NEWYORK ENGINEERS

October 6, 2023

DRAFT REPORT

ASHRAE Level-II Energy Audit Study

NEWYORK ENGINEERS

Grand Cayman Campus – Model 3

- **The Layman E. Scott Block**
- **The Hon. Benson Ebanks Block**
- **The Hon. Sybil McLaughlin Block**

168 Olympic Way, PO Box 702 Grand Cayman, Cayman Islands KY1-1107

Disclaimer

The goal of this energy study is to identify potential energy efficiency and carbon reduction opportunities, help prioritize specific measures for implementation. Most energy conservation measures have received preliminary analysis of feasibility that identifies expected ranges of savings and costs. This level of analysis is usually considered sufficient to establish a basis for further discussion and to help prioritize energy measures. NYE reviewed the energy conservation measures and estimates of energy savings were reviewed for technical accuracy. Actual, achieved energy savings depend on behavioral factors and other uncontrollable variables and, therefore, estimates of final energy savings are not guaranteed. NYE shall in no event be liable should the actual energy savings vary. NYE bases estimated installation costs on our experience at similar facilities, pricing from US & Cayman Island local contractors and vendors, and/or cost estimates from RS Means. We encourage the owner of the facility to independently confirm these cost estimates and to obtain multiple estimates when considering measure installations. Actual installation costs can vary widely based on individual measures and conditions. NYE does not guarantee installed cost estimates and shall in no event be held liable should actual installed costs vary from estimates. The customer and their respective contractor(s) are responsible to implement energy conservation measures in complete conformance with all applicable Cayman Island Local Laws.

NEWYORK ENGINEERS

Table of Contents

Introduction

Hon. Benson Ebank Block and Sybil McLaughing block are two-story blocks while Laymen E Scott block is a single floor building with total area of 30,295 sq.ft. on Grand Cayman Campus, 168 Olympic Way, Cayman Islands. These buildings are built in early 20s. New York Engineers performed an ASHRAE-II energy audit and made recommendations for energy efficiency solutions.

Dr. Robert Robertson, Principle In-charge of university college Cayman Islands (UCCI), contracted New York Engineers (NYE) to perform an ASHRAE Level 2 Energy Audit and solar feasibility study at Grand Cayman Campus. The purpose of the energy audit is to identify energy savings opportunities. NYE built a calibrated energy model based on utility data, building drawings, and site access provided by UCCI. The model was developed with eQuest software, and Energy Conservation Measures (ECM) were applied to acquire the findings of this report.

Methodology

This audit is per ASHRAE Level II requirements. This audit includes a review of existing drawings, annual utility bills, and other data; one-week site visits to check equipment conditions and working performance; Mr. Vishwaraj Nimbalkar and Mr. Thomas Dugan conducted one-week site visits from July 10–15, 2023.

The energy analysis is performed using standard engineering calculation procedures and the building energy simulation program eQuest, an hour-by-hour energy usage modeling program evolved from DOE2, which was jointly developed by National Laboratories for the U.S. Department of Energy. While eQuest is generally accepted as one of the most accurate building energy simulation programs, the estimated energy usage should not be interpreted as an absolute prediction.

The actual energy usage may differ from the prediction due to variables beyond the energy analyst's control. These may include changes in occupancy, schedules, final equipment selection, installation, and operation, weather variations from typical year data used, and other unforeseen circumstances.
A baseline building energy performance model was first developed based on the existing building conditions. Energy conservation measures (ECMs) were identified and analyzed by modifying the baseline building to reflect the impact of each ECM on the building's energy performance. An interactive model was created to simulate the net effect of all ECMs.

The cost-effectiveness of each ECM was evaluated using a simple payback analysis, which yields the time required to recover the cost of implementing the ECM by its annual energy cost savings. The ECM cost estimates are either obtained from RSMeans or provided by the US & Cayman Island local equipment vendors.

Energy Audit Team

The NYE team conveys their gratitude and thanks to the management of M/s Grand Cayman Campus, 168 Olympic Way, PO Box 702 Grand Cayman, Cayman Islands KY1-1107 for giving us an opportunity to study their campus for the Energy Audit, which was conducted in July 10-15, 2023.

Institutional Contact information

Name	E-mail	Phone
Dr. Robert Robertson, president/CEO	-	+1 (345) 623-8224
Cleveland Julien, Project Manager	CJulien@ucci.edu.ky	+1 (345) 623-0528
Sherrilyn Harvey, Facilities Administrator	sharvey@ucci.edu.ky	-
Fernando McLaughlin, Facilities management	FMcLaughlin@ucci.edu.ky	+1(345)-623-0505

Auditor Contact Information

Name	E-mail	Phone
Mr. Vishwaraj Nimbalkar PE, CEM, CEA, CBCP	VNimbalkar@nyc-engineers.com	718-689-7322
Mr. Thomas Dugan, Mechanical Energy Engineer	TDugan@nyc-engineers.com	646-907-5095

