Parkville Armory
Army National Guard
Maryland Department of Military
3727 Putty Hill Ave, Nottingham, MD 21236

Energy Survey Analysis Report

Prepared for:
Maryland Department of General Services (DGS)*

Department of
General Services

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Introduction

Project Team

The Smart and Small Thermal Systems (S2TS) group, led by Professor Dr. Michael Ohadi, within the Center for Environmental Energy Engineering at the University of Maryland, College Park (UMD), performed this project, which is managed by the Maryland Department of General Services (DGS) Office of Energy and Sustainability and collaborates with multiple state agencies. The principal investigator and project director is Prof. Michael Ohadi. The project Deputy Director is Dr. Amir Shooshtari. The UMD S2TS team members who contributed to the present building audit project included Chirag Naga (Team leader), Jordan Higgins, and Dr. Roxana Family.

Acknowledgment

We would like to acknowledge the building manager Mr. Thomas “Sonny” Smith at the Parkville Readiness Center, Army National Guard, as well as other staff members for their help and cooperation during the walkthroughs and for answering our questions. We would also like to thank the officers and the armory building management for their interaction and the overall support and guidance to accomplish this project. We are also grateful to Mr. Tony Myers, Mr. Lorenzo Taylor, and Mr. Olatunde Babalola for their diverse help, including coordinating the walkthroughs, assisting with gathering the relevant technical information for the buildings studied, and reviewing the reports and offering feedback to the energy audit team.

Overview

This energy audit supports Governor Hogan’s Executive Order 01.01.2019.08 - Energy Savings Goals for the State of Maryland Government, which was issued in July 2019 to signal the administration’s desire to improve the energy efficiency of state-owned buildings, reduce their environmental impact, and save taxpayers’ money. The executive order sets the energy savings goal at 10% savings over a 2018 baseline by 2029. The executive order requires DGS to audit 2 million square feet of State facilities annually and to present the audit reports to each building’s owner. The executive order goes on to state that:

> **Each unit of state government that occupies the space audited shall, to the fullest extent practicable, implement the measures identified in the audit.**

The UMD’s S2TS group, led by Professor Michael Ohadi, in general, divides an energy audit project into three phases: Building Comprehension which includes comprehensive walkthroughs and energy survey notes, Energy Model Development (if applicable and necessary), and Energy Efficiency Measures/Opportunities Analysis. The team carried out a facility walkthrough, analyzed the utility data and building plans to evaluate the energy usage of the building, as well as summarized their findings in this report. Due to the smaller size and the energy consumption trends, energy modeling was not deemed necessary for this building.

Based on our overall analysis, this report identifies actionable energy-saving opportunities to increase the building's energy efficiency. The DGS Office of Energy and Sustainability will coordinate with each building owner on financing and implementing the measures identified in this audit report.

Building Description

The Parkville Readiness Center is located at 3727 Putty Hill Ave, Nottingham, MD. This is a one-story building that was constructed in 1964 with an overall building floor area of 39,279 square feet according to the information provided by the facility manager. EnergyCap also shows the same area. Fig. 1 shows an aerial view of the building.

Fig. 1: Aerial views of the Parkville Readiness Center [1].

The building primarily houses one drill floor, approximately twenty-five offices, one kitchen, four restrooms, a boiler room, two locker rooms, a gym, and a dining area as illustrated on the building plans. The equipment in the kitchen includes two freezers, refrigerators, an electric microwave unit, a natural gas commercial oven, and a natural gas stove. Other major plug-in device inventories in the building include fans, computer systems, copier machines, and routers.

Based on the questionnaire, the building occupancy schedule is from 6:30 AM to 5 PM on weekdays (Tuesday to Friday). The building has a typical occupancy of 10 people. However, this number increases during the drills, which usually take place one weekend a month, usually on Saturdays and Sundays.

