

West Norriton Township Ready for 100

Spring 2021

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May 10, 2021

Executive Summary

This paper outlines the work that our group achieved through the Resilient Innovation Sustainable Engineering (RISE) forum in partnership with West Norriton Township (WN) in the Spring of 2021. The scope was to develop energy recommendations to assist in their transition to 100% renewable energy by 2050, aligned with the Sierra Club Ready for 100 initiative.

Our group performed an energy audit at the township building at 1630 W. Marshall Street in Jefferson, PA. This building houses the administration, police, and public works departments for the township. The building's HVAC, envelope, and lighting were analyzed for energy consumption and inefficiencies to lead to a series of recommendations. First, implement insulation upgrades to EnergyStar standards in various areas, install tamperproof thermostats, install motorized dampers, install an OSA unit for circulation, and implement a heat recovery system. Lighting in the building must undergo a shift to LEDs and dimming switches to replace old fluorescent bulbs and fixtures. Available PECO rebates can be applied through the PECO Smart Energy Application with their free engineering consultation. A solar and battery analysis was also performed leading to a scoped 63.3kW rooftop array and 32kAh back-up battery.

The electrification of vehicles and equipment of the township were also analyzed. Police vehicles in the township can be converted to a fleet of hybrids such as the Ford Interceptor. A single hybrid vehicle can lead to \$2,021 a year in fuel savings, \$36,374 for the fleet. WN golf carts can also be phased out to the fully electric EZ-Go carts that are estimated to save \$540 annually per cart. 35 out of 65 of WN inventory of lawn-care equipment can also be electrified in a one-ton one conversion. The comparable products include the greens mowers, utility and work carts, sand traps, rough mowers, blowers, chainsaws, and string and hedge trimmers. An updated greenhouse gas analysis was made to show all savings with these recommendations.

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Introduction

Ready for 100 (RF 100) is an initiative from the Sierra Club, an influential grassroots environmental organization in the United States. RF 100 is a pledge that is made by townships and cities that are committed to transition to 100% clean energy. Over 160 cities and towns have currently committed to the initiative, with another 50 currently 100% clean energy powered [1]. Pennsylvania has been at the forefront of RF100 with 30 committed townships.

West Norriton RF 100 Pledge

West Norriton (WN) Township committed to RF 100 through their Resolution #20- 1654 on April 14th, 2020. Within the pledge, West Norriton resolved that their township vehicle fleet will be 100% renewable energy sourced by 2030, 100% powered by clean renewable energy by 2035, and use 100% clean renewable energy when replacing heating system and transportation equipment by 2050. Before creating this resolution, West Norriton had already implemented a series of energy efficiency improvements such as sewage pump upgrades and streetlight LED upgrades.

Summary of Past Work

Through the Villanova Resilient Innovation Sustainable Engineering (RISE) forum, our team worked to create an electricity and greenhouse gas baseline. This baseline worked to identify possible energy efficient areas for the future development of recommendations for the Township to implement. Along with the baseline, this first phase of the project worked to review and assess renewable energy alternatives and technologies (Wind RECs), procurement strategies including rebates, and develop an initial GHG profile. In addition, our team worked with Environmental Advisory Board for WN to assist in their community day efforts; providing helpful tips for the residents to reduce their electricity consumption and bills.

Current Goal and Scope

Working from Phase 1, this white paper contains recommendations through multiple energy efficiency programs such as a building HVAC and lighting upgrade, vehicle electrification, and equipment electrification.

HVAC & Equipment

HVAC & Equipment preliminary analysis

The energy audit on the WN administration building showed potential energy efficiency improvement recommendations for energy consumers such as HVAC. In addition to the duct work and different air distribution equipment, there was also a major water heater for the township building. The water boiler specs are shown below

Table 1 Water Heater Details

Model	A.O Smith water heater
Model No	BTR 199-188
Manufacturing Date	2006
Average lifetime	6-12 years
Fuel type	Gas
Energy star certified	No
Maximum Energy Input	199,900 BTU/hr

The temperature setting is reported to be at 120F by township staff. The hot water discharge piping from the tank is uninsulated for approximately the first 100 feet of line. It was noticed that the hot water supply line is insulated immediately before penetrating the roof of the basement's mechanical space underneath the building's first floor.

Recommendation: Insulate the 100 feet of uninsulated copper piping on the hot water supply outlet from the hot water heater in the basement to the penetration point into first floor.

As shown in the table, the heater reached its manufacture's listed lifetime and needs to be replaced. Therefore, a preliminary recommendation is to use a hybrid boiler that uses direct electricity and air to heat water. The model recommended can be procured from the same manufacturer, A.O Smith.

The hybrid boiler has the following features:

1. It is 3 times more efficient than its gas fired counterpart
2. Quiet
3. Smart control and adjustable temperature
4. Has automatic sensor to achieve more energy savings
5. It has 73% less operating cost
6. Energy star certified product

One option can be seen here: <https://www.hotwater.com/water-heaters/residential/electric/proline/xe/voltex-hybrid-electric-heat-pump/?f=196,581&s=0&v=15&p=1&st=1155.5999755859375>

Another model was found that best fits the township building hot water demand: the CHP-120. The model is provided by the same manufacturer and has a 4.2 certificate of performance.

Second on the list of equipment that can be replaced with a more energy efficient alternative is the backup diesel generator. An alternative of the diesel generator is another model that is branded as 'gasless', as it runs on electricity instead of diesel and doesn't have any emissions. The new gasless generator model costs around \$4500-6000 to meet the same requirements that

are fulfilled by the current backup generator, 18-22 KW. These models can be seen here:
<https://www.electricgeneratorsdirect.com/power/18-22-kw-home-standby-generators.html>

In addition to the recommendation specified to the different equipment, the following section summarizes general guidelines to improve the current HVAC system.

1. Install tamperproof thermostats
2. Place thermostat in return air duct
3. Install motorized dampers
4. OSA unit for circulation [economizer]
5. Exhaust air dampers to be closed during non-operational hours
6. Heat recovery system (HX)

Admin Building Insulation

Administration building insulation was reviewed as part of energy audit.

The original building engineering plans [2] state the following:

1. Exterior walls have 3 5/8 in. metal studs with 3 ½ in. foil face, FS-25, R-11 batt insulation.
2. Roof has 6 ¼ in., FS-25, R-19 batt insulation blankets.
3. Floor: report suggests original floor may be ceramic tile installed over standard subfloor. 1988 project specifications did not list insulating floor as part of original project scope [2]. March 2021 inspection of admin building's basement mechanical space allowed partial inspection of `Admin building's 1st floor and area beneath first floor above basement mechanical space which appeared to be uninsulated.

Note: Flame spread 25 (FS-25) fiberglass insulation is a light, low-density, and flexible batt insulation with factory-applied facing that has an assured low flame spread and can be used in walls, floors and ceilings where a low flame spread vapor retarder is required [3] [18142-J.indd \(owenscorning.com\)](#). This insulation was likely recommended in accordance with the original building fire rating. R-11 fiberglass insulation is 3 ½ in. thick, while R-19 is 6 ¼ in thick [3].

Energy Star recommendations for Zone 4/5 for exterior walls and roof/attics are R-13 to R15 and R-38 to R60 [4] [What R-value Do I Need? | Johns Manville \(jm.com\)](#).

ENERGY STAR RECOMMENDATIONS



Figure 1 Climate Zones, US [5] [What R-value Do I Need? | Johns Manville \(jm.com\)](#)

Zone	Attic	2x4 Walls	2x6 Walls	Floors	Crawl Spaces
7	R49-R60	R13-R15	R19-R21	R25-R30	
6					
5					
4					
3	R30-R60			R-25	R19-R25
2	R30-R49			R-13	R13-R19
1					

Figure 2 R-Value Ratings for U.S.A Climate Zones [4] [What R-value Do I Need? | Johns Manville \(jm.com\)](#)

Owens Corning data below on FS-25 fiberglass batt insulation suggests 3 ½ in. batts meet both R-11 and R-13 criteria [3] [18142-J.indd \(owenscorning.com\)](#).

Technical Data

Flame Spread 25 FIBERGLAS Insulation

	Width	Length	Thickness	R-Value ¹
Metal Frame Construction	16" (406mm) 24" (609mm)	96" (2,438mm)	3½" (89mm)	11.0
	16" (406mm)	96" (2,438mm)	3½" (89mm)	13.0
	16" (406mm) 24" (609mm)	96" (2,438mm)	6¼" (159mm)	19.0
	16" (406mm) 24" (609mm)	48" (1,219mm)	9½" (89mm)	30.0
Wood Frame Construction	23" (584mm)	93" (2,362mm)	3½" (89mm)	11.0
	23" (584mm)	93" (2,362mm)	3½" (89mm)	13.0
	15" (381mm) 23" (584mm)	93" (2,362mm)	6¼" (159mm)	19.0
	15" (381mm) 23" (584mm)	93" (2,362mm)	5½" (140mm)	21.0

¹The higher the R-value, the greater the insulating power. Ask your Owens Corning representative for the fact sheet on R-values.

Figure 3 Technical Data, FS-25 fiberglass insulation [2]

Recommendations are based on Energy Star criteria and shown below in Table 2.

Table 2 Insulation Recommendations, WNT Administration Building, 1630 West Marshall St

Area	Actual Insulation Thickness (in)*	Actual R value***	Energy Star Recommendation**	Additional Insulation thickness of blown insulation (in.) to meet Energy Star rating
Exterior Walls	3 ½ in. thick foil face, FS-25, R-11 batt insulation.	12.0 - 13.0	R13 - R15	0 in.
Ceiling/Roof	6 ¼ in. thick FS-25, R-19 batt insulation	20.4 - 22.4	R38 - R60	5.3 in. - 11.4 in.
Floor	None		R25 - R30	7.3 in. - 8.8 in.
Notes:				
* per 1988 Engineering Design Report				
** Zone 4/5 (includes PA)				
*** R value Includes insulation and two layers of 5/8 in. gypsum board				

Admin building roof: Recommend WNT assess the possibility of improving the insulation of the roof, such as with blown insulation. It is unsure if the original R-19 insulation recommendation was limited by the construction of the original roof frame or the desire to use FS-25 as part of building's 1-hour fire rating requirement. The underside of the roof, above the ceiling tiles, was not visually inspected. Recommendation will halve current energy losses through the roof.

The VU RISE team was unsure if FS-25 fiberglass insulation batts were required to meet 1 hr. fire rating for Administration building (since is often a building code requirement for an occupied space). In event blown insulation cannot be utilized, and FS-25 is required, please see the table below for reference of comparable R values.

Table 3 R-values for Insulation and Insulation Depths [Insulation R Value Chart - --- \(greatdayimprovements.com\)](http://greatdayimprovements.com)

R-value of Materials and Depths						
Material	R-value/in	3 1/2"	5 1/4"	10"	12"	15"
Fiberglass (batt)	3.1 - 3.4	10.8 - 11.9	16.3 - 17.8	31.0 - 34.0	37.2 - 40.8	46.5 - 51.0
Fiberglass blown (attic)	2.2 - 4.3	7.7 - 15.0	11.5 - 22.6	22.0 - 43.0	26.4 - 51.6	33.0 - 64.5
Fiberglass blown (wall)	3.7 - 4.3	12.9 - 15.0	19.4 - 22.6	37.0 - 43.0	44.4 - 51.6	55.5 - 64.5
Mineral Wool (batt)	3.1 - 3.4	10.8 - 11.9	16.3 - 17.8	31.0 - 34.0	37.2 - 40.8	46.5 - 51.0
Mineral Wool blown (attic)	3.1 - 4.0	10.8 - 14.0	16.3 - 21.0	31.0 - 40.0	37.2 - 48.0	46.5 - 60.0
Mineral Wool blown (wall)	3.1 - 4.0	10.8 - 14.0	16.3 - 21.0	31.0 - 40.0	37.2 - 48.0	46.5 - 60.0
Cellulose blown (attic)	3.2 - 3.7	11.2 - 12.9	16.8 - 15.0	32.0 - 37.0	38.4 - 44.4	48.0 - 55.5
Cellulose blown (wall)	3.8 - 3.9	13.3 - 13.6	19.9 - 20.8	38.0 - 39.0	45.6 - 46.8	57.0 - 58.5
Polystyrene Board	3.8 - 5.0	13.3 - 17.5	19.9 - 26.2	38.0 - 50.0	45.6 - 60.0	57.0 - 75.0
Polyurethane Board	5.5 - 6.5	19.2 - 22.7	28.9 - 34.1	55.0 - 65.0	66.0 - 78.0	82.5 - 97.5
Polyisocyanurate (foil-faced)	5.6 - 8.0	18.2 - 28.0	29.4 - 42.0	56.0 - 80.0	67.2 - 96.0	84.0 - 120.0
Open Cell Spray Foam	3.5 - 3.6	12.2 - 12.6	18.4 - 18.9	35.0 - 36.0	42.0 - 43.2	52.5 - 54.0
Closed Cell Spray Foam	6.0 - 6.5	21.0 - 22.7	31.5 - 34.1	60.0 - 65.0	72.0 - 78.0	90.0 - 97.5

IMPORTANT, SAFETY NOTE: Ceiling above basement mechanical space, and below building first floor, is missing in spots and it essential to recommend that the ceiling's repair/replacement be prioritized. The mechanical space's ceiling may be part of the building one-hour fire envelope and integral to its one-hour fire rating.