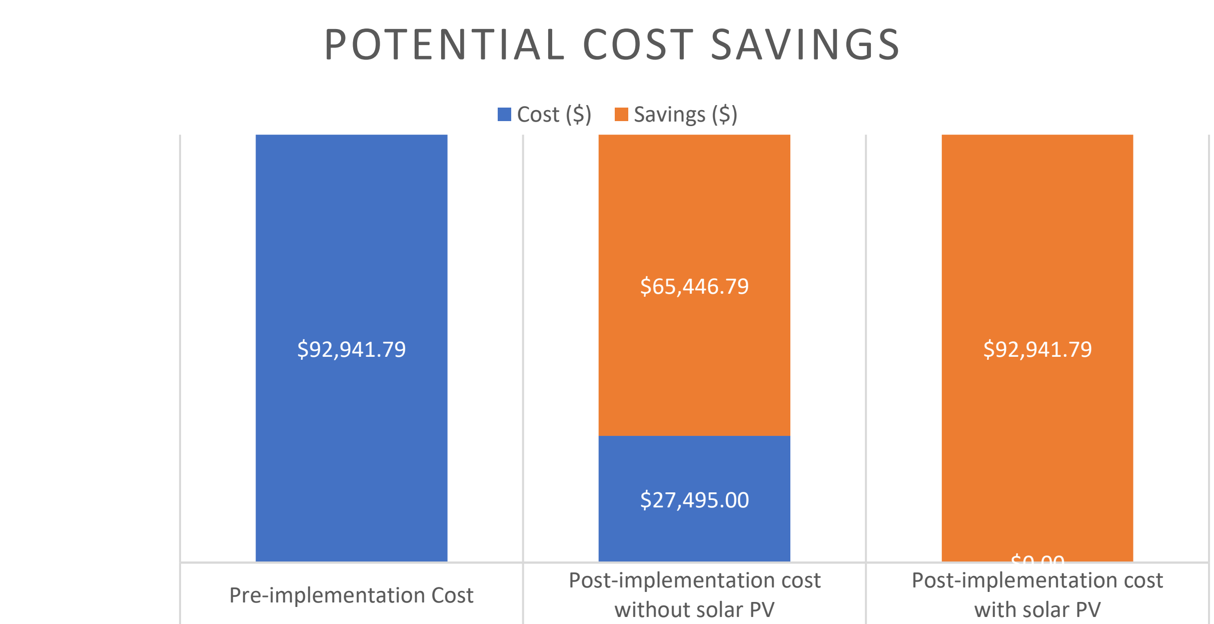
Executive Summary

The NYE team surveyed all the building's major energy-consuming equipment, such as Split Units, Misq. equipment, lighting, and appliances. The Hon. Benson Ebank block and Sybil McLaughlin block and Layman E. Scott block contains DX coil units for space cooling to the respective spaces, such as the classrooms, offices, conference room, computer lab, microbiology lab, manager facility, and observatory. Dehumidifiers serve all the classrooms and offices.

Cost reduction opportunities

Energy conservation measures were studied for heating, ventilation, air-conditioning, building management system, and lighting. Cumulatively, the energy conservation measures (ECMs) would reduce the total energy consumption by 1,190 MMBtu and annual greenhouse gas emissions by about 297-ton CO2e.

Refer to table 1 for an ECM summary for energy values of each measure and table 2 for cost values and simple payback calculations. The breakdown of existing utility costs and projected annual savings following implementation of all measures are shown in Figure 1. Together these measures represent an opportunity to reduce UCCI annual energy usage by about 100%.



	Pre-implementation Cost	Post-implementation cost without solar PV	Post-implementation cost with solar PV
Savings ($)		$65,446.79	$92,941.79
Cost ($)	$92,941.79	$27,495.00	$0.00

Figure 1: Cost saving potential

A detailed description of UCCI existing energy usage can be found in Section Building Energy Use and Costs. Estimates of total cost, energy savings, and financial incentives, which may be available for each ECM, are summarized below in Table 1 & 2. A brief description of each measure category can be found below. A detailed description of each ECM can be found in Section Energy Conservation Measures.

ECM Summary Table

Table 1 Energy Conservation Measure Summary

		Annual Energy Savings						
Measure Number	**Measure Description**	**Annual Energy Use (kWh)**	**Total Energy Use (MMBtu)**	**ton Co2 Emission**	**Saving ton Co2 Emission**	**Electricity Savings (kWh)**	**Total Energy Savings (MMBtu)**	**Energy Savings to Total Baseline use (%)**
	Baseline Consumption	376,399	1,284	320	-			
ECM-1	Lighting Control	361,705	1,234	307	12	14,694	50	4%
ECM-2	Window Upgradation	361,492	1,233	307	13	14,907	51	4%
ECM-3A	BMS - Night Setback Control (NSB)	322,173	1,099	274	46	54,226	185	14%
ECM-3B	BMS - Fan Control	316,806	1,081	269	51	59,593	203	16%
ECM-3C	BMS - Optimal ON-OFF	366,269	1,250	311	9	10,130	35	3%
ECM-3D	BMS - DCV Sensor	363,830	1,241	309	11	12,569	43	3%
ECM-4	VFD Installation	352,120	1,201	299	21	24,279	83	6%
ECM-5	Condensing Unit Replacement	373,661	1,275	318	2	2,738	9	1%
ECM-6	Weatherization	303,116	1,034	258	62	73,283	250	19%
ECM-7 (150 KW)	Solar PV	220,636	753	188	132	155,763	531	41%
Total					**359**	**422,182**	**1,440**	**112%**

