Annapolis Readiness Center
Army National Guard
Maryland Department of Military
18 Willow Street, Annapolis, MD 21401

Energy Survey Analysis Report

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

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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), is performing this project, which is managed by the Maryland Department of General Services (DGS) Office of Energy and Sustainability and collaborates with multiple state agencies. Principal investigator and project Director is Prof. Michael Ohadi. Project Deputy Director is Dr. Amir Shooshtari. The UMD S2TS team members who contributed to the present building audit project included Dr. Roxana Family, Alibek Bekenov (Team leader), Aditya Ramnarayan, Ji Bae, Yash Jatin Oza.

Acknowledgment

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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, to reduce their environmental impact, and to 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. 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 Annapolis Readiness Center is located at 18 Willow Street in Annapolis, Maryland. This is a two-story building that was constructed in 1958 with an overall building floor area of 42,000 square feet according to the information provided by the facility manager. The building plans show a total building floor area of 39,030 square feet, and EnergyCap shows 41,473 square feet. Fig. 1 shows an aerial view of the building.

Fig. 1: Aerial views of the Annapolis Readiness Center (Photo courtesy Google Earth) [1].

The building primarily houses 1 server room, 1 Computer laboratory, 3 Class rooms, 1 Maintenance Bay, approximately 20 offices, 1 SCIF (Sensitive compartmented information facility), 3 custodial closets, 1 boiler room, 2 Locker rooms, approximately 8 toilet/bathrooms, and 1 gymnasium as specified by building manager in building assessment questionnaire. During a renovation in 2000, 1 large kitchen and 2 weapons vaults were added to the building. Although the kitchen is not utilized at the moment as the food is mostly catered in, the equipment in the kitchen include a freezer, refrigerators, an electric microwave unit, an ice machine, a natural gas commercial oven, and a natural gas stove. Other major plug–in device inventories in the building include computer systems, copier machines, drinking fountains, 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 minimum occupancy of 10 people. However, this number increases during drill, which usually takes place one weekend a month, usually on Saturday and Sunday.

The building 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, while the natural gas is metered and supplied by WGL/ Washington Gas and BGE/ Baltimore Gas and Electric company.

Buildings have a lot of open space around, which can be utilized to maximize usage of renewable natural resources.

EUI Analysis

Table 1 shows the Energy Use Intensity (EUI) analysis of the Annapolis Readiness Center and its comparison with the widely known EnergyStar reference. The EUI for the building was calculated for years 2018 and 2019 based on the data available in EnergyCAP [2].

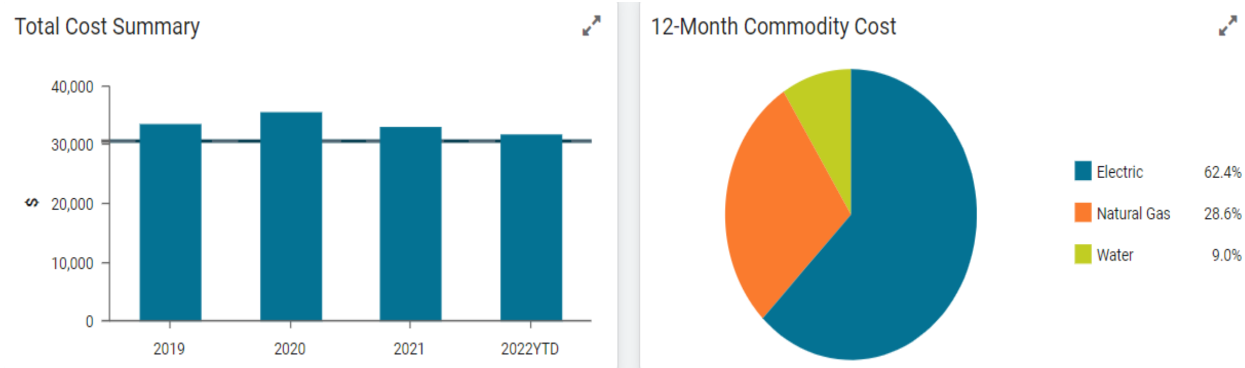
Table 1: EUI analysis of the Annapolis Readiness Center

Building name	FYs 2018 and 2019 EUI (E-cap) (kWh/sq. ft.)	Ref. EUI (Energy Star) (kWh/ sq. ft.) [2]
Annapolis Readiness Center	12.61 (43.02 kBtu/ sq. ft.)	15.50 (52.9 kBtu/sq. ft.)