The facility consumes energy from two primary energy sources – electricity and natural gas. The electricity consumption is metered and supplied by Constellation New Energy and BGE/ Baltimore Gas and Electric Company. The natural gas consumption is metered and supplied by WGL Energy and BGE. In addition, water is supplied by the city and the meter is linked to the Parkville in the EnergyCap.

The building has plenty of open space around it, which can be utilized to maximize the usage of renewable natural resources such as solar energy utilization.

EUI Analysis

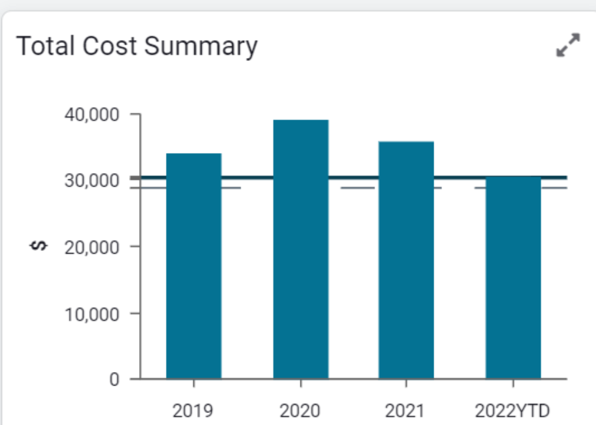
Table 1 shows the Energy Use Intensity (EUI) analysis of the Parkville Readiness Center based on different references.

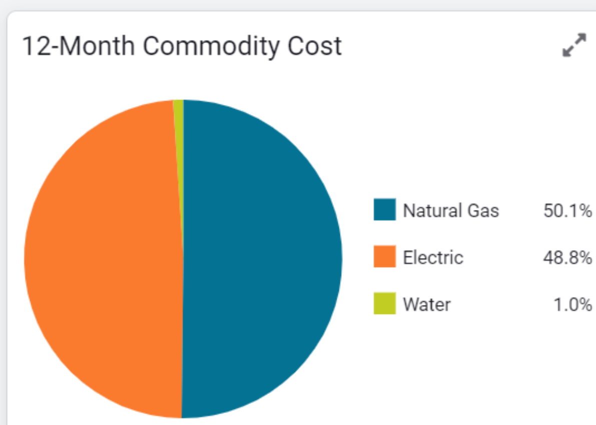
Table 1: EUI analysis of the Parkville Readiness Center.

Building name	FYs 2018 and 2019 EUI (E-cap) (kWh/ sq. ft.)	Ref. EUI (Energy Star) (kWh/ sq. ft.) [2]
Parkville Readiness Center	20.37 (69.52 kBTU/sq. ft.)	15.50 (52.9 kBTU/sq. ft.)

Table 1 shows the Energy Use Intensity (EUI) analysis of the Parkville Readiness Center and its comparison with the widely known EnergyStar reference. The EUI for the building was averaged over 2018 and 2019 based on the data found in EnergyCap. The EUI values for 2020 and 2021 were not included, as they are typically artificially lower due to the COVID-19 pandemic and the fact that buildings were not operating with normal occupancy, among other factors. For example, the EUI for 2021 was 19.46 kWh/sq.ft. (66.43 kBtu/sq. ft.). The calculations listed in Table 1 (above) considered the electricity and the natural gas consumption. Comparing such a figure to the EnergyStar reference for a similarly sized and equipped building is valid. As shown in Table 1, Parkville's EUI for the period analyzed is more than 30% higher than the EnergyStar's. This can be viewed as a valid representation due to two likely factors: the higher than necessary boiler-out water temperature in the building's HVAC system and the consistent use of window type air conditioners in nearly every occupied space, among other inefficiencies in the building.