Table 2: Energy Conservation Measure Results with Payback

		Annual Energy Savings				Payback Analysis		
Measure Number	Measure Description	Electricity Savings (kWh)	Total Energy Savings (MMBtu)	Electric Cost Savings ($)	Total Energy Cost Savings ($)	Measure Cost	Saving ton Co2 Emission	Simple Payback (years)
ECM-1	Lighting Control	14,694	50	$3,674	$3,674	$6,649	12	2
ECM-2	Window Upgradation	14,907	51	$3,727	$3,727	$32,434	13	9
ECM-3A	BMS - Night Setback Control (NSB)	54,226	185	$13,557	$13,557	$40,056	46	3
ECM-3B	BMS - Fan Control	59,593	203	$14,898	$14,898	$18,030	51	1
ECM-3C	BMS - Optimal ON-OFF	10,130	35	$2,533	$2,533	$4,819	9	2
ECM-3D	BMS - DCV Sensor	12,569	43	$3,142	$3,142	$6,489	11	2
ECM-4	VFD Installation	24,279	83	$6,070	$6,070	$5,524	21	1
ECM-5	Condensing Unit Replacement	2,738	9	$685	$685	$2,375	2	3
ECM-6	Weatherization	73,283	250	$18,323	$18,323	$48,513	62	3
ECM-7 (150 KW)	Solar PV	155,763	531	$38,941	$38,941	$327,592	132	8
Total		**422,182**	**1,440**	**$ 105,560**	**$ 105,560**	**$492,481**	**359**	**5**

ENERGY EFFICIENT PRACTICES

A facility's energy performance can be significantly improved by employing certain behavioral or operational adjustments and by performing better routine maintenance on building systems. These practices can extend equipment lifetime, improve occupant comfort, provide better health and safety, as well as reduce annual energy and O&M costs.

Potential opportunities identified at UCCI include:

- Reduce Air Leakage
- Close Doors and Windows
- Ensure Lighting Controls Are Operating Properly
- Reduce Motor Short Cycling
- Perform Routine Motor Maintenance
- Practice Proper Use of Thermostat Schedules and Temperature Resets
- Ensure Economizers are Functioning Properly
- Check for and Seal Duct Leakage
- Perform Proper Water Heater Maintenance
- Install Plug Load Controls
- Replace Computer Monitors
- Water Conservation

For details on these energy efficient practices, please refer to Section Energy Efficient Best Practices.

ON-SITE GENERATION MEASURES

NYE evaluated the potential for installing on-site generation for UCCI campus. Based on the configuration of the site and its loads there appears to be a low potential for cost-effective installation of any solar PV or combined heat and power self-generation measures. For details on our evaluation and on-site generation potential, please refer to Section On-Site Generation.

ECM SUMMARY AND INCREASE IN BUILDING VALUE

As a result of our study utility cost saving packages were bundled together based on our findings. The measures include upgrades for the building envelope, lighting, lighting controls, HVAC. Implementation cost, potential incentives, and energy savings have all been calculated.

- Lighting controls, Window Upgradation, BMS system – BMS night setback, BMS Fan schedule, optimal ON/OFF and solar PV installation.

Upon completion of installation, the building's value will immediately increase due to a higher net operating income. The net operating income increase has been calculated via energy savings and penalty avoidance. Annual energy savings with penalties avoided are the change in net operating income. Given a capitalization rate of 5% from Marcus & Millichap's Institutional Property Advisors (IPA), the following equation was used to calculate the net operating income increase per recommended package.

Table 3: Increase in building value

	Construction Cost	Saving ton Co2 Emission	Annual Energy Savings	Property Value Increase
Total	$492,481	359	$105,560	$2,111,197

$$Capitalization\ Rate = \frac{\Delta\ Net\ Operating\ Income}{\Delta\ Value\ of\ Property}$$

EMISSIONS OUTLOOK

Cayman Island sustainability development Goals report determined that some progress has been made towards the 2030 target. According to the Cayman Islands' 2021 Census Report, Cayman has achieved almost universal access to electricity, i.e. 97 per cent of Caymanian households have access to electricity. Energy policy aims to reduce greenhouse case emissions from 12.3tCO2 e per person in 2014 to 4.8tCO2 e by 2030

In February 2017, the Cabinet approved the Cayman Islands' NEP 2017–2037. The NEP, first drafted in 2013, and reviewed in 2016, set a target of generating 70 per cent of electricity from renewable sources by 2037. When the target was set in 2015, more than 99 per cent of energy in the Cayman Islands was generated from oil products. At that time, renewable energy accounted for 0.2 per cent of electricity generation. In the seven years since the target was set, little progress has been made. By February 2023, renewable energy contributed 3 per cent of Grand Cayman's total energy production. Significant effort will be needed to increase the use of renewable energy over the next 15 years and to achieve the target of 70 per cent.