The EUI values for 2020 and 2021 were not included, 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 11.34 kWh/sq. ft. (38.71 kBtu/sq. ft.), which is ~10% below the average for 2018 and 2019. The calculations listed in Table 1 (above) considered electricity and natural gas consumption based on available data. Based on our team walkthrough and further analysis, the building's envelope and the HVAC equipment are mostly outdated and far from receiving an EnergyStar rating. The EUI of the facility is well within the EnergyStar benchmark; however, there are still many energy efficiency opportunities that could further improve the energy performance of the facility and are discussed further in this report.

Energy Modeling wasn't performed for the facility as no redundant/oversized systems were found to be present in the facility which required further detailed modeling studies. However, numerous energy efficiency measures were identified that can improve the energy efficiency of the facility and are discussed in detail in later sections of this report.

Energy Spend Analysis



Daily Cost

4.1%

$ 92
Previous Year
May 2020–Apr 2021

$ 96
Current Year
May 2021–Apr 2022

Time period	Cost
May 2020–Apr 2021	$ 92
May 2021–Apr 2022	$ 96

Fig. 2: Energy use and cost for Annapolis Readiness Center.

Building Observations:

- Make-up air ventilation unit 1 (MUAV1) is broken and does not work.
- Most of the HVAC equipment was last replaced during a renovation in 2000.
- The interior lighting of the building is provided by CFL/ fluorescent lamps.
- Most plug inventories in the building are not EnergyStar certified.
- No occupancy sensors were found for automatic control of lighting.
- The building does not have any BAS/ Building Automation system for efficient use of resources.

Building HVAC Description

Boiler and Hot water system

The mechanical room on the 1st floor contains two gas furnaces (Weil-McLain 78 boiler, model number P-1078-W) with a heating capacity of 1129 MBH (331 kW) each. They provide hot water for AHU coils, unit and cabinet heaters, as well as radiant water heaters.

Fig. 3: Boilers in the mechanical room.

As shown in Fig. 4, there is also one domestic hot water heater (Lochinvar, model number CNR199-100-DF9-2) with a rated capacity of 200 MBH (58.6 kW). The same DWH is installed in the kitchen, but due to the fact that the kitchen is not used, this DWH does not operate.

Fig. 4: Domestic water heater (DWH) in the mechanical room.

Cooling and Heating Units

The building employs four AHUs with a heating capacity of 139 MBH (40.7 kW) each. They serve the assembly hall.

Fig. 5: AHUs in the assembly room.

In addition, the following HVAC equipment are installed on the rooftop:

- Make-up air ventilation MUAV1 unit (Reznor) is supposed to serve the gymnasium. However, the unit is broken and not in use.
- Make-up air ventilation MUAV2 unit (Reznor) provides heated air to the kitchen. However, due to the fact that the kitchen is not used at all, this equipment does not operate;

Fig. 6: MUAV1 unit on the rooftop.

- Air Conditioning (AC) units AC1 and AC2 (YORK, model number D4CG090N13025A) with a rated cooling capacity of 90 MBH (26.3 kW) each serve offices on the 1st floor;
- AC3 (YORK, model number D4CG090N13025A) with a rated cooling capacity of 90 MBH (26.3 kW) serves offices on the 2nd floor;
- AC6 (YORK, model number D3CE102A25JSD) with a rated cooling capacity of 102 MBH (29.9 kW) serve offices and classrooms on the 1st floor;
- AC7 (YORK, model number D2CG072N07925BDA) with a rated cooling capacity of 72 MBH (21 kW) serves simulation range and storages on the 1st floor.