Spend Summary





Daily Cost

7.8%

$ 104
Previous Year
Apr 2020–Mar 2021

$ 96
Current Year
Apr 2021–Mar 2022

Time period	Cost
Apr 2020–Mar 2021	$ 104
Apr 2021–Mar 2022	$ 96

Building Observations

- Drill floor is heated through four hot water to air heat exchangers.
    - Space has no designated cooling solution.
- Majority of lights used in the drill floor are halogen based.
- Kitchen is rarely used and no significant energy consumption is observed.
- Dining area has one refrigerator and one freezer.
    - The refrigerator was kept at - 8°F (far below accepted refrigeration temperature - approximately 40°F)
    - The freezer was kept at -25.6°F (far below accepted freezer temperature - approximately 0°F)
    - Neither appliance was EnergyStar certified.
- Dinning, kitchen, office, and hallway areas were lit with fluorescent T5 bulbs.
- Mostly all of the control valves for the radiators across the facility were broken.
    - Most radiators were providing heat even when it is not needed.
    - The natural gas boiler (H.B Smith cast iron boiler - manufactured in 1999 [3]) had been turned off for about 24 hours before the site walkthrough. However, the water temperature was still at 100°F.

- The natural gas domestic water heater (Rheem - 97-gal capacity - manufactured in 2019) was set to 155°F (far above the generally accepted range of 120 to 130°F).
- The band/music practice rooms are cooled with two split type air conditioner units (Sanyo- 2-ton capacity - manufactured in 2010 [4])
- Modine hydronic unit heaters (of varying age from 1964 to 2006 [5] and varying capacity 18,000 to 86,000 Btu/h) are present throughout the facility.
  - Currently controlled by wall mounted thermostats.
  - Should be noted that the thermostats did not make much of a difference in the heat output of the unit heaters as explained by the occupants.
- The cooling demand for the office spaces are met with multiple window mounted air conditioners.
  - Various manufacturers: LG, Friedrich, Frigidaire
  - Cooling capacities from 0.50 to 0.75 Tons
  - Many units were not sealed with care and many sizable air gaps existed

Safety Note: There was a hot water storage tank (no longer in use) in the boiler room that apparently contained asbestos in its insulation. We recommend removing the tank as soon as possible to mitigate health concerns for building staff.

Low cost-No cost/Energy Star recommendations

Based energy consumptions in the building, the low-cost/no-cost Energy star recommendations areas are listed below:

- ✓ Regularly change or clean HVAC filters, particularly during peak cooling or heating season, as dirty filters cost more to use, overwork the equipment, and result in lower indoor air quality.
- ✓ Calibrate thermostats to ensure that their ambient temperature readings are correct, and adjust temperature set points for seasonal changes.
- ✓ Use shades and blinds to control direct sun through windows in both summer and winter to prevent or encourage heat gain.

- ✓ Make sure that areas in front of vents are clear of furniture and paper. As much as 25 percent more energy may be required to distribute air if the vents are blocked.

- ✓ Clean the evaporator and condenser coils on heat pumps, air-conditioners, or chillers. Dirty coils inhibit heat transfer; keeping coils clean saves energy.

Other - Low cost-No cost/Energy Star Recommendations

- ➢ Conduct a nighttime audit to find out what's on afterhours that shouldn't be.

- ➢ Consider establishing a "Green Team" of occupants, maintenance staff and administration that can suggest small changes to improve the efficiency or individual workspaces and the building as a whole. This a great way to help increase energy efficiency and reduce waste.

- ➢ Optimize start-up time, power-down time, and equipment sequencing.

- ➢ Install LED exit signs. These signs are brighter, reduce annual electricity costs and can dramatically reduce maintenance by eliminating the need to replace lamps.

- ➢ Install occupancy sensors in areas where there are none to automatically turn off lights when no one is present and back on when people return. *(Storage rooms, back-of-house spaces, meeting rooms, and other low-traffic areas are often good places to start).*

- ➢ Plug air leaks with weather stripping and caulking.

- ➢ Repair damaged insulation and replace missing insulation on piping and ducts with thicknesses calculated for the operating and ambient conditions of the mechanical system.