Admin Building HVAC and Temperature Control

The WNT's Administration building heating, ventilation, and air conditioning (HVAC) systems and temperature controls were also investigated during March and April 2021 through two visits. In general, the building's HVAC system is a forced hot air system supplemented with baseboard electric heating. Review of 1988 design report suggests the original design intent was for the forced hot air system to be the main heating system for the building. However, the reality is the electric baseboard heating is used often, especially in police HVAC zones, due to challenges with the HVAC system. The HVAC is comprised of 13 natural gas rooftop units/furnaces (RTUs) which are combination heaters/air conditioners. The 13 RTUs are summarized in Table 4 below with additional detailed system information in Appendix E. All information was collected from RTU equipment tags except for date of manufacture, which is embedded in serial number. [Carrier AC Age: How To Find The Year of Manufacture | Waypoint \(waypointinspection.com\)](http://waypointinspection.com)

Table 4 WNT Administration Building HVAC Unit Summary

Item# - Engineering Drawings	Item# - In Field/On Roof	Manuf	Model#	Serial #	Date of Manufacture	Thermal Efficiency	Input Max (BTU/hr)
HAC-1	RTU-9	Carrier	48TJE004-511GA	2199G20604	1999	80%	74000
HAC-2	RTU-8	Carrier	48TFE006-A-511	4302G30171	2002	80%	115000
HAC-3	On original 1988 project list but not installed						
HAC-4	On original 1988 project list but not installed						
HAC-5	RTU-6	Carrier	48TME004-A-501	0705G40904	2005	80%	74000
HAC-6	RTU-5	Carrier	48TME007-501	0605G50263	2005	80%	115000
HAC-7	RTU-4	Carrier	48TME007-501	0705G20292	2005	80%	115000
HAC-8	RTU-2	Carrier	48TME007-501	0505G10183	2005	80%	115000
HAC-9	RTU-10	Carrier	48TME006-A-501	0404G50392	2004	80%	115000
HAC-10	RTU-7	Carrier	48TME005-A-501	1005G10154	2005	80%	115000
HAC-11	Trane	Carrier	YSC102H3RHA03	200513857	2020	80%	200000
HAC-12	RTU-12	Carrier	48TME006-A-501	200513857L	2005	80%	115000
HAC-13	RTU-13	Carrier	48TME004-A-501	0705G40212	2005	80%	74000
HAC-14	RTU-3	Carrier	48TME004-A-501	0605G102?? (?)	2004	80%	74000
HAC-15	RTU-1	Carrier	48TME007-501	0705G20297	2005	80%	115000

While the RTUs are on a preventative maintenance plan completed by Dowd Mechanical, the Carrier natural gas furnace/air conditioners are 16-22 years old. Some quick points:

- Highly likely that units will fail at higher rate over the next 1-5 years due to advanced age. Two of these units have failed in 2021 by the date, May 16.
- Recommend Township to develop a capital plan for phased replacement based on available and predicted capital.
- April 15, 2021: Dowd Mechanical requested to provide quotes for 80% and 90% efficiency natural gas furnace units plus heat pumps to inform WNT about possible replacement options.

If natural gas furnace/air conditioner units are selected for purchase (vs. long-term transition to heat pumps), we recommend that WNT purchase Energy Star rated units with Annualized Fuel Utilization Efficiency (AFUE) of 95% where possible seen here: [Furnaces Key Product Criteria | Products | ENERGY STAR](#). If capital costs are too high for these products, it is recommended that WNT purchase two stage furnace units (vs. single stage) to increase seasonal energy efficiency rating (SEER). Two stage units will increase efficiency during fall and spring months: [The Great 80% Vs. 95% Furnace Showdown | PV Heating & Air \(pvhvac.com\)](#). The air conditioner portion of combined furnace/AC system should have a SEER (Seasonal energy efficiency rating) rating of 14.5.

It's understood that WNT may be capital limited and hence the decision on which system to purchase may be driven almost completely on cost. Some key points to consider while making the decision:

- New units expected to have a 15+ year service life.
- Natural gas prices are expected to almost double by 2030, based on 2020 prices. [Natural Gas Price Forecast: 2020, 2021 and Long Term to 2030 - knoema.com](#) Higher prices are additionally expected to continue increase through 2035/2040. This would likely increase WNT natural gas bills by a minimum of 20% by 2030. If PECO decides to also increase the additional charges (distribution charge, balancing charge, or gas cost adjustment charge), then the future natural gas bills may be higher.
- Older AC units often have SEER < 10. Higher SEER, higher efficiency will be paramount in new units. While difficult to separate AC-related electricity costs at WNT Administration building from other electricity uses, Table 5 below shows potential electricity reduction with higher SEER units [DO THE MATH..HIGH EFFICIENCY AIR CONDITIONERS DRASTICALLY REDUCE ENERGY COSTS! | Horizon Services](#) .

Table 5 Electricity Reduction with Higher SEER rating for Air Conditioner portion of RTUs.

Existing Air Conditioner Efficiency: 10 SEER

New Air Conditioner Efficiency	Expected Reduction in Electricity
SEER 13	21%
SEER 14	28%
SEER 15	35%
SEER 16	42%

Additional recommendation: WNT should consider replacing Carrier combination natural gas furnace/air conditioner units with combination natural gas furnace/heat pumps. When the building requires cooling, the heat pump unit functions just like a central air conditioner. When the building needs heat, the heat pump reverses the refrigerant flow to provide warm air to the

building. This will reduce natural gas use. If the heating demand exceeds the heating capacity of the electric heat pump, the heat pump pauses, and the gas furnace takes over until the indoor temperature reaches the desired temperature on the thermostat or control system. This option should be discussed with Dowd Mechanical. Was noted Goodman may sell this system in an outdoor, commercial units and Dowd Mechanical sells Goodman units. Additionally, Trane is likely to have a similar type system. A change in electrical service may not be required.

A summary of WNT electric and natural gas bills shown below.

Table 6 WNT Administration Building, 1630 West Marshall Street Electric/Natural Gas Bills

WNT Admin Building 1630 West Marshall St.					
Billing Dates	Natural Gas - Account#: 01963-00904		Electric - Account#: 48594-00500		
	Monthly Bill	Natural Gas Consumption (ccf)	Monthly Bill	Electric Consumption (kWh)	Distribution (KWh)
3/26/19-4/24/19	\$483.51	426	\$1,371.44	13760	
4/24/19-5/23/19	\$211.76	171	\$1,505.43	15360	47.8
5/23/19-6/24/19	\$135.03	99	\$1,853.95	18640	56.8
6/24/19-7/24/19	\$148.89	112	\$2,200.32	22720	60.8
7/24/19-8/22/19	\$123.30	88	\$2,330.01	24480	60.8
8/22/19-9/23/19	\$127.71	97	\$1,899.62	19360	54.1
9/23/19-10/22/19	\$150.48	122	\$1,600.29	15440	52.6
10/22/19-11/20/19	\$777.08	754	\$1,567.82	15680	46.4
11/20/19-12/23/19	\$1,277.17	1421	\$1,725.34	18080	42.1
12/23/19-1/27/20	\$1,399.67	1630	\$1,783.02	18640	43.5
1/27/20-2/25/20	\$1,103.92	1278	\$1,716.49	17680	44
2/25/20-3/25/20	\$771.69	838	\$1,216.22	16880	41.6
3/25/20-4/23/20	\$508.29	535	\$1,422.07	14560	36.3
4/23/20-5/22/20	\$256.39	253	\$1,480.95	14960	39.8
5/22/20-6/23/20	\$98.70	80	\$1,889.31	19280	49
6/23/20-7/23/20	\$87.29	68	\$2,348.17	24000	61.1
Annual Costs: 5/23/19-5/22/20	\$6,779.62	7227	\$20,796.10	217120	578.8
PECO Gas Charges		Total Building Electrical/Natural Gas Cost	\$27,575.72		
		Natural Gas Cost (10/22/19-4/23/20)	\$5,837.82		

To ensure correct temperature control in the WNT Administration Building, and reduce cost from use of electric baseboard heating, balanced/correct air flow is critical. The forced hot air system is balanced by adjusting the manually adjusted dampers, fed from integral blowers in RTUs. The original 1988 engineering scope included a requirement to balance the HVAC system, including documenting the HVAC commissioning's air balancing results. The VU and WNT team were unable to locate the original air balancing report, which is not uncommon for projects completed 33 years ago. The building thermostats were checked, and a HVAC Zone map was developed, to help locate any trouble spots. The zone map may help WNT in the future as well and can be seen below.

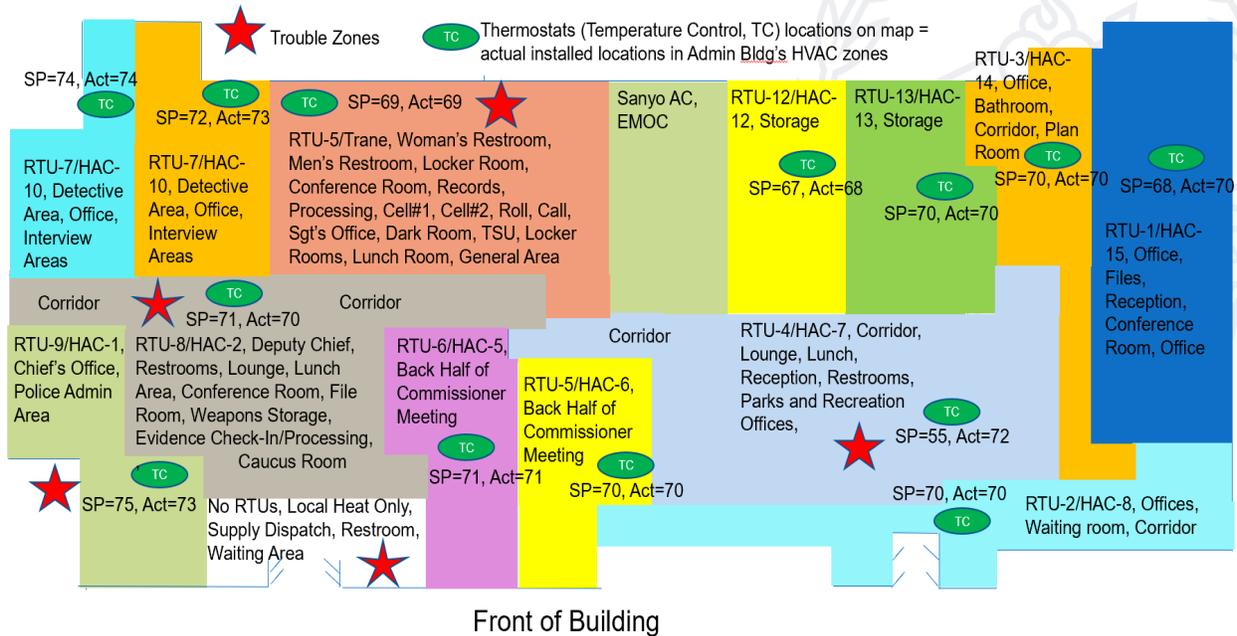


Figure 4 HVAC Zones for WNT Administration Building, 1630 West Marshall St.

As mentioned previously, the heating and cooling system includes the 13 Carrier combination natural gas furnace and air conditioners, 10 Penn Ventilator exhaust fans, the many supply and exhaust vents with manually adjusted dampers used to adjust flow, and local speed controllers (located in various rooms) to control air exhaust from targeted rooms. It is common for rooms/offices to have a supply and return vent in each room to get airflow. For this system to correctly work, the air flow rate into rooms should be balanced/adjusted to meet the original 1988 design flow rates (listed on the HVAC drawing). The March and April walk-throughs identified several issues which should be addressed. The trouble spots identified were as follows:

1. Reception Area: Actual temperature = 72 °F, setpoint = 55 °F. Air flows into this zone from other zones. With the setpoint at 55°F and room at 72°F, the RTU unit rarely supplies heat to the area, resulting in Parks and Receptions offices being cool/cold in winter. This was confirmed by office occupants.
2. Chief's Office, Police Area: Poor/no temperature control/air flow. The Chief's office is often cold when the doors are closed, resulting from the Chief's office having a supply vent but no return vents (per HVAC drawings). In addition, the general Police admin area adjacent to the Chief's office (RTU-9/HAC-1 zone) is often cold, requiring them to often use baseboard electric heaters. Drawings show the return vents for this area are in the adjacent conference rooms (which also have speed control). When conference room doors are closed, air flow to the Police Admin area likely decreases.
3. RTU-8/HAC-2 area: Also in the Police area, this zone is a large zone. The controlling thermostat is in the corridor, not the occupied space. This thermostat may not be

measuring the true temperature in the offices. Recommend relocating this thermostat into the office area (lunch area, conference room, etc) after rebalancing.

4. RTU-5/Trane Zone: Thermostat is located back by the new women's restroom. Recommend relocating it to a more central location where people sit, after rebalancing.
5. Rebalancing: Recommend rebalancing air flows in the building. Data suggests that the building has not been balanced since 1988, so air flows likely need adjustment. The areas that have the greatest need of rebalancing are RTU-4, RTU-5, RTU-8, and RTU-9 zones. Rebalancing will also provide additional knowledge to WNT personnel on the use of local variable fan controls.

Admin Building Kitchen Appliances:

The following appliances were observed during the walk through:

1. Upright refrigerator/freezer #1: Danby Upright refrigerator/freezer, model DFF100C1BSLDB, manufactured in September of 2017. Uses the refrigerant R600a and includes auto defrost. Not energy star rated, although its sister model, the Danby model DFF100C2BSSDD, is energy star certified. US Government Energy Guide Rating states estimated yearly electricity use for this system is 330 kWh at \$40 annually (dependent on utility rates) [6]. Canada Energy Guide states this unit's average energy consumption is expected to be 330 kWh/yr (expected range for these units 296kWh to 391 kWh) [6] <https://www.danby.com/wp-content/uploads/2017/12/DFF100C1BSLDB-Energy-Guide.pdf>.
2. Upright refrigerator/freezer Upright #2: Kenmore Upright refrigerator/freezer, model 253.68802014, that was manufactured in May of 2011. Uses the refrigerant R134a and the unit is not Energy Star Certified. Energy guides for this unit could not be located.

Both refrigerators were set at a midpoint, "normal", temperature setting and not at extreme cold. The Danby refrigerator has an internal temperature indicator and the unit was at 5°C, 41°F. Both freezers were set at a midpoint, "normal", temperature setting and not at an extreme cold setting.

Recommendation: Since neither unit is energy star rated, recommend replacement of units in the future with Energy Star rated refrigerators. The priority for replacement would be the 10-year-old Kenmore upright refrigerator.

Insulation and Doors

Admin Building glass front door: Significant amount of cold air felt flowing through the two front doors into the main lobby during the March visit. Significant gaps in weatherstripping observed at interface for both sets of double doors where doors close together.

Original project specifications state [2]:

1. Exterior doors to include weatherstripping

2. Maximum air penetration: 0.5 cfm of air per linear foot of operable door perimeter at wind velocity of 25 mph.

A literature review suggests there are few options for energy efficient, ADA (American Disabilities Act) compliant commercial glass double doors [7] <https://www.wbdg.org/guides-specifications/building-envelope-design-guide/fenestration-systems/exterior-doors>. Hence, replacement of double doors with highly energy efficient, insulated doors may not be possible.

