the following meetings:

1. One (1) project kickoff meeting and site survey at project site.
2. One (1) project design meeting.
3. One (1) meeting with utility at project site.
4. One (1) construction meeting at project site.
5. Provide one (1) punch list upon substantial completion and attend one (1) start up and testing trip.

Q. Signed and sealed drawings for permits.
R. Shop drawing review.
S. As-built CADD drawings from contractor's markups.

RIGGS DISTLER

April 25, 2018 **Page 3**

2. **Procurement and Construction Services**

- Furnish and Install (Provide) Modules
- Provide racking
- Provide inverters
- Provide DAS monitoring system
- Provide DC, AC and control wiring
- Provide grounding as needed

For the above listed scope of work, we quote the Lump Sum of
Three Hundred Fifty Thousand Dollars ($350,000)

Qualifications

- Work is to be performed during normal working hours, No Overtime
- Proposal is based upon a Four (4) week construction duration
- Permits and Inspection fees for local municipality are by others
- Unless specifically indicated above, all materials and equipment are provided by others
- Performance Bonding is included
- Proposal is valid for Thirty (30) days
- Payment Terms are Net 15, 5% Retainage
- Site security for off-time hours are by others
- Proposal includes One (1) year maintenance warranty for our scope of work and materials provided by Riggs Distler
- Proposal includes a Part-Time Safety Representative as required by onsite personnel

RIGGS DISTLER

April 25, 2018 **Page 4**

Cost Breakdown and Schedule of Values

The cost breakdown and SOV is to be used for accounting purposes only and not for any other use.

System	Total Hrs	Total
|| Racking	96	$ 41,974
|| Modules	509	$ 140,414
|| DC Wiring	194	$ 32,012
|| AC Wirng	186	$ 32,097
|| AC Equipment	128	$ 43,383
|| Grounding	92	$ 14,192
|| Scada	52	$ 45,929
Final Price	1,256	$ 350,000

We thank you for this opportunity to be of service. If you have any questions, please feel free to contact us.

Very truly yours,

Jeffrey R. Simpson
Operations Manager

2.3 Riggs Distler – *Helioscope Annual Project Report*

HelioScope Annual Production Report produced by Jeffrey Simpson

320w Mod 5D Tilt Green Energy Challenge, 39.96824644855143, -75.1655924320221

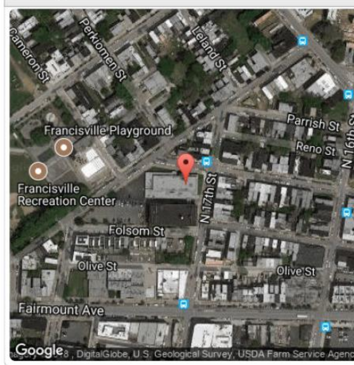
Report

Project Name	Green Energy Challenge
Project Address	39.96824644855143, -75.1655924320221
Prepared By	Jeffrey Simpson jsimpson@riggsdistler.com

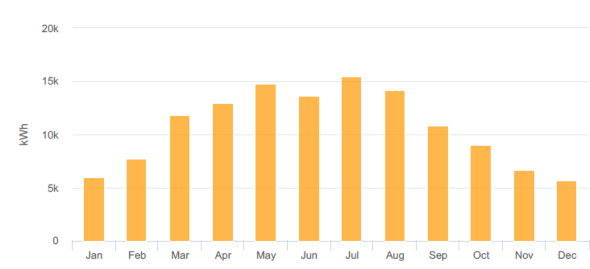
System Metrics

Design	320w Mod 5D Tilt
Module DC Nameplate	103.0 kW
Inverter AC Nameplate	79.5 kW Load Ratio: 1.30
Annual Production	128.6 MWh
Performance Ratio	80.9%
kWh/kWp	1,248.1
Weather Dataset	TMY, 10km grid (39.95,-75.15), NREL (prospector)
Simulator Version	011bb979e5-1de39020c6-95c81c0e14-85c1859242