Combined/Comprehensive EEMs

EEM 1- HVAC Upgrades

Heating

As mentioned in the major findings, the building is heated using a H.B Smith cast iron boiler from 1999. This unit is IBR rated to 3350 MBH of hot water output and is shown in Fig. 2.

Fig. 2: H.B Smith boiler at Parkville Armory.


Fig. 3: Hot water pumps at Parkville Armory

The steam produced by the flame is allowed to expand in an expansion tank before being sent through the building by four 0.5 to 1.5 hp electric pumps shown in Fig. 3. In each space, either a wall mounted (baseboard) radiator or a Modine unit heater, as shown in Figures 4-7, transfers the heat to the occupants.

Fig. 4: Baseboard radiator at Parkville Armory.

Fig. 5: Baseboard radiator at Parkville Armory.

Fig. 6: Modine hydronic unit heater (circa 1964) at Parkville Armory.

Fig. 7: Modine hydronic unit heater (manufactured 2006) at Parkville Armory.

The primary energy saving measure that can be implemented in regards to the boiler system would be a functioning/stand-by schedule, monitored by the hot water temperature. It was found that the temperature of the circulating hot water was approximately100°F after the boiler was shut off for more than 24 hours. Additionally, the hot water temperature at which the boiler generally functions was stated by the building manager to be 140°F. During the night before and the morning of the walkthrough the outside temperature was roughly 41 to 48°F [6], warranting a heating demand for the occupants. That said, the 100°F water at the time of the walkthrough was found to be more than sufficient in providing the necessary heating load. In fact, many of the offices and often used spaces were observed to be uncomfortably warm and window A/C units were used by a few occupants to offset the excess heat from the radiators and unit heaters. As such, the recommendation is to set back the boiler input to achieve hot water at less than 100°F for the days in the year where the heating loads are not at maximum.

Additionally, the radiator valves, shown in Fig.8, in each space need to be fixed as currently many spaces are experiencing overheating. This solution, along with lower hot water temperatures described above, can reduce the overall natural gas consumption of the building by mitigating the overheating problem.

Fig. 8: Example of broken radiator valves found in Parkville Armory.

Cooling

Since it was made clear by the building manager and the occupants that cooling was a major weakness at Parkville Armory, the following is recommended. The main energy saving proposal is to get rid of every window air conditioning (AC) unit and satisfy the cooling needs with ductless, mini-split air conditioning systems. The split air units, generally 0.5 to 4 tons, are approximately 40% more efficient compared to the window units, generally 0.5 to 0.75 tons [7]. Not to mention, the current HVAC market provides split air systems for up to 5 zones operating from a single outdoor unit [8]. This would allow for up to 5 separate offices to share one outdoor unit, shown in Fig.9, reducing the cost associated with purchasing, maintaining, and installing outdoor units.

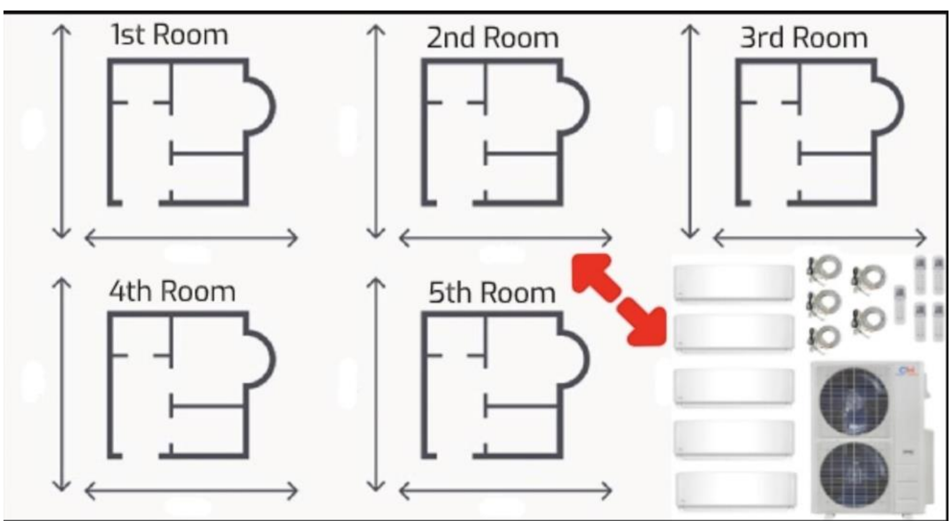


Fig. 9: Schematic of 5 zone split air conditioning system [9].