Facility Information and Existing Conditions

GENERAL SITE INFORMATION

Table 4: General Site information

BUILDING DETAILS	
Client Name	Dr. Christopher Williams
Property Superintendent	Cleveland Julien
Building Name	1. Hon. Benson Ebank Block 2. Sybil McLaughing Block 3. Laymen E Scott Block
Total SF	30,295 SF
Number of Buildings	3
# Stories	1 or 2 Floors

ENVELOPE DESCRIPTION

The envelope or building exterior exchanges energy with the outside air and absorbs energy from the sun, affecting the energy required by the building's HVAC system for indoor comfort. The details of the envelope parameter for the existing building are as follows:

- Exterior Wall: The exterior wall of the project has a U-value, which is the inverse of the R-value and is calculated as 0.58 Btu/h-ft2-°F.
- Exterior Roof: The exterior roof of the project has minimal insulation to resist the heat flow from the sun's rays. The U-value, which is the inverse of the R-value, is calculated as 0.034 Btu/h-ft2-°F.
- Exterior Window Glass: The exterior window glass consists of double-pane clear glass. The U-value is calculated as 1.47 Btu/h-ft2-°F, the shading coefficient is calculated as 0.6 and visible light transmittance is 0.8

OCCUPANCY

All three Block has 370 persons (students, faculty and non-teaching staff members). The building is open Monday through Friday and closed on the weekends. The typical schedule is presented in the table below. During a typical day.

Table 5: Operational Schedule

BUILDING NAME	WEEKDAY/WEEKEND	OPERATING SCHEDULE
1. Hon. Benson Ebank Block	Weekday	9:00 AM to 5:00 PM
2. Sybil McLaughing Block **3.** Laymen E Scott Block	Weekend	Closed

EQUIPMENT SCHEDULES AND SETPOINT

We consider a cooling set point of 75 °F.

SPACE COOLING SYSTEM

The buildings has DX coil units with dehumidifier which is used to provide space cooling and maintain humidity in to the space. Allied Air, Comfort Star, Lennox, Goodman Unit are installed it this space. These models range from 1 ton to 5 ton capacity.

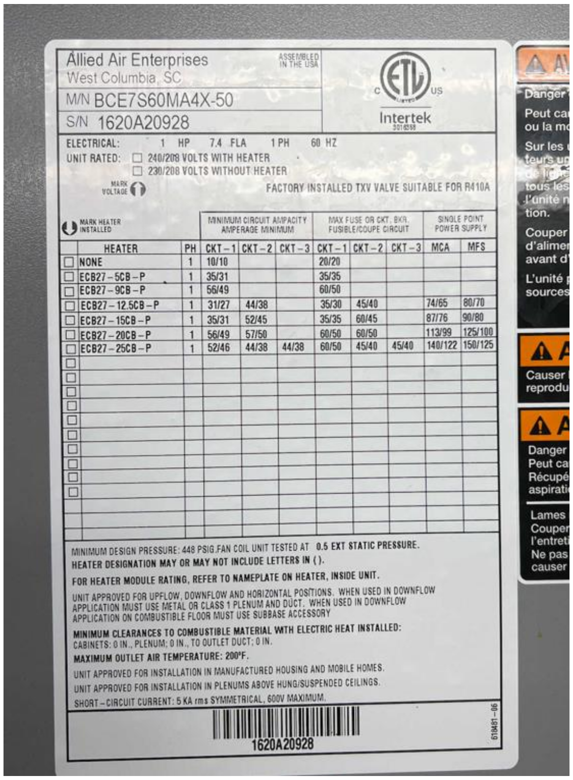
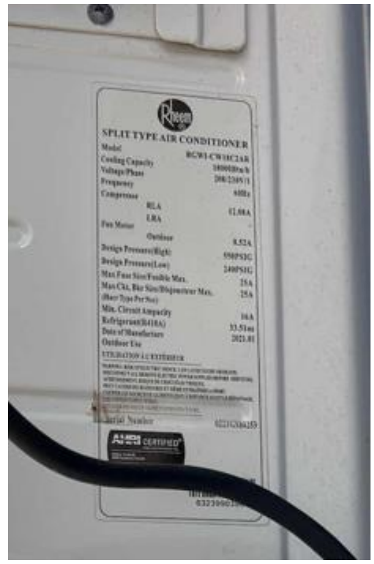
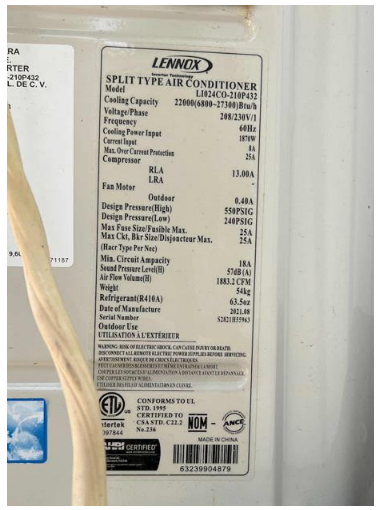


Figure 2: DX coil Unit


Rheem


SPLIT TYPE AIR CONDITIONER
Model
Cooling Capacity
Voltage/Phase
Frequency
Compressor
RLA
LRA
Fan Motor
Outdoor
Design Pressure(High) 550PSIG
Design Pressure(Low) 240PSIG
Max Fuse Size/Fusible Max. 25A
Max Ckt. Bkr Size/Disjoncteur Max. 25A
Min. Circuit Ampacity
Date of Manufacture
Outdoor Use
CERTIFIED