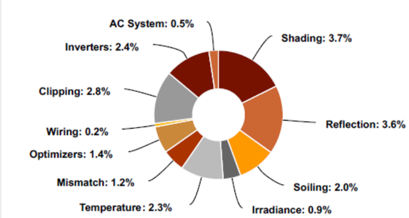
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,478.3	
	POA Irradiance	1,543.0	4.4%
	Shaded Irradiance	1,485.8	-3.7%
	Irradiance after Reflection	1,432.0	-3.6%
	Irradiance after Soiling	1,403.4	-2.0%
	Total Collector Irradiance	**1,403.3**	**0.0%**
Energy (kWh)	Nameplate	144,678.0	
	Output at Irradiance Levels	143,332.0	-0.9%
	Output at Cell Temperature Derate	140,104.4	-2.3%
	Output After Mismatch	138,437.1	-1.2%
	Optimizer Output	136,476.1	-1.4%
	Optimal DC Output	136,235.6	-0.2%
	Constrained DC Output	132,444.5	-2.8%
	Inverter Output	129,246.0	-2.4%
	Energy to Grid	**128,600.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		14.8 °C
	Avg. Operating Cell Temp		22.1 °C
Simulation Metrics			
		Operating Hours	4685
		Solved Hours	4685

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (39.95,-75.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
TSM-PD14 320 (Trina Solar)	Spec Sheet Characterization, PAN

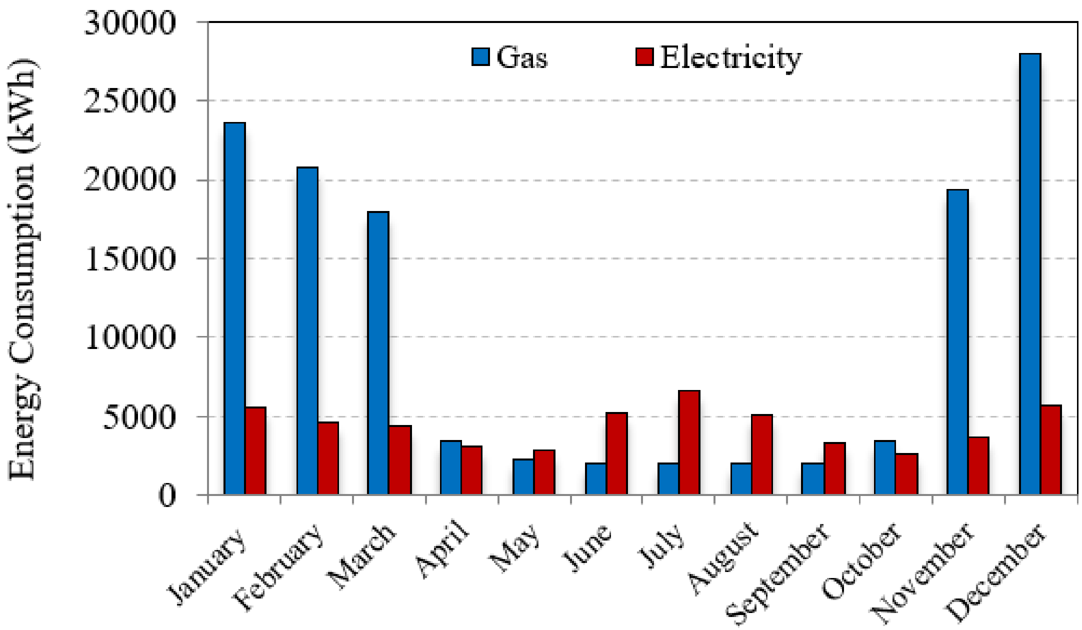
Component Characterizations

Device	Characterization
SE20KUS (SolarEdge)	Default Characterization
SE10K (SolarEdge)	Default Characterization
P700 (SolarEdge)	Mfg Spec Sheet

3. Construction Management

3.1 Utility Bill Analysis

Natural gas is used to cover both heating load and hot water energy consumption and electricity is used to cover cooling, lighting, and equipment energy consumption. The total natural gas consumption is 126,800 kWh per year and the total electricity consumption is 52,720 kWh per year. As it can be seen, the electricity consumption during the cold season is considerably high which explain the use of personal heaters in the office area.