The split air, ductless system makes more sense compared to a centralized air system at Parkville Armory since there is no existing ducting. The cost of installing ductwork alone can exceed any

HVAC equipment [10], and this cost is likely amplified in a building requiring ducting through large square feet like Parkville Armory. Additionally, split systems lack the roughly 30% loss to ducting that central systems suffer from [11], making them even more cost effective in the long run.

Another benefit to transitioning away from the window systems would be reduced air gaps for infiltration. The current window systems have air gaps that were attempted to be plugged by the occupants as shown in Fig.10.

Fig. 10: Air gaps around window unit at Parkville Armory with tape to mitigate the issue.

Domestic Hot Water (DHW)

The primary energy saving measure with the 97-gal Rheem DHW at Parkville Armory is the water temperature setpoint. As mentioned in the major findings, the setpoint temperature was found to be too high, 155°F, as shown in Fig. 11.

Fig. 11: Temperature setpoint for the Rheem DHW at Parkville Armory

Setting the temperature back to approximately 135°F would ensure that the hot water is safe and comfortable to use for showers and sinks while also resulting in approximately 10% energy savings [12].

EEM 2 – Lighting Upgrades

- Replace all fluorescent lights in the building with energy-efficient Light-Emitting Diode (LED) bulbs.
- Provide lighting controls for daylight harvesting and dimming.
- Provide occupancy sensors to control/reduce lighting energy consumption.

The building mostly employs fluorescent lighting consisting mostly of T5's bulbs, shown in Fig. 12. Currently, there are no occupancy sensors in the building. Upgrading the light fixtures to LED along with the implementation of occupancy sensors and lighting controls has multiple end-user benefits. Compared to fluorescent lighting, LED lighting can yield significant energy savings while also reducing the maintenance and labor costs associated with fluorescent lighting. LED light fixtures also have longer rated lifespans which would mean fewer costs associated with replacing them. Lighting controls, such as daylight harvesting and dimming, further enhance the energy-saving potential of LED lighting. Therefore, all fluorescent light bulbs in the building shall be replaced with energy-efficient LED light bulbs to match the existing bulb size/type and fixture styles. Occupancy controls and sensors shall then be integrated with LED lights in all spaces, which are applicable. Additionally, lighting controls with daylight harvesting and dimming shall be provided. Transitioning towards LED lighting along with the implementation of controls could yield electricity savings of around 50% of total annual lighting consumption [13]. The lighting disposal and replacements as well as the lighting controls shall be Design Lights Consortium (DLC) or Energy Star certified and comply with the Maryland Green Purchasing Committee Approved Specifications [14].