Recommendation: Put both sets of front doors on a preventive maintenance plan with inspection of weatherstripping once every 6 months, with replacement of weatherstripping if damaged.

Building Lighting

Lighting Overview

The township building has several varieties of lighting fixtures and installations throughout the building and went through a retrofit in the early 2000s, where many fixtures were upgraded to dual 4-foot linear T8 lamps. These upgrades were primarily done in the police wing in the offices, corridors, and various other spaces. Within the two building audits, these lights were cataloged using the building plans provided by the township and physical inspection. This inventory can be seen in Appendix A, and features each room as identified in the building plan and their appropriate, installed fixtures. It is recommended to keep an inventory spreadsheet of all fixtures with upgrades for future improvements. From here, the police wing was separated from the rest of the building for analysis due to its necessity to have lighting on throughout the day. It is important to note that the police administration and other rooms that do not have to be on for 24 hours each day are included in the rest of building analysis, not the police wing.

Police Wing

The police wing total fixture and lamp count can be seen below:

Table 7 Police Fixture and Lamp Inventory

Label	Fixtures	Lamps	Size	Type	Wattage	Total
A	6	4	2x4	T8	34	24
A2	2	2	2x4	T8	34	4
A4	1	2	2x2	T12 U 6 inch	40	2
A5	3	2	1x4	T8	34	6
B	1	4	1x4	T8	34	4
B2	1	2	2x2	T12 U 6 inch	40	2
C	3	4	2x4	T8	34	12
D1	1	2	2x4	T8	17	2
F	2	4	2x4	T8	34	8
F1	2	2	1x4	T8	34	4

G	2	2	1x4 Troffer	T8	34	4
J	2	2	Screw bulb	CFL	13	4
L	1	2	Mounted	T8	34	2
Y1	4	2	2x2	T8	17	8
Z1	33	3	2x4	T8	34	99
Z2	6	2	1x4	T8	34	12

Most of these lamps were T8s using eco-ballasts, either 34W or 17W. However, there were still a few T12 U lamps that run at 40W. Due to the predominance of these fixtures in the building, the few CFLs was ignored (these can be easily upgraded to screw-in LEDs) and the T8 and T12 fixtures were used for analysis.

Table 8 Lamp Count, Energy Consumption, and Cost for Police Wing

	Fixtures	Watts	Lamp Number	Rated Hours	Product Link	Cost	Rated Years of Use	kWh
T8	29	34	179	15000	GE Ecolux 34W T8	\$2.88	1.712329	53313.36
T8	2	17	10	30000	Sylvania Octron 17W T8	\$4.35	3.424658	1489.2
T12 - 6 inch	2	40	4	18000	Sylvania T12 U-bend FB40	\$6.15	2.054795	1401.6
							Annual MWh	56.20416

The annual cost for the T8 bulbs can be analyzed using the above table using the rated years of use and the MWh consumed. New lamps will cost nearly \$326 each year and at 5.18 cents per kWh as per the new Wind RECs contract, electricity will cost \$2911 each year. It is important to note that this cost estimation may be high and assumes that lighting in these areas are on 24/7. All lights in the building within the police wing were on when the audit occurred.

The initial step to reducing the high electricity consumption within the police wing is to switch from fluorescents to TLEDs. TLEDs can be swapped into existing fluorescent fixtures with little or moderate modification. Toggled offers a 16W linear T8 LED bulb that can replace the 34W fluorescent bulb as seen here: [Toggled T8/T12, 4 ft., Dimmable Direct-wire LED Tubes, 24-pack – toggled](#) [2]. However, these are not direct replacement bulbs and needs an electrical contractor to come in, disconnect the balance, and rewire the live and neutral wires to the appropriate terminals. This job is relatively simple and should be able to be performed by any electrical contractor in 15-20 minutes. The reason that linear TLEDs should be used is that they offer a lower wattage than simple, replacement LEDs (these do not replace the ballast) and also

allow further energy savings by being dimmable. Bypassing the ballast allows for additional, more effective lighting control.

These new bulbs cost \$220 dollars per pack of 24 which comes to a unit cost of \$9.20. However, PECO offers a rebate for these bulbs at \$5 per bulb that can be applied through their Instant Lighting Discount for Business seen in Appendix B. With this reduction to \$4.20 per bulb, the total material cost for replacing all the T8 bulbs in the police wing would come out to \$793.80. The T12 U bulbs are an extremely outdated bulb and has a high cost per watt for its hour rating. All of these fixtures should be replaced with updated LED fixtures. Two options are available:

1. Update these fixtures to 2x4 or 1x4 T8s for bulb continuity/ ease of maintenance and use TLEDs as seen above.
2. Update these fixtures to LED Kits such as the 2x4 Sylvania Doorkit or Panel [3] [UltraLED™ Retrofit Doorkit \(sylvania.com\)](#)

The Sylvania Doorkit was quoted by Colonial Electric Supply Company at \$85 per retrofit kit. However, as these are DLC listed, they are eligible for a \$10 rebate. These LED kits are rated for up to 100,000 hours. Due to the low wattage of the Doorkits, we will model the savings for this building off their installation. Using the model RDORKIT5AS034UNVD83524UWH, this model consumes 34W and will slot into the existing 2x4 mounts in the ceiling. As these are LED fixtures, they can be wired the same way as the updated TLED fixtures. The material replacement of these two fixtures in the police wing will cost \$150. This electrician job is similar to the job of bypassing the ballasts as discussed before.

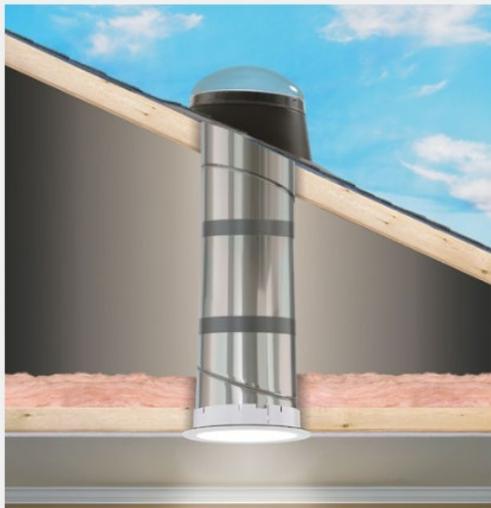
The energy savings seen through the shift to LEDs are as follows. With the replacement of the T8s to 16W TLEDs and the 35W retrofit kits, the annual energy consumption will become 27.7MWh, equating to an electricity reduction of 49.3%, roughly \$1430 per annum.

An additional step can be added to replace the switches that are found in the building with common dimming switches. These switches have been recorded to reduce energy consumption in buildings from 20 to 50% when properly used, especially during the daytime when there is adequate daylight. The dimmers sensors quoted by Colonial were \$58.50 and were model LUTDVSTVWH 0-10V Dimmer, although there are several cheaper models on the market such as the Lutron Diva LED+ Dimmer [Lutron Single-Pole or 3-Way Diva LED+ Dimmer Switch for Dimmable LED, Halogen and Incandescent Bulbs, White-DVCL-153PR-WH - The Home Depot](#). This switch costs \$29, but with a \$5 PECO rebate, would cost roughly \$600 to retrofit the police wing with 25 of these switches. It is important to get 0-10V LED Dimmers Assuming a reduction of 20%, this can further increase annual energy savings up to 58.4%. More of these switches may be needed if there are currently multiple installed per lighting zone. With the installation of these dimmer switches, a training/education program must be implemented to teach about the proper use of these switches for the electricity reduction.

Meeting Rooms, Large Areas, and Blue Room Daylighting

Due to the construction of the building with the flat roof and narrow ceiling space seen in the plans, there is an ability to install a type of daylight harvesting called a light tube. This is a hollow structure that can reflect daylight with a coated piping surface and disperse it into a building area. These are offered by manufactures such as SolarTube and VELUX lighting. These lighting sources are best used for large areas were the light can be used to illuminate a large space. Inside West Norriton’s administrative building, three of these rooms exist: the police administration room (74), the meeting room (56) and the blue room (26). The storage room (27) was also considered for this retrofit but may contain documents and other inventory that may be photosensitive (possible ink fading). These sun tunnel options are pictured below with VELUX on the left, and SolarTube on the right.

Rigid Sun Tunnel



These daylight harvesting applications are additionally useful due to fact that these rooms are often only used in the daytime, unlike the police wing in the building. The SolarTube options also offer a daylight dimmer and sensing control to ensure that the room is not too bright through a smart controlled ‘light valve’. These options also offer a potential 30% federal rebate. Russell Skylight LLC can be used to quote and install the VELUX systems who are located in Oreland, PA. [VELUX Skylights | Russell Skylight, LLC | Oreland, PA \(veluxusa.com\)](#). These daylight harvesting techniques are also expected to reduce the electricity consumption for lighting by 20-60%, dependent on the weather. Although there is no direct local rebate offered through PECO for these light tubes, if this can reduce the number of fixtures in the area, there is a \$0.25 per watt rebate for fixture reduction. This can be beneficial in the removal of older T12 U-bulb fixtures.

Rest of Building (RoB)

The other rooms in the building can also be retrofitted like the police wing as well. The table in Appendix A shows these fixtures and bulbs and the compiled list for these are as seen below.

Table 9 RoB Lighting Inventory

Label	Fixtures	Lamps	Size	Type	Wattage	Total
A	2	4	2x4	T8	34	8
A1	5	3	2x4	T8	34	15
A2	1	2	2x4	T8	34	2
A3	2	2	2x2	T12 U 6 inch	40	4
A4	50	2	2x2	T12 U 6 inch	40	100
A5	10	2	1x4	T8	34	20
B	2	4	1x4	T8	34	8
B1	18	2	2x2	T12 U 6 inch	40	36
B2	54	2	2x2	T12 U 6 inch	40	108
C	3	4	2x4	T8	34	12
C1	17	2	2x2	T12 U 6 inch	40	34
D	2	2	Wall 4	T8	34	4
D1	2	2	Wall 2	T8	20	4
J1	5	1	Screw Recessed	Quad Tube8" CFL	26	15
K	9	2	Straightliner	T8	28	27
K1	2	4	Straightliner	T8	28	6
Z1	43	3	2x4	T8	34	129
Z2	4	2	1x4	T8	34	12

Within these fixtures, most of them are T8s and T12 U lamps with a 6-inch spacing. Although there are several CFLs and shorter linear T8s, this analysis will focus on the 4-foot fluorescent tube variants. Replacement LED bulbs for the 15 CFLs are a simple replacement, with options found at any hardware store. The compiled T8s and T12s are seen below.

Table 10 RoB Bulbs, Energy Consumption, and Predicted Cost

	Wattage	Fixtures	Lights	Rated Hours	Cost	Rated Years of Use	kWh
T8	34	72	214	15000	\$2.88	5.136986	21245.92
T8	28	11	33	36000	\$4.72	12.32877	2698.08
T12 - 6 inch	40	141	282	18000	\$6.15	6.164384	32937.6
			436			MWh	56.8816

These lamps were assumed to be used on an average of 8 hours every day, 5 days a week. Replacing the same T8 bulbs with the 16-Watt Toggled replacements will result in a reduction of 11.54 MWh of electricity. This would require the replacement of 247 bulbs in the existing T8 fixtures and at \$4.20 per bulb, would be a material cost of \$1037 dollars.

When it comes to replacing the T12 U lamps, there was a consensus between administrators in the building that the spacing between the fixtures were too small. This resulted in many fixtures being left without tubes to reduce the overall brightness of the areas and rooms. Additionally, it was noted that different employees preferred different brightness levels in their workspace, creating various pockets in buildings with lacking bulbs. These fixture areas were notably in the police administration workspace and the secretary workspace on the other side of the building. Using the same 2x4 LED retrofits from Sylvania, we can install a lower number of these panels to replace the T12 U fixtures. There is also a 2x2 version of this LED retrofit as well as seen here: [Sylvania LED Retrofit Door Kit 2x2 5000K - Office Depot](#). Assuming that half of the fixtures are needed throughout the building. This results in the total number of replacement fixtures to be 70. Using the Sylvania LED retrofit door kit of 32W, this would result in a reduction of electricity consumed by 13.08 MWh per year. With the kit cost of \$75, material replacement would total to \$5950.

This combined reduction of energy would come to be 25.35 MWh, a 44.5% reduction and a retrofit sticker price of \$7877. In addition to these cost savings, PECO offers an incentive of indoor permanent fixture removal at \$0.25 per watt reduced. After consulting with a PECO Incentives employee, each of these fixtures would be rated around 48W (based off T8 bulbs) and would therefore constitute a \$12 rebate per removed fixture. This comes to a total rebate of \$852 with the same fixture reduction of 50%.

We can further reduce the electricity by using the same dimmer switches found before. However, with the furthered recommendation of also creating zoned lighting within the police administration, meeting room, and warehouse. These rooms should have 3 zoned lighting options, each on their own dimmer switch. The number of switches for the entire building is unknown, but the same reduction of electricity will occur at around 20%-50% if used appropriately. Lastly, these switches do have a \$5 rebate per unit that is offered by PECO a previously mentioned.

Lighting Conclusion and Recommendations

Within the administration building, the priority list is as follow for lighting upgrades. Replacement of fixtures in the police wing is paramount due to the higher hourly usage.

1. Replace T12 U bulb fixtures to Sylvania 2x2 or 2x4 UltraLED Retrofit Doorkits, or a DLC alternative.
2. Rewire existing T8 fixtures to adopt linear TLEDs and use the Toggled 16-Watt LED replacements, or a DLC dimmable alternative, with the PECO rebate.
3. Replace all existing switches to dimmer switches.
4. Explore daylighting options for appropriate rooms.

The priority is to eliminate the use of T12 U bulbs. These bulbs have the highest wattage of any of the bulbs and are also rated for a low number of hours. Along with this, these fixtures are spaced too closely together and have non-dimmable ballasts

UltraLED™ Retrofit Doorkit



2x2



2x4

Figure 5 Sylvania UltraLED Retrofit Doorkit

One option for the retrofit is to get the Sylvania 2x2 or 2x4 Retrofit Doorkits. These can be procured from a nearby electric supplier, Colonial, that has its headquarters in the King of Prussia: [Colonial Electric Supply](#). Colonial provided quotes for these retrofits, dimmers, and TLEDs, but only had the best price for the LED retrofits. These kits have a rated life for 100,000 hours, well above the 18,000-hour rating for the T12s. It is recommended to use the 3500K option in line with LEED guidance. This can be a priority due to the additional rebate for the reduction of these fixtures within the building, also increasing it's cost-effectiveness.