Fig. 7: AC1 on the rooftop.

- Two split systems are shown in Fig. 8 (Goodman Manufacturing company, model number GSX160241FF), with capacity of 24 MBH (7 kW) each serve offices and storages on the 1st floor

Fig. 8: Goodman split systems on the rooftop.

- One split system shown in Figure 9 (YORK, model number H1DB012S06C) with a capacity of 12 MBH (3.5 kW) serves weapon vaults and storages on the 1st floor.

Fig. 9: YORK split system on the rooftop.

The building employs six-unit heaters (Fig. 10) and three Cabinet heaters with capacities indicated in Table 1. They serve locker rooms, maintenance shop and weapon vaults.

Table 2: UH and CUH schedule.

SCHEDULE OF AIR-HANDLING EQUIPMENT						
EQUIPMENT & DESIGNATION	C.F.M. STD. AIR	S.P.	F.A.T.	MIN. OUTDOOR AIR	TOTAL M.B.H.	REMARKS
UNIT HEATER N°1	2135	—	118°	—	139.0	1/4 H.P., 850 FAN R.P.M., 120 V., 1φ
UNIT HEATER N°2	2135	—	118°	—	139.0	1/4 H.P., 850 FAN R.P.M., 120 V., 1φ
UNIT HEATER N°3	2135	—	118°	—	139.0	1/4 H.P., 850 FAN R.P.M., 120 V., 1φ
UNIT HEATER N°4	2135	—	118°	—	139.0	1/4 H.P., 850 FAN R.P.M. 120 V., 1φ
UNIT HEATER N°5	855	—	132°	—	69.0	1/8 H.P., 570 FAN R.P.M., 120 V., 1φ
UNIT HEATER N°6	855	—	132°	—	69.0	1/8 H.P., 570 FAN R.P.M. 120 V., 1φ
CAB. UNIT HEATER N°1	1250	—	125°	—	90.4	1/3 H.P., 560 FAN R.P.M. 120 V., 1φ
CAB. UNIT HEATER N°2	280	—	116°	—	17.3	1/20 H.P., 870 FAN R.P.M. 120 V., 1φ
CAB. UNIT HEATER N°3	280	—	116°	—	17.3	1/20 H.P., 870 FAN R.P.M. 120 V., 1φ

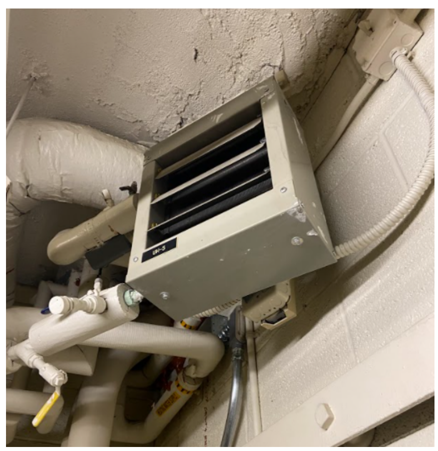


Fig. 10: Unit heater.

Most of the equipment mentioned above were installed during a renovation in 2000. There is currently no BAS to regulate heating and cooling during operational hours. Switching on and off of HVAC elements is regulated by existing thermostats (Fig. 11), as well as manually by a building manager. It is important to note that existing thermostats are not of the Smart/programmable thermostat type.