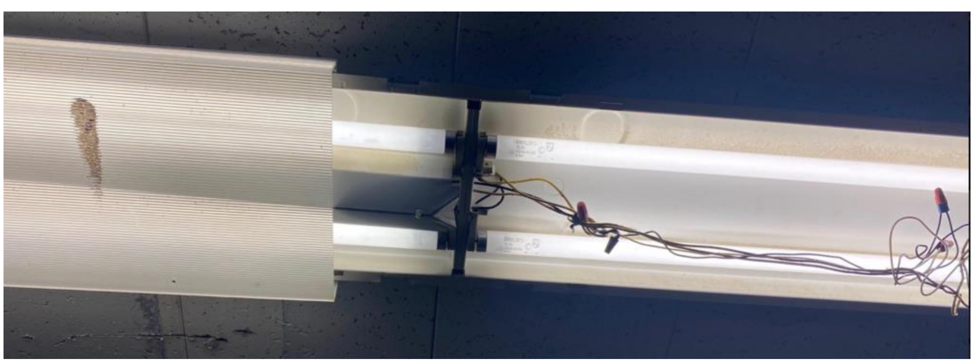


Fig. 12: T5 bulbs used throughout Parkville Armory

EEM 3 –Thermostat Upgrades

Smart thermostats assure automatic and programmable temperature settings based on daily schedules, weather conditions, and heating and cooling needs. The advantage of a smart thermostat is its ability to learn a building's patterns and adjust heating and cooling according to when a space is occupied or is about to be occupied. This reduces the use of heating and cooling systems during the unoccupied times. Smart thermostats that earn the ENERGY STAR label have been independently certified, based on actual field data, to deliver energy savings. Analysis conducted by Ecobee on their customers' data found that some smart thermostat users saved up to 23% on their heating and cooling costs [15].

Fig. 13: Currently employed thermostat in the building.

EEM 4 – Energy Star Certified Appliances

There are currently several different appliances being used throughout the building. For example, refrigerators, microwave ovens, and fans, as shown in Figs.14-16. These appliances can be high energy consumers depending on their energy ratings and age. Replacing all appliances that are more than five years old and are also not Energy Star certified with new ones that are Energy Star certified will result in savings in electricity consumption [16], and savings may be shown in water consumption as well. The contractor shall locate all applicable appliances within the building and after careful and professional assessment provide replacement options with pricing to include installation costs and estimated payback periods. For appliances where the Energy Star rating is unknown, replace these as necessary with products with energy efficiency ratings that are in the top 25% in their respective markets.




Figs. 14-16: Plug-in equipment throughout the building.

EEM 5– Plug-in Process Load Reduction (PPL)

Smart Power Strips - Smart power strips can reduce energy waste, prolong the life of electronics, and offer premium fireproof surge protection. It will be advantageous from an energy audit standpoint to replace all power strips in the building with smart power strips to reduce annual electricity consumption. The payback period of a smart power strip is estimated at about 1.1 years [17].

All power strips in the building should be replaced with smart power strips, e.g., similar to the ones provided by Tricklestar or similar brands. The contractor shall provide pricing for the provision of smart power strips as well as for their installation by existing power connection setups for each room in the building.

EEM 6 – Water Conservation Measures

1) Bathroom Sink Faucets/Accessories
    a. Replace the older models with new WaterSense labeled faucets to reduce water usage.

2) Toilets and Waterless Urinals
    a. Many high-efficiency toilets are sold in two parts, with the tank and bowl sold separately. When components combine to make a WaterSense labeled product, tanks should include the words "When used in combination with [bowl model number/name]" in close proximity to the label, and similarly with bowl labeling.
    b. Waterless urinals are available in the market which use Eco-Trap technology and can last up to 1500 sanitary uses [18].

3) Showerheads
    a. With a WaterSense labeled showerhead, one can save a considerable amount of water. Water-saving showerheads that earn the WaterSense label must demonstrate that they use no more than 2.0 GPM. The WaterSense label also ensures that these products provide a satisfactory shower that is equal to or better than conventional showerheads on the market.