The second priority is to upgrade the T8 fixtures to accommodate linear TLEDs. The reason why this is a second priority is because of the manual labor that will have to go into disconnecting the ballasts for the fluorescent tubes and rewiring the live and neutral to the appropriate locations. For these tubes, the 24 pack Toggled 16-W direct wire LED tubes can be used. It is important to note that these tubes are dimmable, and many other T8 LED replacements are non-dimmable. If the township intends to install dimmer switches, a dimmable LED must be used. If the township does not want to use dimmers, a cheaper non-dimmable replacement bulb can be found, although not recommended. It is also recommended to use the Toggled 4000K option. These LEDs also have a rated lifespan for 50,000 hours, well above the lifespan of their fluorescent alternatives at 18,000. This product can be seen in Appendix C.

The Applicable PECO Rebates are as follows:

- TLEDs (DLC certified): \$5

- LED Retrofit Fixtures (DLC certified): \$10
- Dimmer Switches: \$5
- Fixture Removal: \$0.25 /W of fixture

To be eligible for all these rebates, an application must be filled out with PECO before the installation of these kits. These rebates will renew on June 1st of this year, so it is imperative that the rebate numbers be revisited if the retrofits occur after that date. The PECO Incentives hotline can be called at 8663719343 to ask any questions about the direct lighting rebates. To plan out the project, the PECO line is 8444249728. The online application center is [PECO | PECO - An Exelon Company \(programprocessing.com\)](http://PECO-PECO - An Exelon Company (programprocessing.com)). PECO engineers will assist in the process of determining whether a product is eligible for a rebate and the amount of the rebate. LED's require a DLC certification (Design Light Consortium). Most LEDs will have this certification, and it can be assumed that larger manufactures' products will have this cert.

Vehicle Fleet

Vehicle Analysis

An analysis of West Norriton Township's police vehicles and public works vehicles was completed. Only the vehicles which had all relevant information (annual mileage and total mileage) were evaluated. The vehicles were assessed based on their age, annual mileage, and total mileage to determine which vehicles are the best candidates for electric vehicles (EVs) and hybrid electric vehicles (HEVs). The police vehicle fleet was focused on due to their high fuel consumption due to idling.

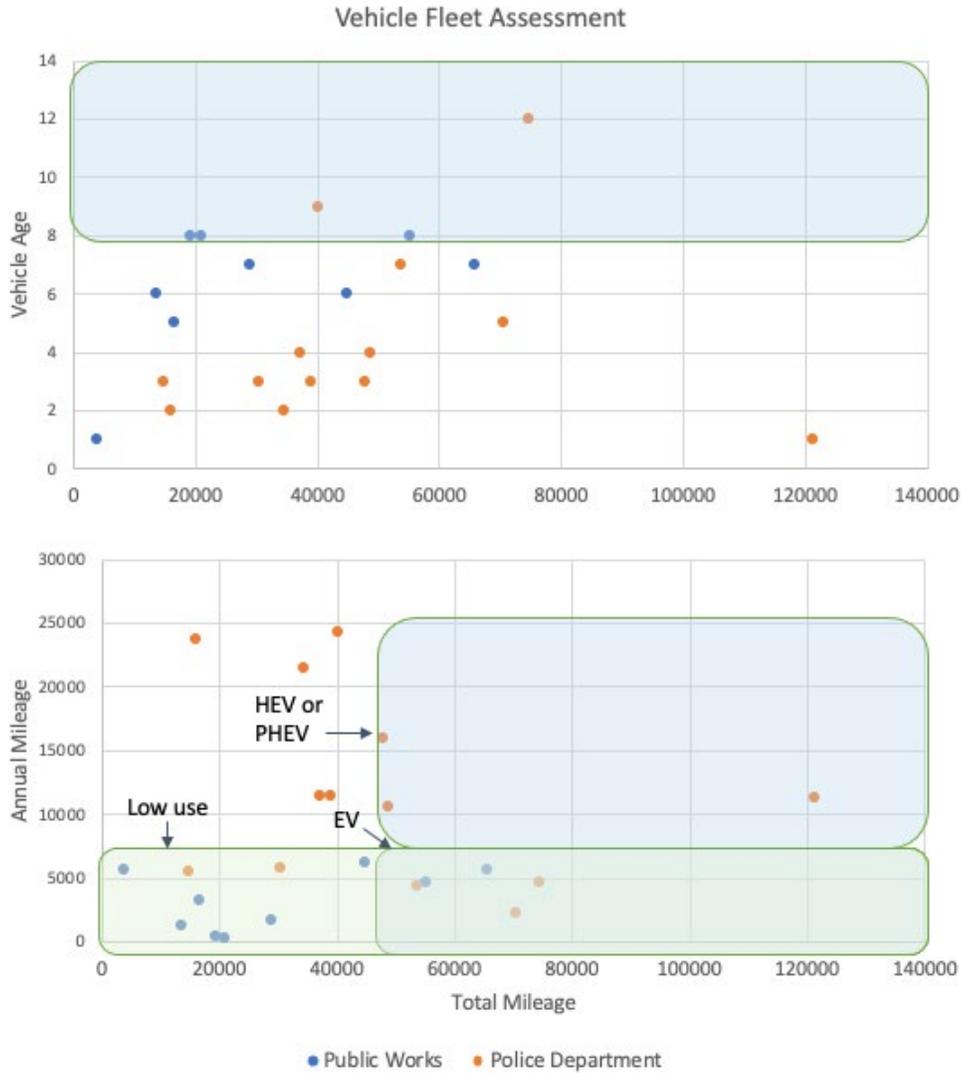


Figure 6 Vehicle Assessment for EV and HEV candidates

Table 11 Vehicle Information and EV and HEV Candidates

Police Department	Vehicle Type	Vehicle ID	Age	Annual Mileage	MPG	Mileage
2018 Chevy Traverse	Mid-Size SUV	62-1	3	5454	16.2	14740
2018 Chevy Traverse	Mid-Size SUV	62-2	3	5810	18.1	30383
2016 Ford Expedition	SUV	62-10	5	2273	8.1	70582
2019 Dodge Charger	Passenger Car	62-11	2	21489	7.7	34473
2017 Chevy Tahoe	SUV	62-12	4	10655	8.2	48683
2017 Dodge Charger	Passenger Car	62-15	4	11461	7.5	37146
2012 Chevy Tahoe	SUV	62-16	9	24285	8.3	40189
2018 Chevy Tahoe	SUV	62-14	3	15942	7.4	47901
2020 Dodge Charger	Passenger Car	62-18	1	11241	7.5	121120
2019 Chevy Silverado	PickUp Truck	62-20	2	23696	8.3	15831
2009 Ford Fusion	Passenger Car	62-31	12	4614	15.9	74504

2018 Chevy Tahoe	SUV	62-17	3	11432	12.4	38791
2014 Dodge Charger	Passenger Car	62-33	7	4373	14.9	53695
Public Works Dept						
2013 International	Heavy Duty, On Road Truck	PW-23	8	219	3.4	20988
2015 Chevy Silverado	PickUp Truck	PW-24	6	6249	8.1	44727
2015 Ford Dump Trk	Heavy Duty, On Road Truck	PW-25	6	1254	2.8	13422
2014 Chevy Silverado	PickUp Truck	PW-28	7	1705	9.5	28830
2014 Chevy Silverado	PickUp Truck	PW-29	7	5683	9.3	65674
2020 Chevy Silverado	PickUp Truck	PW-32	1	5708	18.3	3752
2013 Chevy Silverado	PickUp Truck	PW-34	8	4728	9.7	55243
2016 GMC Sierra	PickUp Truck	PW-27	5	3209	8.5	16595
2013 International	Heavy Duty, On Road Truck	PW-21	8	387	4.9	19196

 EV Candidate
 HEV Candidate

Out of the 13 police vehicles evaluated, 7 of them can be considered candidates for EVs or HEVs. Four of the vehicles are best suited for HEVs, and 3 of them have the potential to be replaced by EVs. At this time, it is not considered feasible for the police fleet to transition to fully EVs, because of the unique requirements for police vehicles. Therefore, it is recommended that the township transition to both hybrid vehicles and electric vehicles wherever possible. It is recommended that the township does not buy any more solely gas-powered vehicles unless deemed completely necessary.

Hybrid Savings

Based on a case study in Lancaster County, PA, a cost and GHG analysis of transitioning the West Norriton police fleet to the Ford Interceptor hybrid vehicle has been completed. The Ford Interceptor was created specifically for police fleets. The total cost of fuel for the Ford hybrid vehicle and of a non-hybrid vehicle was estimated. Then, the total savings of transitioning the entire police fleet to hybrid vehicles was estimated, along with the savings of carbon dioxide emissions.

Table 12 Hybrid Vehicle Cost Per Vehicle

FORD HYBRID VEHICLE - COST PER VEHICLE PATROL FLEET	
Estimated Fuel Efficiency - Miles Per Gallon	24
Estimated Miles Per Year	10269
Estimated Idle Time Per Year (IN HOURS)	1460
Estimated Price Per Gallon	\$2.69
Estimated Yearly Sub-Total cost for miles driven per year	\$1,151.00
Estimated Yearly Sub-Total cost for time idled per year	\$801.19

Estimated Gallons USED Per Year - DRIVING	427.88
Estimated Gallons USED Per Year - IDELING (based on .204 gallons per hour)	297.84
Estimated Gallons USED Per Year - TOTAL	725.72
GRAND TOTAL COST PER YEAR - FUEL USED	\$2,250.03

Table 13 Non-Hybrid Vehicle Cost Per Vehicle

NON-HYBRID VEHICLE - COST PER VEHICLE PATROL FLEET	
Estimated Fuel Efficiency - Miles Per Gallon	11.3
Estimated Miles Per Year	10269
Estimated Idle Time Per Year (IN HOURS)	1460
Estimated Price Per Gallon	\$2.69
Estimated Yearly Sub-Total cost for miles driven per year	\$2,444.56
Estimated Yearly Sub-Total cost for time idled per year	\$1,826.24
Estimated Gallons USED Per Year - DRIVING	908.76
Estimated Gallons USED Per Year - IDELING (based on .465 gallons per hour)	678.9
Estimated Gallons USED Per Year - TOTAL	1587.66
GRAND TOTAL COST PER YEAR - FUEL USED	\$4,270.81

The total annual fuel cost of the Ford hybrid vehicle was estimated to be \$2250, while the total annual fuel cost for the regular vehicle was \$4,271. Therefore, the hybrid vehicle leads to \$2,021 a year in fuel savings. When multiplied across the entire police fleet (18 vehicles), the total savings comes to \$36,374 a year. This transition also saves 17,238 pounds of carbon dioxide emissions a year.

Table 14 Vehicle Fleet Summary, Savings & Costs

FUEL COST FLEET WIDE (18)	
Hybrid Units	\$40,500.48
Non-Hybrid Units	\$76,874.50
Fleetwide Savings Per Year	
Fuel	\$36,374.01
CO2 (lbs)	17238.8
Initial Cost of Vehicle	
2021 Chevy Traverse	\$30,000
2021 Ford Interceptor	\$40,000

The Ford Interceptor may come at a higher initial cost than a regular vehicle, however, the fuel savings will easily return this investment. The 2021 Ford Interceptor is about \$40,000 while the 2021 Chevy Traverse is about \$30,000. With these prices, the return on investment is estimated at 5 years. Another cost to be considered is the cost of charging infrastructure, which can vary based on installation and quality of the equipment.

Police EV and Hybrid Fleet Case Studies

The police department in Northern Lancaster County, PA has rolled out a new patrol fleet of Ford Hybrid SUVs. The Ford Interceptor is a hybrid SUV made specifically for police fleets. The hybrid fleet is projected to save \$30,835.64 and 339,613 lbs of CO2 per year. This case study was used for the above hybrid cost analysis.

(https://lanaster.crimewatchpa.com/sites/default/files/8795/post/attachments/2020_-_2024_nlcprpd_fleet_plan_.pdf)

In another case study, the city of Tacoma purchased 34 Ford Police Interceptor hybrids, an SUV-type vehicle made specifically for police fleets, with an anticipated fuel savings of 40 percent. The savings will reduce fuel consumption by more than 28,800 gallons of fuel per year and saved the city an estimated \$73,700. This comes to about \$2000 of savings per vehicle per year.

(<https://www.govtech.com/public-safety/Cities-Are-Inching-Toward-Fully-Electric-Police-Vehicles.html>)

Ford also has a sedan Police Interceptor, and recently released a new Police Responder Hybrid Sedan in 2019. The Police Responder will be the first pursuit-rated hybrid vehicle and will be ideal for urban or local patrol work. The Police Responder is projected to get an EPA-estimated 38 mpg combined (40 mpg city/36 mpg highway), which Ford says is more than double the EPA-estimated rating of 18 mpg combined for the 3.7L Police Interceptor AWD gasoline sedan. The Ford Police Interceptor Utility SUV and the Police Responder sedan demonstrated top speeds of 137 and 119 mph respectively. Acceleration was impressive with 0 to 60 times running 7.27 and 9.24 seconds respectively. (<https://www.government-fleet.com/157374/fords-new-hybrid-police-sedan-doubles-fuel-efficiency>)

As for fully electric vehicles, Tesla Model 3s replaced a few retiring Dodge Chargers for the police department in Bagersville, Indiana. In the first year with the Teslas, the department recorded cost savings of over \$6,000 in fuel and maintenance **per vehicle** compared with the Dodge Chargers, in the fleet with officers driving around 22,000 miles annually.

(<https://www.arcweb.com/blog/electric-vehicles-law-enforcement>)

Equipment Electrification

Golf Carts

The electrification of any equipment relies heavily on batteries for energy storage. Lithium batteries have been around since the 1970's and the first commercial lithium battery was

available in 1985 by Sony. Over the years, the Lithium battery has advanced into a cleaner, more advanced version [4].