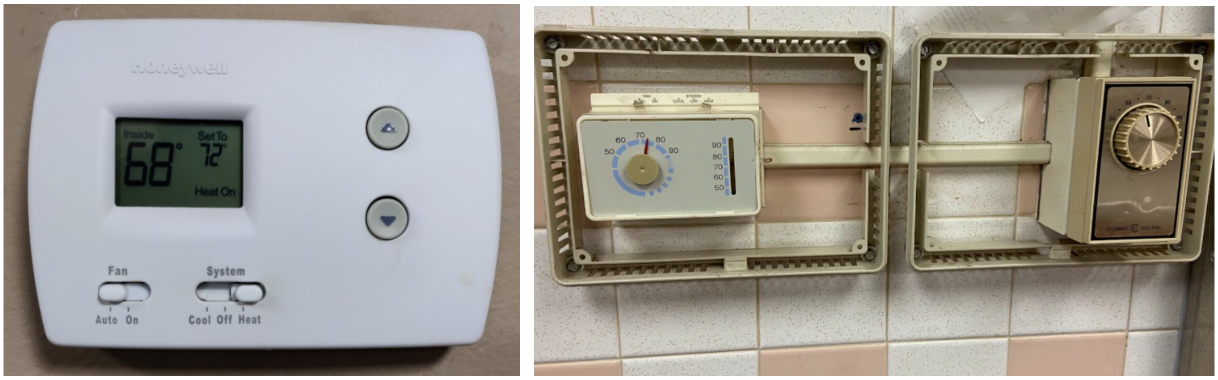


Fig. 11: Thermostats throughout the building.

Water fixtures that are currently employed by the building are old and not WaterSense labeled.

Double glazed tinted windows (Fig. 12) are installed throughout the building. The impermeability seals are broken in some places and replacement is recommended.

Fig. 12: Double glazed tinted windows.

Major Energy Efficiency Measure (EEM) Recommendations

EEM 1 – Lighting Upgrades

- Replace all fluorescent lights in the building with energy efficient LED bulbs
- Provide lighting controls for daylight harvesting and dimming.

The building mostly employs fluorescent lighting consisting mostly of 834 T8's bulbs and 24 Compact Fluorescent Light, CFLs, (Fig. 13). There are also 12 HID (high-intensity discharge light) lamps (Fig. 14) at the entrance. Currently, there are no occupancy sensors in the building. Upgrading the light fixtures to LED along with 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 with short payback periods of 2-3 years [3]. The lighting disposal and replacements as well as the lighting controls shall be DLC or Energy Star certified and comply with the Maryland Green Purchasing Committee Approved Specifications [4].

Fig. 13: CFL lamps in the assembly hall.

Fig. 14: HID lamps at the entrance.

EEM 2 – HVAC replacement to VRF systems with centralized controller

As mentioned above, MUAV1 unit is broken and is not functioning. Most of the HVAC equipment were last replaced during a renovation in 2000, thus they have been operating for over 20 years and need to be replaced (Fig. 15).

Fig. 15: HVAC equipment on the rooftop.

We recommend replacing the current HVAC equipment with Variable Refrigerant Flow (VRF) systems. VRF is HVAC system configuration with multiple outdoor (condenser) units connected in a modular fashion and multiple indoor (evaporator) units. The term VRF refers to the ability of this system to individually control the amount of refrigerant flowing through every evaporator, enabling the use of multiple evaporators of differing capacities and configurations, individualized comfort control, simultaneous heating and cooling in different zones, and heat recovery from one zone to another. VRF systems operate on the direct expansion (DX) principle, meaning that heat is transferred to or from the space directly by circulating refrigerant through condensers/evaporators located near or within the conditioned space. Refrigerant flow control is the key to many advantages as well as the major technical challenge of VRF systems. Figure 16 shows a schematic VRF arrangement.