LENNOX


LENNOX
Inverter Technology
SPLIT TYPE AIR CONDITIONER
Model LI024CO-210P432
Cooling Capacity 22000(6800~27300)Btu/h
Voltage/Phase 208/230V/1
Frequency 60Hz
Cooling Power Input 1870W
Current Input 8A
Max. Over Current Protection 25A
Compressor
RLA 13.00A
LRA -
Fan Motor
Outdoor 0.40A
Design Pressure(High) 550PSIG
Design Pressure(Low) 240PSIG
Max Fuse Size/Fusible Max. 25A
Max Ckt. Bkr Size/Disjoncteur Max. 25A
(Hacr Type Per Nec)
Min. Circuit Ampacity 18A
Sound Pressure Level(H) 57dB (A)
Air Flow Volume(H) 1883.2 CFM
Weight 54kg
Refrigerant(R410A) 63.5oz
Date of Manufacture 2021.08
Serial Number S2821H55963
Outdoor Use
UTILISATION À L'EXTÉRIEUR
WARNING: RISK OF ELECTRIC SHOCK. CAN CAUSE INJURY OR DEATH:
DISCONNECT ALL REMOTE ELECTRIC POWER SUPPLIES BEFORE SERVICING.
AVERTISSEMENT. RISQUE DE CHOCS ÉLECTRIQUES.
USE COPPER SUPPLY WIRES.
CONFORMS TO UL STD. 1995
CERTIFIED TO CSA STD. C22.2 No.236
NOM - ANCE
CERTIFIED
MADE IN CHINA
63239904879


Goodman

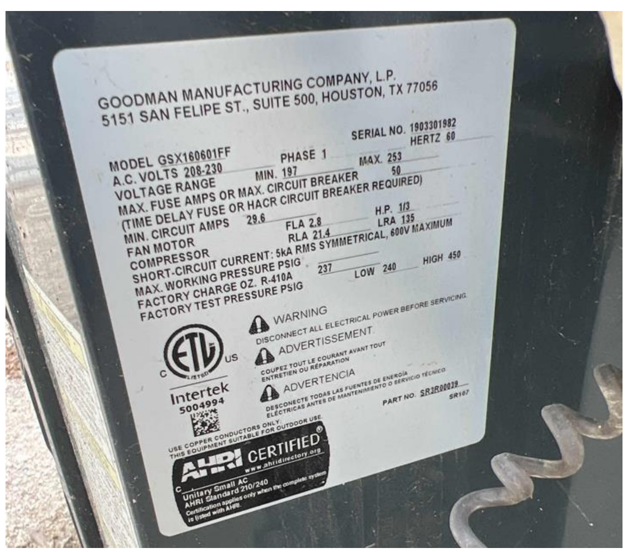

GOODMAN MANUFACTURING COMPANY, L.P.
5151 SAN FELIPE ST., SUITE 500, HOUSTON, TX 77056
SERIAL NO. 1903301982
HERTZ 60
MODEL GSX160601FF
A.C. VOLTS 208-230
PHASE 1
VOLTAGE RANGE MIN. 197 MAX. 253
MAX. FUSE AMPS OR MAX. CIRCUIT BREAKER 50
(TIME DELAY FUSE OR HACR CIRCUIT BREAKER REQUIRED)
MIN. CIRCUIT AMPS 29.6
FAN MOTOR FLA 2.8 H.P. 1/3
COMPRESSOR RLA 21.4 LRA 135
SHORT-CIRCUIT CURRENT: 5kA RMS SYMMETRICAL, 600V MAXIMUM
MAX. WORKING PRESSURE PSIG
FACTORY CHARGE OZ. R-410A 237
FACTORY TEST PRESSURE PSIG LOW 240 HIGH 450
WARNING
DISCONNECT ALL ELECTRICAL POWER BEFORE SERVICING.
ADVERTISSEMENT
COUPEZ TOUT LE COURANT AVANT TOUT ENTRETIEN OU REPARATION
ADVERTENCIA
DESCONECTE TODAS LAS FUENTES DE ENERGÍA ELÉCTRICAS ANTES DE MANTENIMIENTO O SERVICIO TÉCNICO
Intertek 5004994
USE COPPER CONDUCTORS ONLY
THIS EQUIPMENT SUITABLE FOR OUTDOOR USE
PART NO. SR2R00028
AHRI CERTIFIED
Unitary Small AC
AHRI Standard 210/240

Figure 3: Condenser Units

LIGHTING POWER

The lighting system in the blocks are provided mostly by LED- Fixtures 20W & 32W lamps with magnetic ballasts, some 12-Watt linear LED T8 Linear tubes, plus few 15W Linear fluorescent lights. Most of the fixtures are 2-lamp or 3-lamp, 4-foot long troffers with diffusers. Lighting control in most spaces is provided by wall switches. Nearly all of the buildings exit signs have been upgraded to LED fixtures. The building's exterior lighting is minimal and consists primarily of LED surface mounted fixtures that are controlled by photocells. The lighting plan is used to calculate lighting power density (LPD) on a space-by-space basis. The Appendix D contains the lighting power density (LPD) for each space.