The older lithium batteries used metallic lithium, but newer versions have been replaced with an intercalated lithium compound (electrode) making them a lot more efficient and environmentally friendly. These batteries offer a high amount energy density and require little to no maintenance. The power output also does not drop during use which is beneficial for vehicles and power tools. They have a low charging time and a low self-discharge rating, making for a longer shelf life. Compared to lead-acid batteries, lithium-ion batteries are roughly half the weight and have a life span up to ten times longer [5].

Jeffersonville Golf Course currently has 73 gas operated golf carts in their fleet. The models range from the year 2008 - 2017. Twenty-five of the golf carts are to be replaced in the Spring of 2021 with continued gas-powered carts. However, to continue moving toward 100% clean energy, the fleet of gas-powered golf carts would need to be replaced gradually, as cost permits, over the next 3-5 years to electric alternatives. Here are two models that can be recommended: the E-Z-Go Express S4 (\$12,049) and the E-Z-Go Freedom RXV (\$10,382). E-Z-Go is currently the #1 brand in the electric golf cart industry known for quality, reliability, and reasonable prices [6] and began building golf carts in 1954.

Using the E-Z-Go savings calculator, this study compared the E-Z-Go Freedom RXV (base price \$10,382) to the YAMAHA Brand Drive DC 2 (base price \$8,200) [5] (for one golf cart, estimated 382.5 rounds of golf in 1 season and estimated 6.43 miles/round course length). Results showed the E-Z-Go Freedom RXV would save approximately \$540 annually in operational and maintenance costs. [6] It would take approximately 2 years to match the base price, but the benefit of clean energy is insurmountable.

Features include:

- Elite lithium battery with an 8 year warranty
- Charges twice as fast as a lead acid battery
- 3.3 rounds of golf per charge
- High efficiency
- Lightweight (weighs 250lbs less than lead-acid battery cart)
- Less wear and tear on turf
- Save money on turf repairs
- Zero maintenance
- Cost less to operate
- Half of out of the wall energy as an average lead-acid powered cart
- Zero Emissions vs approximated 25,000 lbs. CO2 emissions per gas operated golf cart with 20 hours of operation per week [7]

[5] “2021 NEW Yamaha Drive 2 PTV Quietech Gas Golf Cart with 4 Year Factory Warranty.” *Mike's Golf Carts of NJ*, 3 May 2021, customgolfcartsnj.com/2020-new-yamaha-drive-2-ptv-quietech-gas-golf-cart-with-4-year-factory-warranty/.

[6] “ELiTE Lithium Powertrain.” *E*, ezgo.txtsv.com/personal/technology/elite-lithium-powertrain.

[7] Yvkoff, Liane. “Community's Proposed Gas Golf Cart Ban Too Much of a Green Thing?” *Roadshow*, CNET, 6 Aug. 2010, www.cnet.com/roadshow/news/communitys-proposed-gas-golf-cart-ban-too-much-of-a-green-thing/.

Lawncare Electrification

With respect to the electrification of lawncare equipment, it has been expressed that the West Norriton groundskeepers would like to see the technology develop further before making the transition. Advances in design and efficiency would allow for longer use times as well as lower market prices. Some preliminary research found a commercial mower, comparable to what is currently used, for \$13,800 from GreenWorks Commercial. The GZ60R 82-Volt Ride-On Zero-Turn Mower has an 82-volt lithium battery which is more efficient and has a longer lifespan than a lead acid option. It has a 60” deck with 16 cutting heights and an approximate coverage of 12 acres on one charge [6]. There are also lithium battery-operated chainsaws, blowers and hedge trimmers on the market that have the capability of sharing batteries which can be useful if all chainsaws, blowers, and hedge trimmers will not be used at the same time.

After working with a GreenWorks Commercial representative, a one-to-one conversion was identified for 35 out of 65 of the original lawncare equipment products. The comparable products include the greens mowers, utility and work carts, sand traps, rough mowers, blowers, chainsaws, and string and hedge trimmers. Many of these recommended replacements are made by GreenWorks. However, several of the original manufactures are now creating electric versions of their gas products. For example, Cushman has an electric work cart and the current Smithco bunker rakes can be replaced with Smithco’s new battery powered Sand Star E 48V AC bunker rakes [7]. Similarly, Jacobsen will be releasing the Jacobsen Eclipse 360 this summer which would be a suitable replacement for the greens, tees and fairways mowers with the addition of different reels. Rough mowers are typically wide-area mowers, ranging from 10’ to 16’ and would be more difficult to replace with electric at this time. The recommendation is a GreenWorks CZR 60” zero turn because it has a larger battery and can be fitted with attachments such as a blower. The full list of replacement recommendations can be found in Appendix D of this report.

GreenWorks manufactures power equipment with brushless motors and rechargeable, interchangeable, lithium-ion batteries. When West Norriton is ready to make a full or partial conversion, it will be helpful to know how many tools would be in use at any given time which

may allow for a scaled quantity of batteries. It is recommended that the township purchase one 2.5 A battery per a tool with the exception of the GMS250 and GBB700 mowers which would require two 5A batteries and the GS181 chainsaw which would require one 4A battery. Once the total number of batteries has been calculated, an appropriate number of 6-port chargers will need to be purchased as well.

In terms of pricing, West Norriton is a Co-stars member which is a purchasing agency for municipalities in Pennsylvania and New Jersey and qualifies the township for dedicated discounts on all products ranging from 10%-25%. GreenWorks estimates that the five-year savings between a gas and electric tool kit would be around \$26,592.50 [8]. In addition to upfront costs, electric equipment can save golf courses on lawn maintenance due to gas or oil leaks.

In March of 2013, an 18-hole course outside of Chattanooga, Tennessee called The Bear Trace at Harrison Bay, began their conversion from gas to electric. The table below summarizes many of the environmental and economic benefits that they experienced. In addition, electric equipment runs much quieter than their gasoline counterparts, making for a more enjoyable experience for both the groundskeepers and golfers.

Table 15 The Bear Trace at Harrison Bay's Electric Equipment Initiative Gasoline to electric comparisons, 2014 [9]

The Bear Trace at Harrison Bay's Electric Equipment Initiative Gasoline to electric comparisons, 2014

	Average hours operated		Gallons of fuel		Gallons of waste oil		CO ₂ emissions (pounds)		Cost of maintenance	
	Gasoline	Electric	Gasoline	Electric	Gasoline	Electric	Gasoline	Electric	Gasoline	Electric
Riding greens mower	1,304.00	1,304.00	1,004.00	0.00	37.00	0.00	20,080.00	0.00	\$6,085.00	\$750.00
Riding tee mower	1,440.00	1,440.00	1,108.00	0.00	41.00	0.00	22,160.00	0.00	\$6,720.00	\$828.00
Green roller	576.00	576.00	444.00	0.00	17.00	0.00	8,880.00	0.00	\$2,707.20	\$334.08
Green sprayer	144.00	144.00	111.00	0.00	1.00	0.00	2,220.00	0.00	\$426.24	\$195.84
Bunker rake	768.00	768.00	591.00	0.00	23.00	0.00	11,820.00	0.00	\$3,609.60	\$445.44
Mid-duty utility vehicle	6,000.00	6,000.00	4,617.00	0.00	24.00	0.00	92,340.00	0.00	\$14,225.20	\$1,755.00
Light-duty utility vehicle	3,360.00	3,360.00	2,800.00	0.00	8.00	0.00	56,000.00	0.00	\$9,945.60	\$1,227.33
Totals	13,592.00	13,592.00	10,675.00	0.00	151.00	0.00	213,500.00	0.00	\$43,718.84	\$5,535.69

Calculations based on:
Gasoline: \$3.06/gallon
Electricity: \$0.0925/kilowatt-hour

Riding greens mower: 1 unit x 4 hours daily use x 326 days of use
Riding tee mower: 2 units x 5 hours daily use x 144 days of use
Green roller: 1 unit x 4 hours daily use x 144 days of use
Green sprayer: 1 unit x 4 hours daily use x 36 days of use
Bunker rake: 1 unit x 4 hours daily use x 192 days of use
Mid-duty utility vehicle: 5 units x 5 hours daily use x 240 days of use
Light-duty utility vehicle: 2 units x 5 hours daily use x 336 days of use

Gallons of fuel: Jacobsen and Toro equipment operation calculator websites
Gallons of waste oil: Jacobsen and Toro equipment operation calculator websites
CO₂ emissions: EPA and Department of Energy fuel economy guide; 1 gallon of gasoline burned = 20 pounds of CO₂ emitted
Cost of maintenance: Jacobsen and Toro equipment operation calculator websites; includes labor, oil, hydraulic fluid, brake fluid and filters

Potential PV Solar Rooftop System

Upon investigating the potential of the administration building to have solar rooftop system, the team ran a preliminary system design and feasibility study on a photovoltaic (PV) solar rooftop system implementation using Helioscope for PV system design.

The preliminary design showed the limited rooftop area available for PV system installation due to existing shade-casting objects; a tree next to the building as well as an electric pole at the back of the building as shown in the figure below. In addition, the HVAC roof units limited the area available for a solar roof top.

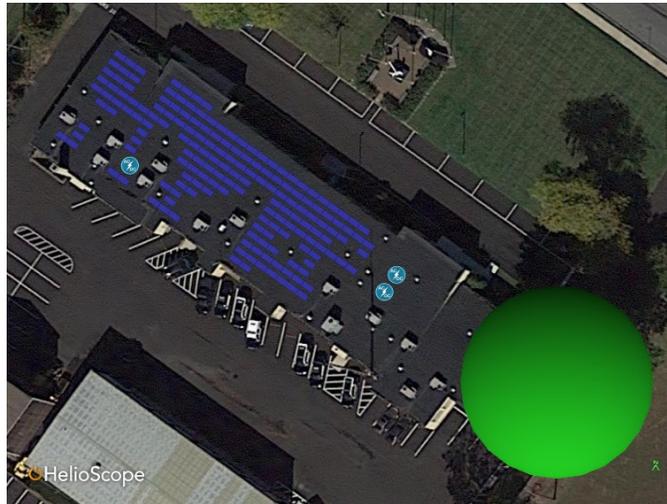


Figure 7: Solar Rooftop Layout

Design Specifications

The below table shows the solar system components to be installed. In addition, the next table shows the technical specifications of the proposed solar rooftop system, while the chart shows the expected monthly generation capacity.

Table 16: Electrical Components of The Solar System

Components		
Component	Name	Count
Inverters	Sunny Tripower 24000TL-US (SMA)	3 (72.2 kW)
Home Runs	12 AWG (Copper)	6 (1,376.0 ft)
Combiners	1 input Combiner	3
Combiners	3 input Combiner	3
Strings	10 AWG (Copper)	12 (557.9 ft)
Module	Hanwha, Q.PEAK L-G4.5 370 (370W)	171 (63.3 kW)

Table 17: Solar System Metrics

System Metrics	
Design	Design 1
Module DC Nameplate	63.3 kW
Inverter AC Nameplate	72.2 kW Load Ratio: 0.88
Annual Production	83.22 MWh
Performance Ratio	83.8%
kWh/kWp	1,315.3
Weather Dataset	TMY, 10km grid (40.15,-75.35), NREL (prospector)

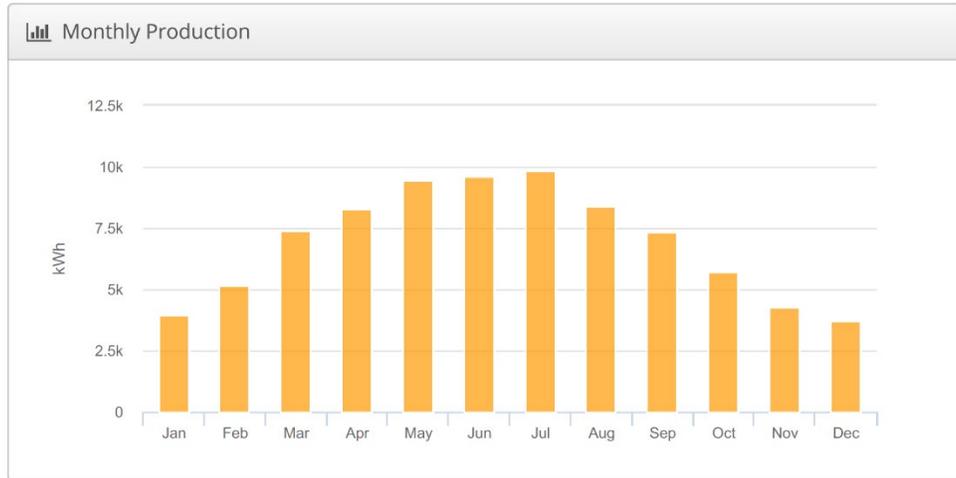


Figure 8: Predicted Monthly Electricity Production out of Solar Energy

Design Consideration

Due to the limited roof area, a module of **370 W** was chosen to maximize the generation capacity of the constrained roof area.

Spacing due to module shading was set to 2 feet to allow for the workers’ free movement during the cleaning process of the solar panels. In addition, a 4 ft spacing was left between the roof edges and the solar system for safety measures

Solar Rooftop System Economics

The following table shows the purchase price of the different system components:

Table 18: Price Breakdown of The Solar System Components

Product	Description	Unit Price	Quantity	Total
Sunny Tripower 240000TL-US (SMA)	Inverter	\$4,500.00	3	\$13,500.00
Hanwha, Q.Peak L-G4.2 370	Module	\$237.00	171	\$40,527.00
Everest Cross Rail System	Support		171	\$0.00
Combiner Box	Combiner		6	\$0.00
#12 CU	Copper Wiring	\$0.24	1367	\$328.08
#10 CU	Copper wiring	\$0.17	557.9	\$94.84
Total				\$54,449.92

Rail systems are usually accounted for with the modules prices, and the combiner boxes prices are negligible if compared to the total price of the equipment. A 10% overhead can be used to attribute for these additional costs.

The next table shows the cost per watt through the cost estimates of the system, including labor. GC stands for general contractor and OH&P stands for overhead and profit.