4. Outreach

4.1 *Stall Stories* - Published Article

The College of Earth and Mineral Sciences

Stall Stories

EMS Stall Stories is brought to you by the EMS Student Council. We'll be updating the content every few weeks. If you have any questions or would like to have something added, please contact **Chris Long** (cjl5738@psu.edu).

Spring 2018 Final Edition

PENN STATE NECA

As the school year winds down, the PSU National Electrical Contractors Association (NECA) is gearing up for the 2018 Electri-International Green Energy Challenge (GEC). The GEC is an annual competition in which NECA student chapters across the country combine their knowledge to help a local organization improve energy efficiently in their facilities. The competition focuses on working with community partners in 5 areas: energy efficiency, lighting, construction management , solar, and outreach.

Penn State students chose the Samuel D. Cozen Police Athletic League (PAL) center in Philadelphia as their building for assessment. While the PAL Serves as a safe place of tutoring and learning for kids from ages 6-18, the building was found to be wholly inefficient and in need of improvements. Throughout the competition, the team hopes to raise awareness for the importance of energy efficiency, as well as shine a spotlight on the work done at PAL centers all across the US.

Penn State NECA would like to give a special thanks to Pat Winner, Chief Development Officer at the Police Athletic League of Philadelphia and Officer Cedric Jones of Southwest PAL for making this partnership possible. Thanks to Helen Levins of NECA Penn-Del-Jersey and Joelle Salerno of the Western PA NECA chapter, as well as Mark Stutman of Penn State University, Gabrielle Reese of Sprig Electric, Jeff Simpson of Riggs Distler, and Ryan Holleran of H. B. Frazer Co. for their professional assistance in this endeavor. The team eagerly awaits the reception of their 2018 Green Energy Challenge proposal and hopes to present their findings at the conference in Philadelphia this fall.

FINALS WEEK @ THE LIBRARY

With the onset of finals week Penn State Libraries are preparing for the rush of finals studying. The Pattee/ Paterno library will be open 24/7 starting Sunday morning, April 29th and continuing through Friday night May 4th. CATABUS will also be offering extended blue and white loop service throughout the week to help students return to their dorm or apartment after studying. Both the blue and white loop will run until 2:30am every night from Thursday April 19th through Saturday May 5th.

CONGRATS GRADS!

On behalf of the College of EMS Student Council, we would like to congratulate all of the EMS seniors who will be graduating at the end of next week. We wish you luck in all of your future endeavors and hope that you come back to visit whenever you find yourself nearby. For the glory!

2018

UPCOMING EVENTS

Movin' On	Apr. 27
Final Exams	Apr. 30-May 4
EMS Spring Commencement	May 4
Summer Break Begins!	May 5

ENERGY DAYS POSTER SESSION

The Institutes of Energy and the Environment has issued a call for posters related to energy. The poster session is a part of Energy Days, a conference dedicated to identifying, discussing, and developing solutions for society's energy challenges. Energy Days is free to attend for any Penn State student or employee. The session will take place on May 30, 2018 at the Penn Stater Hotel and Conference Center (in Innovation Park) from 4-6:30pm. Students interested in submitting posters must do so by May 23rd. Additional information can be found at energydays.psu.edu/posters.

RIDDLE OF THE WEEK

1. What can you hold but not touch?
2. What table can you eat?

The College of Earth and Mineral Sciences Undergraduate Student Council

@Emsstudentcouncil

2. A vegetable
1. A conversation