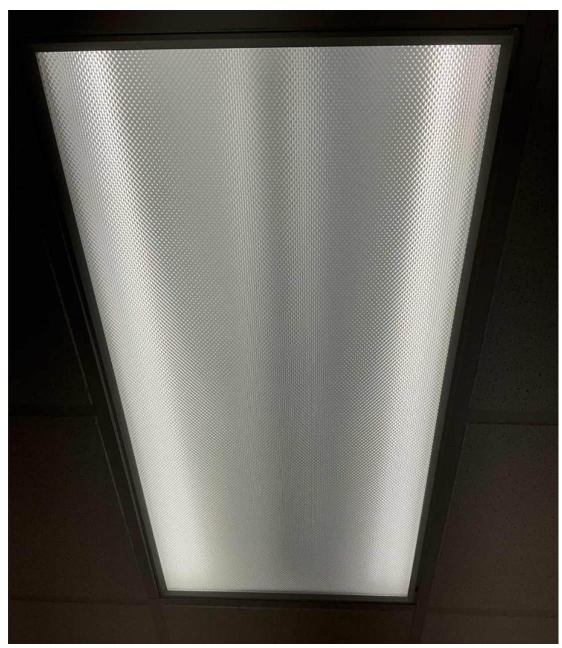


Figure 4: Lighting Load

PLUG LOAD

The building has classrooms, offices, labs, kitchen and Maintenance room equipment like computers, projectors, printers, 3D printers, laptops, monitors, Microwave, coffee maker and pumps. The equipment power density (EPD) load is calculated on space-by-space basis. The appendix D contains the Equipment power density (EPD) for each space.

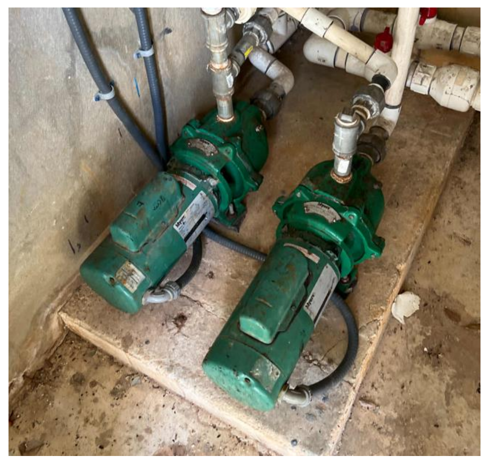


Figure 5: Plug Loads

EQUIPMENT CONTROL

The building does not have a centralized BMS system. Basic Honeywell wall mounted thermostat are installed on wall.

INDOOR AIR QUALITY (IAQ)

Indoor air quality (IAQ) is the quality of the air within and around buildings and structures, particularly as it relates to the health and comfort of building occupants. Understanding and controlling common indoor pollutants can help you reduce your risk of developing indoor health issues. However, indoor air pollution can have serious and negative health consequences.

EPA studies of human exposure to air pollutants indicate that indoor levels of pollutants may be two to five times and occasionally more than 100 times, higher than outdoor levels. Because most people spend 90 percent of their time indoors, these levels of indoor air pollutants are of particular concern. The following are examples of good indoor air quality (IAQ) management for this guide:

- Control of airborne pollutants.
- Introduction and distribution of adequate outdoor air.
- Maintaining a comfortable temperature and relative humidity.

Temperature and humidity cannot be overlooked because thermal comfort concerns underlie many complaints about "poor air quality." Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the area. High temperature and humidity levels can also increase concentrations of some pollutants.

The temperature and humidity of indoor air have been widely recognized as factors that influence directly the thermal sensation of the human body (Fanger 1972). However, they were mainly considered indirect factors that influence perceived air quality due to their influence on indoor air pollution sources.

Outdoor air enters Collage buildings through windows, doors, and ventilation systems, so it should be considered. As a result, transportation and grounds maintenance activities influence both indoor pollutant levels and outdoor air quality on Collage grounds.

Building Energy Use and Costs

Home Gas Ltd Supplies on demand propane in UCCI. Caribbean Utilities Company, Ltd. (CUC) supplies utilities in UCCI. It has three electrical services, one (24505-302934) of which is classified as large commercial based on its consumption levels, and the other two (24505-317270 and 24505-342700) are classified as general commercial. At the outset of the review, the metered data for all three services was looked at to determine whether there could be immediate benefits through either the aggregation of the three services into a single metered service or the splitting of the large commercial electrical service into multiple services such that each new service was lowered to general commercial rates. In each case, there were no immediate savings due to the specific consumption characteristics of the electrical services and the charge component differences for the general commercial (consumption-only rates) and large commercial (demand and consumption rates) rate classes. CUC would therefore not recommend, all else being equal, investments made to aggregate or split electrical services for cost-optimization efforts.