Table 19: Per-Watt Cost Estimates of The Solar System

Item	System Size (kWdc)	Material Rate (\$ / Watt)	Material Total	Labor (\$ / Watt)	Prevailing Wage Adjustment	Total
PV Equipment (\$/W)	63.3	0.86	\$54,449.92	0.45		\$54,478.41
PV Conduit, Conductors and Gear (\$/W)	63.3	0.5	\$31,650.00	0.6		\$31,687.98
Electrical OH&P (15%)	15%	-	-	-	30%	\$16,802.45
GC OH&P (15%)	15%	-	-	-	30%	\$16,802.45
Total Cost						\$119,771.28
\$/kW						\$434.27

Due to the increase of the kWh price out of solar rooftop system against the kWh purchased through Hudson Energy, the system does not prove to be profitable. In addition, due to the low price of solar renewable energy credits (SRECs) in PA, \$20/MWh generated, the system did not have a good payback period or good ROI as shown below, that summarizes the cash flow analysis for the solar system.

Table 20: Cash flow Analysis Summary

Total Savings Over 25 years	\$119,129.42
IRR	0%
ROI	(\$641.86)
NPV Discount Rate	5%
Pay Back (Years)	25.13
NPV after 25 years	(\$54,275.75)
Average Annual Revenue	\$4,765.18

- IRR stands for internal rate of revenue
- ROI stands for return on investment
- NPV stands for net present value
- **Red** indicates negative values or loss

In order to cover the capital investment needed for installation, a survey on available incentives has been performed. The majority of incentives available through the state and government are

segmented into two categories: a tax rebate or credit system and a low interest rate or APR on loans.

Unfortunately, municipal buildings are tax exempt facilities that are not eligible for tax credits. As for the loans, the team does not have information on the budget West Norriton has to put into the system. Therefore, the team recommends involving a third party, a solar energy company, that can afford the capital investment, while benefiting from the tax credits. In turn, the third party can offer lower prices for the township to account for the tax credits. This would result in a long-term PPP agreement between the energy firm and West Norriton. Additionally, it is recommended that this to be done nearing the end of the current 5-year energy contract with Hudson. In the upcoming years, there may be additional incentives or an increase in price of SRECs that can prove beneficial to the township.

Backup Battery System

In addition to the solar rooftop system, the team studied the feasibility of having a battery backup system that can supply the demand of the administration building for two days in case of an outage. With the emergency control center in the administration building, it is recommended that an electrical contractor be used to determine the load profile for emergency use. The calculations presented below can then be replicated with this given information for a properly sized battery system. Additionally, the days accounted for storage must be evaluated for what is the hour timeframe that the building needs back-up power for. It is important to note that a basement generator is now being used to fulfill this requirement.

The detailed design specs are as follows:

$$\text{Admin Building AC Load} = 217120 \text{ (KWh/year)} = \frac{217120 \times 1000}{365} = 59,849.32 \text{ Wh/day}$$

$$\text{Battery DC load} = \frac{\text{Admin. Building AC load}}{(\text{Inverter efficiency} \times \text{Controller efficiency})}$$

$$= \frac{59,849.32 \text{ (Wh/day)}}{(0.85 \times 0.97)}$$

$$= 712,466.73 \text{ Wh/day}$$

$$\text{Load} = 712,466.73 \text{ (Wh/day)} / 48 \text{ (V)}$$

$$= 15030.56 \text{ Ah/day @ 48 V}$$

Accounting for two days of storage with 100% of the load met.

$$\text{Usable Storage} = \text{Load} * 2 = 300,61.11 \text{ Ah @ 48V}$$

Max. depth of discharge (DOD) is 80%

Assuming the minimum Temp. of the battery is -10 C.

Total discharge rate for C/48 is 90%

$$\begin{aligned}\text{Nominal Capacity (C/20, 25 C)} &= \frac{\text{Usable Storage}}{\text{MDOD} \times \text{TDR}} \\ &= \frac{15030.56}{(0.9 \times 0.8)} \\ &= \mathbf{20,875.8 \text{ Ah @48 V}}\end{aligned}$$

Upon surveying the market for batteries with high capacity to accommodate the building's demand, the Trojan SIND 06 1225 Deep Cycle has been chosen. The battery specs are as follows:

- Flooded lead acid battery
- Max Charge Current 13% of C20 rate
- Max Absorption Phase Time – 4 hours
- Size 6 volt industrial
- 1083 AH @ C48
- 942 AH @ C20
- 835 AH @ C10
- 27.13"L x 10.44" W x 24.01" H
- 415 pounds
- Unit price: \$1,098.31
- Warranty 18 month
- Estimated end-of-life (EoL): 10 years

<https://www.altestore.com/store/deep-cycle-batteries/flooded-lead-acid-batteries/trojan-sind-06-1225-ind17-6v-solar-industrial-line-deep-cycle-flooded-battery-p9704/>

In total, the number of batteries = 20,875.8/ 942 = 22.16 units

Total number of units will be 24.

With 6V batteries @ 48V, the configuration of the 24 units will be three strings of 8 batteries per each string as shown in the figure below.

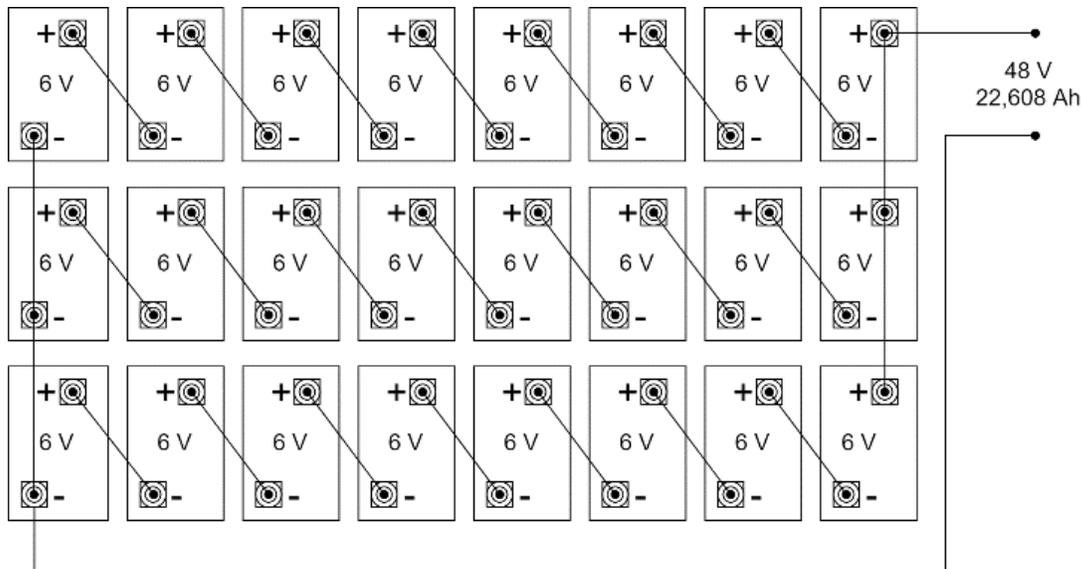


Figure 9: Backup Batteries System Configuration

Backup Battery Systems Economics

Based on market values, the total cost of batteries is **\$26,352.00**. However, the cost can be reduced by choosing other battery types with lower capacities/energy densities. Yet, this will result into a greater number of batteries, around 70 units, and this may cause an issue to provide space to accommodate for the 70 units.

In addition, due to the unavailability of information on the percentage of critical loads the building has, as well as the unknown generator capacity that is usually needed during outages, an assumption of 48 hours has been made that accounts for 100% of the load during outages.

Updated Greenhouse Gas Inventory

A previous greenhouse gas (GHG) analysis was performed in the winter of 2021 on the various energy consumers in the township that included electricity, natural gas, and vehicle fuel consumption. To create a more complete GHG inventory analysis, gasoline use for lawncare equipment and golf carts will also be included.

It was reported that 2000 gallons were used for various two-stroke engines within the township equipment and golf carts at the golf course. This results in a large amount of CH₄ and N₂O being released due to the lack of regulations for these motors to have catalytic converters. The translated CO₂e for these devices relate to a previous 2% of their overall emissions in the base case.

Table 21 Two Stroke Engine GHGs

Mobile Source Combustion- gasoline - Scope 1		Gallons	Kg CO2/gallon	g CH4/gallon	g N2O/mile	CO2 tonne	CH4 tonne	N2O tonne
General Equipment	Motor Gasoline	2,000	8.78	15.57	0.06	50.046	0.00253	0.00102
CO2e (tonne)	CH4 to CO2e (tonne)	N2O to CO2e (tonne)	TOTAL CO2e by Category	TOTAL CO2e				
50.046	0.07074	0.2711	50.38784	50.38784				

Potential Savings

The calculated base case be follows, that was derived from Phase 1 of the project. Within this figure, buildings and municipal pumps are the largest contributors to the greenhouse gas portfolio. This is due to the use of grid mix electricity, which in PA has a large mix of fossil fuel resources, primarily natural gas. Gas vehicles also take up a significant proportion of the GHGs.

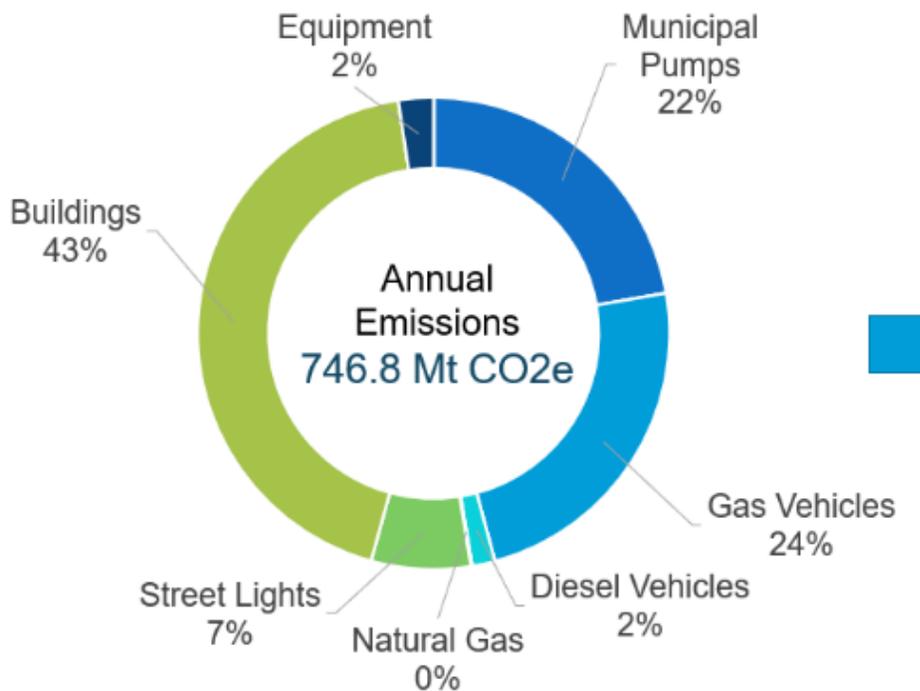


Figure 10 Base case GHG emissions for township energy sources

The next figure shows the compiled reductions of GHGs with all recommended courses of action taken place discussed in this paper. The major reduction in GHG emissions comes from the switch to green energy wind RECs as the township source of electricity. With the general switch of equipment and vehicles to electric, smaller reductions in the GHG were seen. Gas vehicles continue to impact the township's emissions because of the larger maintenance equipment being

used. These larger trucks do not have direct electric or hybrid replacements that can be implemented in the upcoming years.

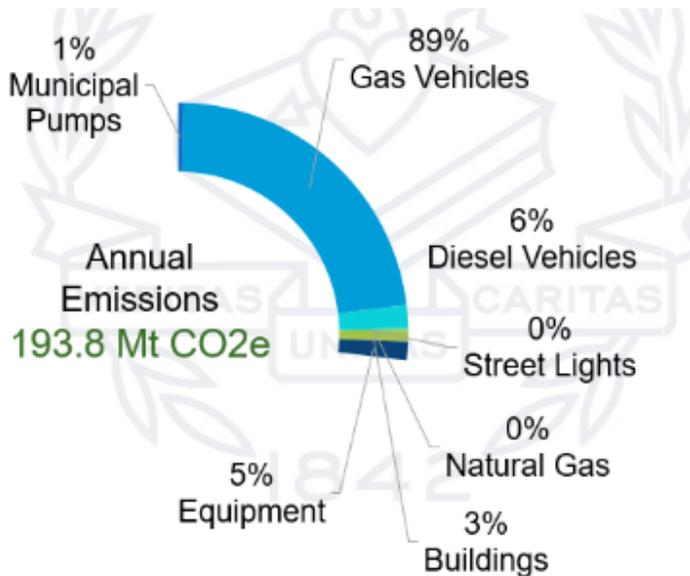


Figure 11 Projected GHG emissions for township energy sources from given recommendations

It can be seen that with these provided recommendations, the energy GHGs from the township can be almost quartered from 746.8Mt to 193.8Mt of carbon equivalent.

Final Recommendations

This study recommends the following action plan for West Norriton's Township commitment to ReadyFor100.

Short-term (1-2 yrs.)

- Develop capital plan for replacement of Admin Bldg. HVAC units (e.g. NG Furnace/Heat Pump)
- Rebalance Admin Bldg. HVAC air flow/relocate two thermostats
- Repairs/Insulate - Repair hole in basement ceiling, insulate hot water supply line from boiler, repair weather stripping in front doors, insulate floor, insulate roof.
- Stop purchasing any new solely powered gas vehicles unless deemed completely necessary, and instead replace any vehicles going out of commission with HEV
- Replace all fluorescent T8 bulbs with TLED counterparts and install dimmer switches

Medium-term (3-5 yrs.)

- Replace rooftop HVAC units

- Recommend: E-Z-Go Elite Lithium golf carts for performance, efficiency & cost savings
- Consider purchasing EVs for lower use vehicles
- Replace T12 U-bulb fixtures with dimmable LED retrofit kits
- Replace smaller, handheld lawn care equipment (blowers, chainsaws, trimmers)

Long-term (6-10 yrs.)