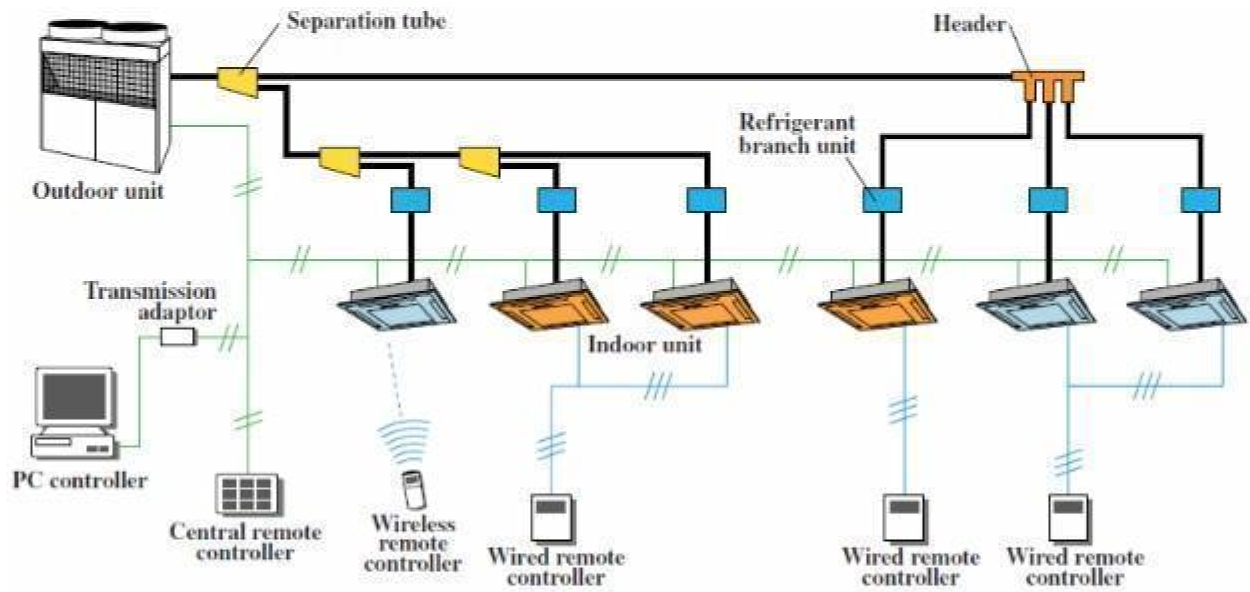


Fig. 16: Schematic VRF arrangement [3].

There are two types of VRF systems: heat pump and heat recovery. VRF heat pump systems permit heating or cooling in all indoor units but not simultaneous heating and cooling. VRF systems with heat recovery capability can operate simultaneously in heating and/or cooling mode, enabling heat to be used rather than rejected - as it would be in traditional heat pump systems.

All in one VRF systems such as the ones offered by Mitsubishi Electric can be considered for the Annapolis Readiness Center [5]. The City Multi products (R2 series, Y-series, WR2-series, WY-series) from Mitsubishi are designed for commercial applications. They provide zone control, design flexibility, quiet operation, hyper heating inverter (H2i), personalized comfort control, and simultaneous cooling and heating operations (R2 and WR2-series). The City Multi Controls Network (CMCN) enables control of multiple centralized controllers, and it can be utilized from any networked PC, tablet, or smartphone.

VRF systems are 20% to 30% more efficient than conventional HVAC systems [6] due to partial load operation, speed modulation, zoning capabilities, and heat-recovery technology. It could replace the current AHUs and boilers of the building, and would also enable progress toward the State of Maryland’s future greenhouse gas and environmental goals, starting with Electrification of State Buildings and Elimination of Fossil Fuel Systems.

Other Recommendations

Thermostat Upgrades

Smart thermostats create 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 property is occupied or is about to be occupied. This reduces the use of heating and cooling systems during unoccupied time. 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 [7]. Here, installation of smart thermostats can reduce a significant amount of the energy in the building.

Air Curtain System

The assembly hall and maintenance shop employ wide doors (16x14 feet and 16x16 feet respectively) through which vehicles enter for maintenance and cargo delivery (Fig. 17). Open doors in this case lead to a large loss of energy, increasing utility costs.