Summary Scope of Work

System Description	Current System/Issue	Proposed System/Solution	Comments
Lighting Throughout the Building	Fluorescent lighting	LED lighting along with occupancy sensors and controls for daylight harvesting and dimming	LED lighting and controls can yield around 50% savings in lighting consumption [13]
HVAC	H.B Smith boiler/water temperature unnecessarily high (140 deg F)	Setback boiler input so output water is lower temperature (<100 deg F), thus avoid over heating of the respective building zones.	
Thermostat upgrade	Mechanical and Programmable thermostats	Smart Thermostats throughout the building.	Smart Thermostats can save approximately 23% on combined heating and cooling costs [15]
Non-HVAC Related Appliances	Some are old and not Energy Star certified.	Replace the more than 5-yr-old appliances that are not energy efficient with the new Energy Star certified ones.	Energy Star-certified appliances can result in 10% to 25% of electricity savings compared to non-Energy Star certified appliances [15].
Plug-in Process Load Reduction	Identify and implement (PPL) opportunities.	Smart Power Strips. Energy Star rated vending machines and water coolers.	Plug-in and process loads (PPLs) can consume up to ~ 47% of the primary energy in U.S. commercial buildings. PPL efficiency has become pertinent in achieving aggressive energy targets [22].
Water Conservation	Identify and implement WaterSense opportunities, including leak detection.	WaterSense rated sinks, faucets, urinals. Leak detection system.	Water-saving techniques can save budget and reduce water withdrawal from rivers, bays, and estuaries.

Renewable Energy	Domestic water heater (Rheem - 97 gal)	Solar water heater/ Solar PV panels	A typical 10-kW solar PV system can generate about 13,700 kWh/year of electricity [19].

Future Renewable Energy Scope

The Climate Solutions Now Act of 2022 increases Maryland's target for reducing greenhouse gas emissions to 60 percent below 2006 levels by 2031 and sets a 2045 deadline for achieving net-zero greenhouse gas emissions across the state's economy. It also creates a building energy performance standard for the state that will require most buildings over 35,000 square feet to start reporting their data in 2025 and achieve a 20% reduction in direct emissions (as compared to 2025 levels for average buildings of similar construction) by January 1, 2030, and net-zero direct emissions by January 1, 2040.

Building electrification is a critical part of the path to transition away from fossil fuels and to meet the state's aggressive climate goals. Based on DGS data on carbon emissions by the year 2029, the carbon emissions in lb/MWh from the electricity grid will be along the same level as the amount from natural gas sources. This downward trend would continue after 2029 with the CO2 emissions from the electricity grid being less than that of natural gas sources.

Hot water heaters

- Hot water heaters could be replaced with Heat pump water heaters (HPWHs).

ENERGY STAR certified electric storage water heaters use a highly efficient heat pump – essentially a refrigerator run in reverse – to transfer heat from the surrounding air to the water, using less than half the energy of an electric resistance unit.

Transitioning towards an all-electric system for heating, cooling, and hot water needs, instead of burning natural gas or fuel oil can reduce overall energy use, reduce emissions, ensure that occupants have access to cleaner, healthier, more resilient buildings and enable the opportunity to deploy renewable energy options at the site to supplement the energy demands.

Solar PV panels can be installed at the site to provide supplemental electricity to the building. The solar system would need to be provided with a battery system to offset the intermittent availability of sunlight throughout the year at the location. Using the NREL PVWATTS Calculator, an assumption of the system parameters can be made [19]. For example, at the Parkville Readiness Center, a 10-kW solar system can generate about 13,700 kWh/year of AC power. This system can be sized appropriately based on the available space at the site, preferably the roof. If the roof space is limited, further space can be explored near the site such as parking spaces or other open spaces. Further opportunities include purchasing renewable electricity from utilities wherein the sourced renewable energy could go hand in hand with the site renewable energy implementation. Rebate incentives can be claimed in the form of Solar Renewable Energy Credit (SRECs) [20], also called alternative energy credits in Maryland. SRECs are created for each 1,000 kWh of electricity produced by a qualified alternative energy source. There is no specific size limit, but the systems generally must be connected to the distribution system serving the State, for qualifying.

Appendix

List of the Nomenclature used in the report:

BGE – Baltimore Gas and Electric company
DGS – Department of General Services
DHW – Domestic Hot Water
EEM – Energy Efficiency Measure
EUI - Energy Use Intensity
LED – Light-Emitting Diode
S2TS – Smart and Small Thermal Systems
SREC – Solar Renewable Energy Credit
VFD – Variable Frequency Drive

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