- Transition entire vehicle fleet to HEVs and EVs
- Consider daylighting options for larger rooms
- Consider replacing larger lawn care mowers (tees, greens, fairways) and attachments (sand traps and rough attachments)
- Re-evaluate solar and battery backup potential

Works Cited

- [1] Sierra Club, "Ready for 100," Sierra Club, 2020. [Online]. Available: <https://www.sierraclub.org/ready-for-100>. [Accessed 1 December 2020].
- [2] A. Wirt-Vitabile, E. E. H. E. Corp and M. E. P. Engineering, *Project Specification, Renovations for the West Norriton Township Building, 1630 West Marshall Street, Norristown, PA*, Norristown, PA: Wirt Vitabile Architects.
- [3] Owens Corning, *Flame Spread 25 FIBERGLAS Insulation*, Toledo: Owens Corning, 2007.
- [4] Johns Manville, "What R-value Do I Need?," Johns Manville, [Online]. Available: <https://www.jm.com/en/homeowner-insulation/homeowner-faq/what-r-value-do-i-need-/#:~:text=What%20R-value%20Do%20I%20Need?%20Depending%20on%20where,R-49%20are%20common%20for%20ceilings%20and%20attic%20spaces>. [Accessed 10 May 2021].
- [5] Home Depot, "17-W Linear T8 LED Light Bulb," Home Depot, 2021. [Online]. Available: <https://www.homedepot.com/p/Sylvania-17-Watt-Linear-T8-LED-Light-Bulb-25-Pack-75026/305907093>. [Accessed 28 April 2021].
- [6] Canada EnerGuide, "EnergyGuide," Canada EnerGuide, [Online]. Available: <https://www.danby.com/wp-content/uploads/2017/12/DFE100C1BSLDB-Energy-Guide.pdf>. [Accessed 2021 10 May].
- [7] WBDG , "Exterior Doors," Whole Building Design Guide, [Online]. Available: <https://www.wbdg.org/guides-specifications/building-envelope-design-guide/fenestration-systems/exterior-doors>. [Accessed 10 May 2021].
- [8] Sylvania, "UltraLED Retrofit DoorKit," Sylvania, 2021. [Online]. Available: <https://www.sylvania.com/products/luminaires/Luminaires/Pages/Retrofit-DoorKit.aspx>. [Accessed 28 April 2021].
- [9] ScienceStruck, "Advantages and Disadvantages of Lithium-ion Batteries," Science Struck, 2021. [Online]. Available: <http://sciencestruck.com/advantages-disadvantages-of-lithium-ion-batteries>. [Accessed 27 April 2021].
- [10] RELiON, "Lithium Battery Advantages," RELiON, 2021. [Online]. Available: <https://reliionbattery.com/resource-center/technology/why-choose-lithium>. [Accessed 27 April 2021].
- [11] GreenWorks Commercial, "GZ60R 82-VOLT 60" RIDE-ON ZERO-TURN MOWER," GreenWorks Commercial, 2021. [Online]. Available:

<https://greenworkscommercial.com/gz60r-82-volt-60-ride-on-zero-turn-mower>. [Accessed 2 April 2021].

[12] Smithco, "Sand Star E 48V AC," Smithco, 2021. [Online]. Available: <https://smithco.com/sand-star-e-48v-ac/>. [Accessed 28 April 2021].

[13] GreenWorks Commercial, "GreenWorks Commercial 2020 Lookbook," Sunrise Global Marketing, Hong Kong, 2020.

[14] P. L. Carter, "Electric maintenance equipment: Can you hear me now?," *Golf Course Management*, July 2017. [Online]. Available: <https://www.gconline.com/course/environment/news/electric-maintenance-equipment>. [Accessed 28 March 2021].

Appendices

Appendix A – Fixtures Per Room

Plan Number	Name	Fixture	Number	Fixture	Number
1	Equipment	Z1	5		
2	Bathroom	D1	1		
3	Police - Training	Z1	8		
4	Police - Projection	A2	2		
5	Police - Hallway	Y1	1		
6	Police - Interview	C	1		
7	Police - File Storage	Z1	1	Z2	2
8	Police - Detective	Z1	8		
9	Police - Office	A	3		
10	Police - Conference	C	2		
11	Police - Records	A5	2		
12	Police - Vestibule	Y1	1		
13	Police - Processing	F	2	F1	2
14	Police - Cell 1	G	1		
15	Police - Cell 2	G	1		
16	Police – Lunchroom	Z1	1		
17	Police - Patrol & Hallway	Z1	6	Y1	2
18	Police - Sergeant's Office	A	2		
19	Police - Roll Call	A	1		
20	Police - Shower	L	1	A5	1
21	Police - Locker	Z2	4		
22	Police - TSU	B	1	B2	1
23	Police - Dark Room	J	2	J2	1
24	Police - Work-out	Z1	4		
25	Police- Hallway	A4	1		
26	Blue Room - Storage/Maintenance	Z1	6		
27	Storage	K	6		
28	Vestibule	A3	1		
29	Toilet	A4	1		
30	Office	A4	7		
31	Office - Plan Room	A4	6		
32	Toilet	D1	1		
33	Lounge	A	1		
34	Lunchroom	A1	1		
35	Toilet	D1	1		
36	Janitor Closet	H	1		

37	Small Storage	H	1		
38	Files	K1	2		
39	Office	B2	6		
40	Reception Office	B1	8		
41	Computer Room (Office)	B	2		
42	Conference Room	C1	6		
43	Office	J1	5		
44	Office	C1	5	C	1
45	Secretary's Office	B2	7		
46	Files - Server Room	A5	2	B2	1
47	Book-Keeping (Office)	B2	10		
48	Vestibule	Z1	1		
49	Supplies	Z1	2		
50	Reception	Z1	1		
51	Waiting Room	Z1	1		
52	Office	B2	6		
53	Office	B2	6		
54	Toilet - Women's	A5	3		
55	Toilet- Men's	A5	3		
56	Meeting Room & Platform	A4	29		
57	Office - Marty's	A4	6		
58	Police - Security	K	1		
59	Police -Evidence Check-in	A1	1		
60	Police - Evidence Processing	A	1		
61	Corridor	Z1	8		
61	Police - Evidence	K	2		
62	Corridor	Z1	3		
62	Police - Toilet	D1	1		
63	Corridor	Z1	6		
63	Police -ESU & Weapon Storage	Z2	4		
64	Police - Complaint	A1	2		
64	Corridor	Z1	8		
65	Corridor	Z1	2		
65	Police - Waiting	Z1	2		
66	Police - Vestibule	A4	1		
67	Corridor	Z1	3		
67	Police - Toilet	D1	1		
68	Police - Reception, Dispatch	B1	6		
69	Police - Lieutenant	B1	4		
70	Toilet- Women's	D	1		

71	Toilet - Men's	D	1
72	Police - Kitchen	A2	1
73	Police - Lounge	A1	1
74	Police -Administration	B2	18
75	Police - Conference	C	2
76	Police - Files and Supply	A5	2
77	Police - Chief's Office	C1	6
78	Police - Vestibule	A3	1
			304

Appendix B – PECO Rebates

Qualifying equipment is subject to the specifications, terms and conditions outlined in the program application and application manual for Phase III. Incentives are available until May 15, 2021, or while funds last.

Interior Lighting Equipment Type	Incentive	Unit
DLC 2' and 3' TLED Tubes	\$3	Lamp
DLC 4' TLED Tubes	\$4 \$5	Lamp
DLC 8' TLED Tubes	\$4 \$7	Lamp
DLC Pin-Based LED Lamp	\$0.50–\$1.00	Lamp
ENERGY STAR® Integral LED Fixture or Retrofit Kit	\$10	Fixture
ENERGY STAR GU24 Pin-Based LED Lamp	\$1	Lamp
ENERGY STAR MR16 Pin-Based LED Lamp	\$3	Lamp
ENERGY STAR Screw-In Decorative, Globe or Directional/Reflector Lamp	\$4	Lamp
HPT8 and T5 Fixtures	\$1	Fixture
HPT8 High-Bay Fixture	\$40	Fixture
Interior Ceramic HID Lamp	\$5	Lamp
Interior Pulse Start HID	\$10	Lamp
LED Accent/Track Lighting Fixture	\$1	Head
LED Indoor Channel Signage	\$1	Letter
LED Exit Sign	\$10	Sign
LED High-Bay Fixtures and/or Retrofit Kits	\$60 \$70	Fixture
LED Low-Bay Fixtures and/or Retrofit Kits	\$60 \$70	Fixture
LED Refrigerated Vertical Door (Case and Freezer)	\$15	Door
LED Refrigeration Case Lighting (Open Case)	\$0.05	kWh Saved
LED Troffer Linear Fixtures 2'	\$10	Fixture
LED Troffer Linear Fixtures 4'	\$12	Fixture
NEW LED Surface and Suspended Linear Fixtures 2'	\$5	Fixture
NEW LED Surface and Suspended Linear Fixtures 4'	\$10	Fixture
NEW LED Surface and Suspended Linear Fixtures 8'	\$25	Fixture
Reduced Wattage T8 Lamp	\$1	Lamp
T5 HO High-Bay Fixture	\$50	Fixture
Unitary Sensor Controls	\$5	Sensor
Controls Combination — Daylighting and Occupancy, Fixture Mounted	\$5	Sensor
Interior Central Lighting Controls	\$0.01	Sq. Ft.
Indoor Permanent Fixture Removal	\$0.25	Watts Reduced

Exterior Fixtures	Incentive	Unit
LED Parking Garage and Canopy Fixtures and Retrofit Kits	\$35–\$70	Fixture
ENERGY STAR Integral LED Fixture — Outdoor Recessed Downlight and Retrofit Module	\$10	Fixture
LED Outdoor Flood Light Fixtures	\$25	Fixture
LED Pole/Arm-Mounted Parking and Roadway Fixtures and Retrofit Kits	\$20–\$75 \$75–\$100	Fixture

Exterior Fixtures	Incentive	Unit
LED Wall Mount Fixtures and Retrofit Kits	\$20–\$50 \$40–\$75	Fixture
Outdoor Permanent Fixture Removal	\$0.25	Watts Reduced
LED Traffic, Turn and Pedestrian Signals	\$5	Signal
LED Outdoor Channel Signage	\$1	Letter

Plug Load Control	Incentive	Unit
Tier 2 Advanced Power Strip	\$1	Unit

HVAC	Incentive	Unit
Air-Cooled or Water-Cooled Air Conditioner	\$10	Ton
Air-Cooled Heat Pump	\$25	Ton
Water-Cooled Heat Pump	\$50	Ton
Packaged Terminal Air Conditioner (PTAC)	\$30	Ton
ENERGY STAR Ductless Mini-Split Heat Pump	\$10	Ton
Ground Source, Water Source and Groundwater Source Heat Pump	\$15	Ton

Unitary HVAC Chillers	Incentive	Unit
Air-Cooled Chiller	\$7	Ton
Water-Cooled Chiller	\$5	Ton

Other HVAC Measures*	Incentive	Unit
Hotel Guest Room Occupancy Sensors (Electric Resistance Heat and Air Conditioning)	\$30	Room
Integrated Dual Enthalpy Economizer Controls	\$2.50	Ton
Circulation Fan — High-Volume, Low-Speed	\$15	Unit
Electronically Commutated Motor (ECM) Circulation Fan	\$1	Fan
ECM Circulation Pump	\$1	Pump
Retrocommissioning, Cooling Systems**	\$0.75	Ton
Retrocommissioning, Whole Building†	\$0.15	Sq. Ft.
Energy Management System**	\$40	Ton
Demand Controlled Ventilation**	\$25	Ton

Refrigeration	Incentive	Unit
Anti-Sweat Heater Controls	\$50	Door
Evaporator Coil Defrost Controls	\$52	Controller
Evaporator Fan Controls	\$7	Controller
Floating-Head Pressure Controls	\$7 \$50	HP
Automatic Door Closers	\$20	Door
Evaporator Fan ECM for Refrigerated Cases	\$7.50	Motor

Refrigeration	Incentive	Unit
ENERGY STAR Commercial Freezer	\$75	Unit
ENERGY STAR Commercial Refrigerator	\$10	Unit
Suction Pipe Insulation	\$0.20	Linear Foot
Night Cover	\$2.50	Night Cover
Strip Curtains	\$1	Linear Foot
Variable-Speed Refrigeration Compressor	\$15 \$40	Compressor
Doors Added to Open Refrigerated Cases	\$15 \$75	Door
Door Gaskets	\$1	Door
Zero Energy Doors	\$17.50	Door
Air-Cooled Refrigeration Condenser	\$10	Ton
Oversized Condenser With Variable-Frequency Drive	\$5	HP
Case Light Occupancy Controls	\$3.50	Door

Food Service	Incentive	Unit
Beverage Machine Controls	\$12.50	Unit
Snack Machine Controls	\$10	Unit
ENERGY STAR Refrigerated Beverage Vending Machines	\$62.50	Unit
ENERGY STAR Electric Steam Cooker	\$75	Unit
ENERGY STAR Combination Oven	\$75	Unit
ENERGY STAR Commercial Convection Oven	\$75	Unit
ENERGY STAR Commercial Fryers	\$30	Unit
ENERGY STAR Commercial Hot Holding Cabinet	\$100	Cabinet

Motors and Drives	Incentive	Unit
Variable-Frequency Drive on HVAC Fan, Chilled Water or Heating Hot Water Pump	\$50	HP
Variable-Speed Drive on Kitchen Exhaust Fan	\$250	HP
Variable-Speed Drive on Process Motor < 50 HP	\$50	HP
Early Replacement Motors With Premium Efficiency Motors	\$20	Motor
Variable-Speed Drive on Dust Collection System Motor	\$10	HP

Domestic Hot Water	Incentive	Unit
Fuel Switch — Electric Water Heater to ENERGY STAR Commercial Gas Water Heater	\$50	Unit
Heat Pump Water Heater From Electric Coil Water Heater	\$1	Water Heater
Low-Flow, Pre-Rinse Spray Valve	\$1	Valve

Custom Measures	Incentive	Unit
All Retrofit Custom Measures	\$0.05	kWh saved

LED Traffic Signals	Incentive	Unit
Round Signals, 8" and 12"	\$5	Sign
Turn Signals, 8" and 12"	\$5	Sign
Pedestrian Signals, 9", 12" and 16"	\$5	Sign

Compressed Air	Incentive	Unit
No-Loss Condensate Drains	\$10	Drain
Air-Entraining Air Nozzle	\$2.50	Nozzle
Storage Tanks for Load/No Load Screw Compressors	\$5	Compressor HP
Cycling Refrigerated Thermal Mass Dryer	\$5	Compressor HP
Variable-Speed Air Compressor	\$40	Compressor HP
Compressed Air System Optimization	\$10	Compressor HP

New Construction — Interior Lighting ¹⁾	Incentive	Unit
≥ 10% of Code	\$0.12	Sq. Ft.