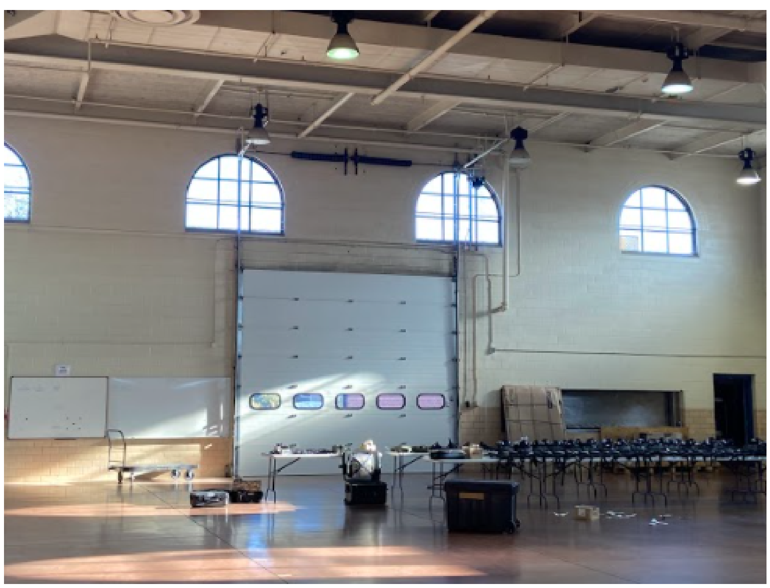


Fig. 17: Door in the assembly hall.

To reduce the air infiltration, an air curtain system can be installed. There are conventional air curtain systems that could be considered [8]. An air curtain uses a fan to force a curtain of air in a downward direction. The forced air creates an invisible barrier that helps to control temperatures by preventing hot or cold air from entering a doorway or building at an opening.

Air curtains also are used to keep contaminants such as insects, dust, pollen, and other debris, from entering an interior space. Air curtains provide an ideal alternative to traditional doors (Fig. 18).

Fig. 18: Air Curtain System.

Energy Star Certified Appliances

There are currently several different appliances being used throughout the building. For example, refrigerators, coffee machine, heated serving cart, microwave oven (Figs. 19 and 20). 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 [9], 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.

Fig. 19: Equipment in the kitchen.

Fig. 20: Coffee machine in the kitchen.

(PPL) – Plug Process Load Reduction

- Smart Power Strips - Smart power strips can reduce energy waste, prolong 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 in order to reduce annual electricity consumption. The payback period of a smart power strip is around 1.1 years [10].
    - o All power strips in the building should be replaced with smart power strips, equal to ones provided by Tricklestar or similar brands. The contractor shall provide pricing for provision of smart power strips as well as for their installation in accordance to existing power connection setups for each room in the building.
- Replace aging drinking fountains and bottled water coolers with Energy Star non-cooled drinking fountains.

Water Conservation Measures

1) Bathroom Sink Faucets/Accessories

- Replace the older models with new WaterSense labeled faucets to reduce water usage.

2) Toilets and Waterless Urinals

- 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.
- Waterless urinals are available in the market which uses Eco-Trap technology and can last up to 1500 sanitary uses. [11]

3) Showerheads

- 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.

Energy usage attachments

The main energy commodities are electricity and natural gas. Historical utility bills (electricity, natural gas, and water) for the past year 2020 for Annapolis Readiness Center are collected and presented in Figures 21-23. We notice the rapid rise in electricity demand in summer due to the increased cooling loads and the sharp reduction in demand of natural gas for the same duration.

YEAR: 2020										
Month	Bill Date	Days in Period	Ave. Temp. (F)	Actual Demand (kW)	Billed Demand (kW)	Electric Use (kWh)	Demand Cost ($)	Electric Use ($)	Other Fees ($)	Total Bill ($)
January	1/27/2020	32		41		19976				$1,785
February	2/25/2020	29		38		15326				$1,452
March	3/25/2020	29		34		14348				$1,373
April	4/23/2020	29		35		15803				$1,470
May	5/26/2020	33		37		17797				$1,631
June	6/24/2020	29		47		19766				$1,764
July	7/27/2020	33		58		26783				$2,283
August	8/25/2020	29		54		23628				$2,049
September	9/24/2020	30		55		22145				$1,965
October	########	33		39		18451				$1,687
November	########	29		31		14746				$1,389
December	########	33		36		17556				$1,617
					Annual Totals	**226,325**	**$0**	**$0**	**$0**	**$20,465**
Peak Demand (kW)			58							
Total Annual Cost ($)			$20,465							

Figure 21: Electricity Usage for the year 2020 [12].