Combined utility data for electricity and Propane was evaluated to determine the annual energy performance metrics for the building in terms of energy cost per square foot and energy usage per square foot. These metrics are an estimate of the relative energy efficiency of this building. There are a number of factors that could cause the energy use of this building to vary from the "typical" energy usage profile for facilities with similar characteristics. Please refer to the benchmarking section for additional information.

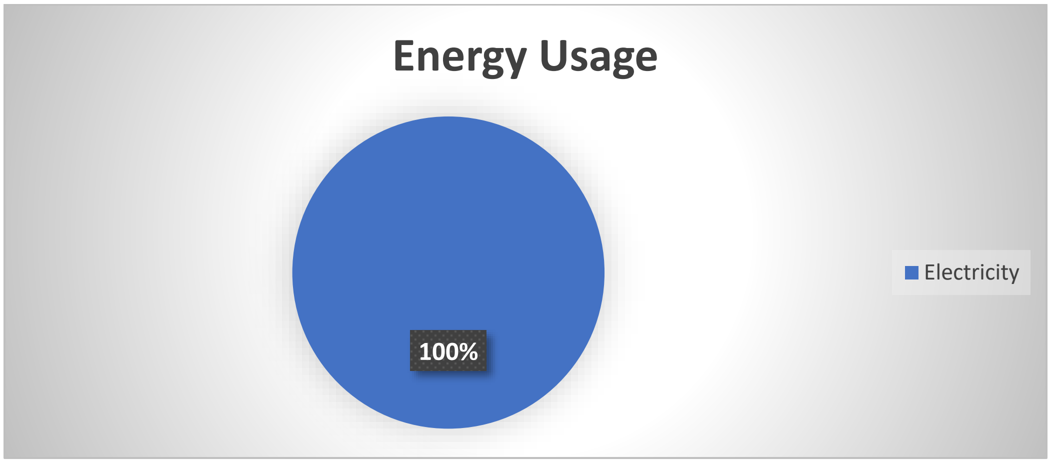
TOTAL COST OF ENERGY

Twelve months of utility billing data are used to develop annual energy consumption and cost data. This information creates a profile of the annual energy consumption and energy costs.

Table 6: Utility Summary

Utility Summary		
Fuel	Usage	Cost
Electricity	371,767	92,942
Total	371,767	92,942

Figure 3: Utility Summary



An energy balance identifies and quantifies energy use in your various building systems. This can highlight areas with the most potential for improvement. This energy balance was developed using calculated energy use for each of the end uses noted in the figure.

The energy auditor collects information regarding equipment operating hours, capacity, efficiency, drawings and other operational parameters from facility staff and on-site observations. This information is used as the inputs to calculate the existing conditions energy use for the site. The calculated energy use is then compared to the historical energy use, and the initial inputs are revised as necessary to balance the calculated energy use to the historical energy use.

UTILITY USAGE

Utility usage for UCCI includes electricity measured in kilowatt-hours. The electric per unit cost was utilized is $ 0.25 per kWh

Electricity is used for the following applications in the base building:

- Base buildings
  - Interior Lighting
  - Plug Loads
  - HVAC system
  - Lab equipment's

UTILITY BILLING

- Electricity
  - Supplied by: Caribbean Utilities Company, Ltd. (CUC)
  - Billed to UCCI
  - Number of Meters: 03 (24505-302934, 24505-317270 & 24505-342700)
  - The total average electric cost over the past 12 months was $0.25/kWh, which is the blended rate that includes energy supply, distribution, demand, and other charges. This report uses this blended rate to estimate energy cost savings.

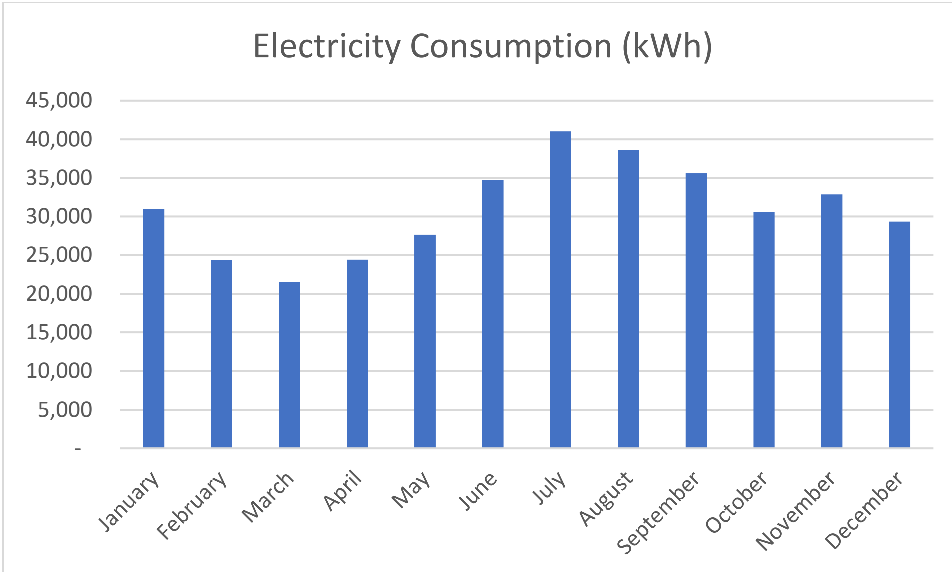


Table 7: Annual Electric Usage (kWh)

Month	Electric Usage KWh	Total Electric Cost
January	31,022	$7,756
February	24,387	$6,097
March	21,507	$5,377
April	24,413	$6,103
May	27,670	$6,917
June	34,716	$8,679
July	41,019	$10,255
August	38,611	$9,653
September	35,591	$8,898
October	30,593	$7,648
November	32,869	$8,217
December	29,368	$7,342
Total	**371,767**	**$92,942**

BUILDING UTILITY CONSUMPTION

All three buildings in this model use electricity as their main energy source. The monthly consumption of electricity at each building can be seen in Table 8 below.