New Construction — Whole Building Systems	Incentive	Unit
≥ 10% of Code	\$0.15	Sq. Ft.

Data Centers	Incentive	Unit
Air-Cooled Chiller	\$5	Ton
Air-Cooled Chiller Without Condenser	\$5	Ton
Computer Room Air Conditioner	\$5	Ton
Efficient Fans for CRAH or CRAC Units	\$5	Ton
Water-Cooled Centrifugal Chiller	\$5	Ton
Water-Cooled Positive Displacement or Reciprocating Chiller	\$5	Ton
Uninterruptible Power Supply, 20–100 kVA	\$0.50	kVA
Mainframe Refresh	\$2.50	kW Installed
Server Refresh	\$2.50	kW Installed
PC Power Management System	\$3	PC Controlled
HVAC System Optimization	\$0.02	kWh Saved
Hot/Cold Aisle Containment	\$0.02	kWh Saved
Server Virtualization	\$200	kW Reduction
Thin Clients	\$2.50	Thin Client

Note: Specific equipment will determine the exact incentive level when an incentive range is provided. All lighting products must be DLC or ENERGY STAR certified.

¹⁾Must meet minimum SEER requirements.

²⁾Subject to actual kWh savings achieved.

³⁾To be eligible for an incentive, the project must save a minimum of 1 kWh per square foot.

⁴⁾New construction interior lighting controls and exterior lighting power efficiencies that exceed code will be incentivized as custom measures using \$0.05/kWh rate.

Appendix C – T8 Dimmable LED



All Products

Why Toggled

Company

COLLECTIONS

- Standard LED T8/T12
- Dimmable LED T8/T12
- Color Changing T8/T12
- High Output T8/T12
- Grow LED T8/T12
- Fixtures T8/T12
- Fixture Conversion
- Accessories
- Closeout Specials

LENGTHS

- 4 foot / 48 inches
- 3 foot / 36 inches
- 2 foot / 24 inches

Home > 24-pack BULK - 4 ft., Dimmable Direct-wire LED Tubes (Closeout)

24-pack BULK - 4 ft., Dimmable Direct-wire LED Tubes (Closeout)

D416-50321-24

☆☆☆☆☆ No reviews

Color

Daylight (5000K)

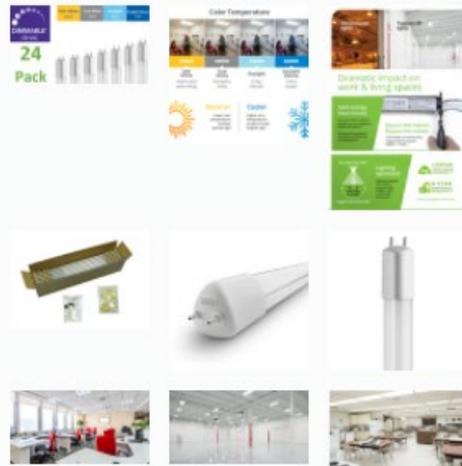
\$219.99

Quantity

Add to Cart

Free shipping for orders of \$50.00 or more.
\$5.99 Standard Shipping applies otherwise.

Free and Standard Shipping is not available for AK, GU, HI, PR, VI and countries outside of the U.S.
Contact info@toggled.com directly for availability and shipping costs to these destinations.



Appendix D—Lawncare Recommendations

Make	Model	Replacement	Retail	Price	Total Discount
honda	push mower	GMS250 - 25" s/p mower	\$ 649.99	\$ 519.99	20%
honda	push mower	GMS250 - 25" s/p mower	\$ 649.99	\$ 519.99	20%
honda	push mower	GMS250 - 25" s/p mower	\$ 649.99	\$ 519.99	20%
		back pack		\$ 263.99	
red max	blowers ebz 7500	GBB 700 back pack blower	\$ 329.99		20%
		back pack		\$ 263.99	
red max	blowers ebz 7500	GBB 700 back pack blower	\$ 329.99		20%
		back pack		\$ 263.99	
red max	blowers ebz 8550	GBB 700 back pack blower	\$ 329.99		20%
echo	pb 250 ln	82B600 handheld blower	\$ 159.99	\$ 127.99	20%
echo	pb 250 ln	82B600 handheld blower	\$ 159.99	\$ 127.99	20%
echo	pb 250 ln	82B600 handheld blower	\$ 159.99	\$ 127.99	20%
sthil	ms290	GS181 - "50cc" chainsaw	\$ 349.99	\$ 279.99	20%
sthil	ms460	GS181 - "50cc" chainsaw	\$ 349.99	\$ 279.99	20%
		48TH12 - 12" chainsaw		\$ 399.99	
echo	cs310	(48V)	\$ 499.99		20%
redmax	bcz 260 ts	GT161 - String trimmer	\$ 249.99	\$ 199.99	20%
redmax	bcz 260 ts	GT161 - String trimmer	\$ 249.99	\$ 199.99	20%
red max	bcz 230 ts	GT161 - String trimmer	\$ 249.99	\$ 199.99	20%
red max	bcz 230 ts	GT161 - String trimmer	\$ 249.99	\$ 199.99	20%
red max	bcz 230 ts	GT161 - String trimmer	\$ 249.99	\$ 199.99	20%
		GHX200 - Pole Hedge		\$ 239.99	
red max	lirtz 2460	trimmer	\$ 299.99		20%
little				\$ 159.99	
wonder		GH260 - Hedge Trimmer	\$ 199.99		20%
black &				\$ 159.99	
decker		GH260 - Hedge Trimmer	\$ 199.99		20%
		GL250 - 2.5 AH Battery	\$ 169.00	\$ 135.20	20%
		GL500 - 5 AH battery	\$ 299.00	\$ 239.20	20%
		GL400BT - 4 AH battery /		\$ 239.20	
		bluetooth	\$ 299.00		20%
		GL900 - backpack battery	\$ 899.00	\$ 719.20	20%
		AWP1000 - waist pack	\$ 149.00	\$ 119.20	20%
				\$ -	
		GC400 - single port rapid		\$ 55.20	
		charger	\$ 69.00		20%

GC420 - dual port charger	\$	79.00	\$	63.20	20%
GC460 - 6 port charger	\$	479.00	\$	383.20	20%

Carts

toro	workman mdx	U400	\$16,999	\$ 15,299.10	10%
toro	workman gtx	U400	\$16,999	\$ 15,299.10	10%
toro	workman gtx	U400	\$16,999	\$ 15,299.10	10%
toro	workman gtx	U400	\$16,999	\$ 15,299.10	10%
cushman	turf truckster	U400	\$16,999	\$ 15,299.10	10%
cushman	truckster	U400	\$16,999	\$ 15,299.10	10%
yamaha	g23 work cart	Cushman Hauler Pro	\$ 10,749.00	\$ 8,061.75	25%
yamaha	adventurer one	Cushman Hauler Pro	\$ 10,749.00	\$ 8,061.75	25%
yamaha	adventurer one	Cushman Hauler Pro	\$ 10,749.00	\$ 8,061.75	25%
yamaha	work cart	Cushman Hauler Pro	\$ 10,749.00	\$ 8,061.75	25%

Fairways, tees, greens, rough, sand traps

	super star 3			\$ 27,287.10	
smithco	wheel drive plow	Sand Star E	\$ 30,319.00		10%
smithco	super star 49 volt	Sand Star E	\$ 30,319.00	\$ 27,287.10	10%
		CZR 60 - 60" zero turn		\$ 16,199.10	
Jacobsen	hr 5111	mower	\$ 17,999.00		10%
	pro-flex 120	CZR 60 - 60" zero turn		\$ 16,199.10	
progressive	rotary mower	mower	\$ 17,999.00		10%
	articulator model	CZR 60 - 60" zero turn		\$ 16,199.10	
lastec	3682	mower	\$ 17,999.00		10%
buffalo	turbine blower	blower attachment on CZR	TBD		
		Jacobsen Eclipse 360	TBD		
		Smithco Roller	TBD		

Appendix E – HVAC Inventory

Item# - Engineering Drawings	Item# - In Field/On Roof	Electrical Panel/Disconnect Switch #	Initial Installation - 1988 (per Engineering Drawings)													
			Manuf	Model#	General Carrier Information	Nominal Tons - Chiller	Standard CFM	Net Cooling Capacity (BTU/h)	Chiller - Total kW	SEER	EER	Heating Input (BTU/h)	Heating Output (BTU/hr)	AFUE (%)	SS Efficiency (%)	CA Seasonal Efficiency (%)
HAC-1	RTU-9	PBB-5	Carrier	DJE 005	48DJE005 - Gas Heat, Constant volume, High heat	4	1600	48000	5.8	9.1	8.3	115000	90850	76	80	74.1
HAC-2	RTU-8	PBB-2	Carrier	DJE 006	48DJE006 - Gas Heat, Constant volume, High heat	5	2000	59500	7	9.3	8.6	115000	90850	76	80	74.1
HAC-3	Don't seem to exist/Can't	Carrier		52BQA3143												
HAC-4	Don't seem to exist/Can't	Carrier		52BQA3093												
HAC-5	RTU-6	PBA-6	Carrier	DJE 004	48DJE004 - Gas Heat, Constant volume, High heat	3	1200	34600	4.1	9.5	8.4	74000	58460	76	80	73.3
HAC-6	RTU-5	PBA-1	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
HAC-7	RTU-4	PBA-4	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
HAC-8	RTU-2	PBA-2	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
HAC-9	RTU-10	PBB-4	Carrier	DJE 004	48DJE004 - Gas Heat, Constant volume, High heat	3	1200	34600	4.1	9.5	8.4	74000	58460	76	80	73.3
HAC-10	RTU-7	PBB-3	Carrier	DJE 005	48DJE005 - Gas Heat, Constant volume, High heat		1600	48000	5.8	9.1	8.3	115000	90850	76	80	74.1
HAC-11	Trane	PBB-1	Carrier	48HHD009												
HAC-12	RTU-12	PBA-3	Carrier	DJE 006	48DJE006 - Gas Heat, Constant volume, High heat	5	2000	59500	7	9.3	8.6	115000	90850	76	80	74.1
HAC-13	RTU-13	PBA-8	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
HAC-14	RTU-3	PBA-7	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
HAC-15	RTU-1	PBA-5	Carrier	DJE 007	48DJE007 - Gas Heat, Constant volume, High heat	6	2400	71000	8.45	NA	8.4	115000	90850	76	80	74.1
Notes:																
1. SEER = Seasonal Energy Efficiency Ratio.																
2. EER = Energy Efficiency Ratio																
3. AFUE = Annualized Fuel Utilization Efficiency																

1999-2005 HVAC Upgrades																							
Item# - Engineering Drawings	Item# - In Field/On Roof	Electrical Panel/Disconnect Switch #	Manuf	Model#	Serial #	Date of Manufacture	Refrigerant	Thermal Efficiency	Input Max (BTU/hr)	Output Capacity (BTU/hr)	min input BTU/hr	Subunit	Qty	Volts-AC	Phase	RLA	LRA	FLA	Air Temp Rise	Design Maximum Outlet Air Temp	Maximum External Static Pressure	Certifications	
HAC-1	RTU-9	PBB-5	Carrier	48TJE004-511GA	Z199G20604	1999	R-22	80%	74000	59200	NA								25 F - 55 F	185 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	11.7	75						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	1			4.9					
												Other-Combustion	1	208-230	1			0.6					
HAC-2	RTU-8	PBB-2	Carrier	48TFE006-A-511	4302G30171	2002	R-22	80%	115000	92000	NA								35 F - 65 F	185 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	16.0	114						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.6					
HAC-3	Don't seem to exist/Can't locate																						
HAC-4	Don't seem to exist/Can't locate																						
HAC-5	RTU-6	PBA-6	Carrier	48TME004-A-501	0705G40904	2005	R-22	80%	74000	59200	NA								25 F - 55 F	???	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	10.2	75						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	1			4.9					
												Other-Combustion	1	208-230	1			0.6					
HAC-6	RTU-5	PBA-1	Carrier	48TME007-501	0605G50263	2005	R-22	80%	115000	92000	NA								35 F - 65 F	155 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	20.6	146						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.57					
HAC-7	RTU-4	PBA-4	Carrier	48TME007-501	0705G20292	2005	R-22	80%	115000	92000	NA								35 F - 65 F	155 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	20.6	146						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.57					
HAC-8	RTU-2	PBA-2	Carrier	48TME007-501	0505G10183	2005	R-22	80%	115000	92000	NA								35 F - 65 F	155 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	20.6	146						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.57					
HAC-9	RTU-10	PBB-4	Carrier	48TME006-A-501	0404G50392	2004	R-22	80%	115000	92000	NA								35 F - 65 F	185 F	0.75 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	16.0	114						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.6					
HAC-10	RTU-7	PBB-3	Carrier	48TME005-A-501	1005G10154	2005	R-22	80%	115000	92000	NA								35 F - 65 F	185 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	15.4	90						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	1			4.9					
												Other-Combustion	1	208-230	1			0.6					
HAC-11	Trane	PBB-1	Carrier	YSC102H3RHA03	200513857	2020	R-410A	80%	200000	160000	140000												Complies with energy efficiency ratings of ASHRAE 90.1
HAC-12	RTU-12	PBA-3	Carrier	48TME006-A-501	200513857L	2005	R-22	80%	115000	92000	NA								35 F - 65 F	185 F	0.75 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	16.0	114						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.6					
HAC-13	RTU-13	PBA-8	Carrier	48TME004-A-501	0705G40212	2005	R-22	80%	74000	59200	NA								25-55 F	185 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	10.2	75						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	1			4.9					
												Other-Combustion	1	208-230	1			0.6					
HAC-14	RTU-3	PBA-7	Carrier	48TME004-A-501	0605G102??	2004	R-22	80%	74000	59200	NA								25-55 F	185 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	10.2	75						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	1			4.9					
												Other-Combustion	1	208-230	1			0.6					
HAC-15	RTU-1	PBA-5	Carrier	48TME007-501	0705G20297	2005	R-22	80%	115000	92000	NA								35 F - 65 F	155 F	1.0 in WC	Complies with energy efficiency ratings of ASHRAE 90.1	
												Compressor	1	208-230	3	20.6	146						
												Fan Motor-Outdoor	1	208-230	1			1.4					
												Fan Motor-Indoor	1	208-230	3			5.2					
												Other-Combustion	1	208-230	1			0.57					