YEAR: 2020										
Month	Bill Date	Days in Period	Ave. Temp. (F)	Actual Demand* (______)	Billed Demand* (______)	therms	Demand Cost ($)	Gas Use ($)	Other Fees ($)	Total Bill ($)
January	1/26/2020	32				2114				$1,785.26
February	2/24/2020	29				1850				$1,617.00
March	3/24/2020	29				1259				$1,100.57
April	4/22/2020	29				981				$847.74
May	5/25/2020	33				1002				$936.32
June	6/23/2020	29				248				$263.67
July	7/26/2020	33				20				$60.26
August	8/24/2020	29				15				$55.80
September	9/23/2020	30				19				$59.38
October	10/26/2020	33				34				$72.75
November	11/24/2020	29				416				$413.54
December	12/27/2020	33				1645				$1,509.95
					Annual Totals	**9,603**	**$0**	**$0**	**$0**	**$8,722**

* Choose appropriate units for gas (typically MMBtu, therms, or MCF).

Peak Demand (______)	0
Total Annual Cost ($)	$8,722

Figure 22: Natural Gas consumption for the year 2020 [12].

Month	Bill Date	Days in Period	Ave Temp (F)	Actual Demand* (MGal)	Billed Demand* (MGal)	Use* (MGal)	Demand Cost ($)	Gas Use ($)	Other Fees ($)	Total Bill ($)
Quarter 1	3/30/2020	91				19				$1,039
Quarter 2	6/30/2020	90				15				$925
Quarter 3	9/30/2020	92				19				$1,063
Quarter 4	12/30/2020	91				18				$1,034
					Annual Totals	**71**	**$0**	**$0**	**$0**	**$4,062**

Figure 23: Water consumption for the year 2020 [12].

Summary of Energy and Dollar Savings Potential

EEMs	Proposed Solution	Annual Energy Savings Potential	Annual Dollar Savings Potential	Water Savings (Gallons)
Variable Refrigerant Flow (VRF) system	Replacing current HVAC equipment with a Dedicated Outdoor Air System (DOAS) coupled with a Variable Refrigerant Flow (VRF) system	4.86-5.54 kWh/sq. ft. [13]	-	-
Lighting Upgrades	Replacing the CFLs and T8 fluorescent lamps past their useful life with LEDs	-	$0.33/sq. ft. or higher [14]	-
SMART Thermostat Installation	Switch from manual controls to Smart Thermostats	0.18 kWh/sq. ft. [15]	-	-
Air Curtain System	Installing an Air Curtain System	1146 - 18989 kWh (Range based on IECC climate zones 3-8) Maryland is in zone 4 - so annual energy savings would likely be closer to 1146 kWh [16]	-	-
Plug-in Process Load Reduction (PPL)	Advanced Power Strips (APS)	0.2 – 0.7 kWh/day [17]	-	-
Water Conservation	WaterSense Labelled products and Waterless urinals for efficient use of water in the facility.	-	-	Up to 40,000 gallons of water annually [18].

Summary Scope of Work

A summary scope of work is provided in the following table. The estimated payback periods are to be used as a general guide and otherwise represent average estimated costs offered in the open domain. With the current inflationary market prices, the numbers will certainly need updating when the implementation of any/all of the respective EEMs is intended.

System Description	Current System/Issue	Proposed System/Solution	Comments
Lighting Throughout the Building	Fluorescent and HID lighting in the facility.	Replace with LED lighting along with occupancy sensors and controls for daylight harvesting and dimming.	LED lights with the implementation of controls could give 50% electricity savings annually while having a typical payback period as short as 2-3 years [3].
Boilers, AHUs, Unit heaters, Split systems	Weil-McLain, P-1078-W; YORK, D4CG090N13025A, D3CE102A25JSD, D2CG072N07925BDA, H1DB012S06C; Goodman Manufacturing GSX160241FF	Replace the 21 years old HVAC equipment with VRF systems with centralized controller	VRF systems are 20% to 30% more efficient than conventional HVAC systems while having typical payback periods of 6-8 years [6].
Thermostat upgrade	Mechanical and Programmable thermostats	Smart Thermostats	Smart Thermostats can save approximately 23% on combined heating and cooling costs with an average payback period of 2-3 years [7].
Air Curtain System	Wide doors (16x14 and 16x16 feet)	Air Curtain System	Helps to control temperatures, and keep contaminants such as insects, dust, pollen, and other debris from entering the interior space [8]. Air curtain systems typically have payback periods of less than 2 years [8].

Non-HVAC Related Appliances	Miscellaneous equipment past their useful life and not Energy Star certified.	Replace the more than 5-yr-old appliances that are not Energy Star certified with 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 [9].
Plug Process Load Reduction	Identify and implement (PPL) opportunities.	Smart Power Strips. Energy Star rated vending machines and water coolers.	Plug and process loads (PPLs) consume about 47% of primary energy in U.S. commercial buildings. PPL efficiency has become pertinent in achieving aggressive energy targets [22]. Smart Power Strips help reduce annual electricity consumption with typical payback periods of 1.1 years [10].
Water Conservation Measures	Identify and implement WaterSense opportunities, including leak detection.	WaterSense rated sinks, faucets, and urinals. Leak detection system.	Water-saving techniques by installing WaterSense labeled products that have typically short payback periods of 2-3 years [23].
Renewable Energy	Domestic hot water heater (Lochinvar, CNR199-100-DF9-2)	Solar water heater/ Solar PV panels	Based on a 3,365 ft^2 roof (which represents 50% of the available roof area) a typical 50-kW solar PV system can generate about 69,381 kWh/year of electricity [12]. The typical payback period of a Solar PV system in Maryland is ~11 years [24].

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 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 the same level as the amount from natural gas sources. This downward trend would continue after 2029 with the CO_2 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, and ensure that occupants have access to cleaner, healthier, more resilient buildings.

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 Annapolis Readiness Center, by assuming 50% of the total roof area for installation of a Solar PV system, a 50-kW solar system can generate about 69,381 kWh/year of electricity. This system can be sized appropriately based on the available space at the site, preferably the roof. If 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 1000 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.

General Low cost-No cost Energy Efficiency Opportunities (General EnergyStar recommendations)

Following is a general list of low-cost/no-cost energy-saving opportunities that apply to most buildings in the areas of lighting, heating, cooling, and water heating consumption. It is offered as a supplementary piece of information for the report.

✔ 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.

✔ Maximize daylight harvesting by opening or closing blinds to make the best use of the natural daylight. Take advantage of skylights or other natural daylight sources to reduce lighting consumption during daytime hours.

✔ Program the lights so that they are off when not in use or when natural daylight is sufficient. This can reduce lighting energy consumption expenses by 10-40% [21].

Appendix

List of the Nomenclature used in the report

AHU – Air Handling Unit
BAS – Building Automation System
BGE – Baltimore Gas and Electric company
CFL – Compact Fluorescent Lamp
DGS – Department of General Services
DOAS – Dedicated Outdoor Air System
GMP – *Gallons Per Minute*
IAQ – Indoor Air Quality
DHW – Domestic Hot Water
DLC – Design Lights Consortium
EEM – Energy Efficiency Measure
EUI - Energy Use Intensity
ERV – Energy Recovery Ventilator
HID – High-Intensity Discharge
LED – Light-Emitting Diode
NFRC – National Fenestration Rating Council
RTU – Roof Top Unit

S2TS – Smart and Small Thermal Systems
SCIF – Sensitive Compartmented Information Facility
SHGC – Solar Heat Gain Coefficient
SREC – Solar Renewable Energy Credit
VFD – Variable Frequency Drive
WGL – Washington Gas Limited

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