Table 8: Annual Electricity Usage (KWH)

Description	Total	A – Hon. Benson Ebank Block	B – Hon. Sybil McLaughing Block	C – Laymen E Scott Block
Jan	31,022	12,422	13,674	4,926
Feb	24,387	9,765	10,749	3,873
Mar	21,507	8,612	9,480	3,415
Apr	24,413	9,775	10,761	3,877
May	27,670	11,079	12,196	4,394
Jun	34,716	13,901	15,302	5,513
Jul	41,019	16,424	18,080	6,514
Aug	38,611	15,461	17,019	6,132
Sep	35,591	14,251	15,688	5,652
Oct	30,593	12,250	13,485	4,858
Nov	32,869	13,161	14,488	5,220
Dec	29,368	11,759	12,945	4,664
Total	**371,767**	**148,861**	**163,868**	**59,038**

Energy End-Use Breakdown

To provide a complete overview of energy consumption across building systems, an energy balance was performed at this facility. An energy balance utilizes standard practice engineering methods to evaluate all components of the various electric systems found in a building to determine their proportional contribution to overall building energy usage. This chart of energy end uses highlights the relative contribution of each equipment category to total energy usage. This can help determine where the greatest benefits might be found from energy efficiency measures.

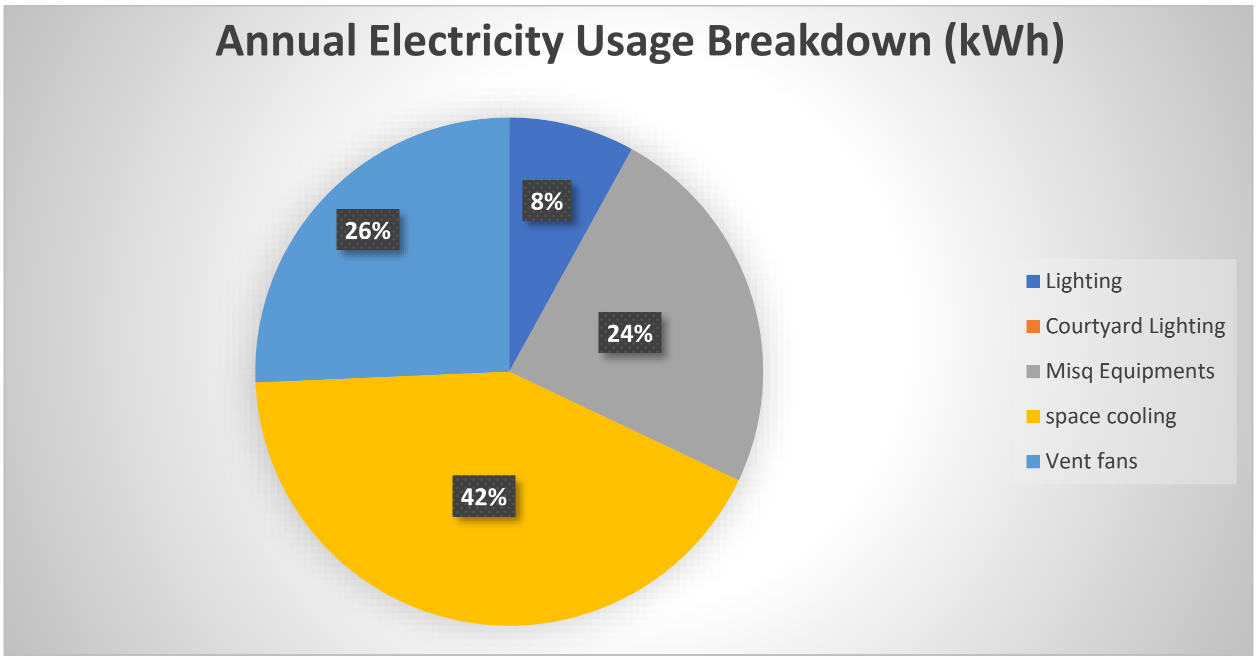


Figure 4: Annual Electricity Usage Breakdown

MODEL CALIBRATION

The existing building is modeled with inputs based on the actual conditions of the project, and the existing annual consumption of the building is matched with the energy simulation results within a permissible variation range of ±10%.

CALIBRATED MODEL AS PER EXISTING CONDITIONS

Model Result:

The annual electricity and annual Propane consumption of eQuest, when compared with the baseline building, were calibrated with a variation of -1.2% in the case of annual electricity consumption. The variation is within the permissible range of ±10%.

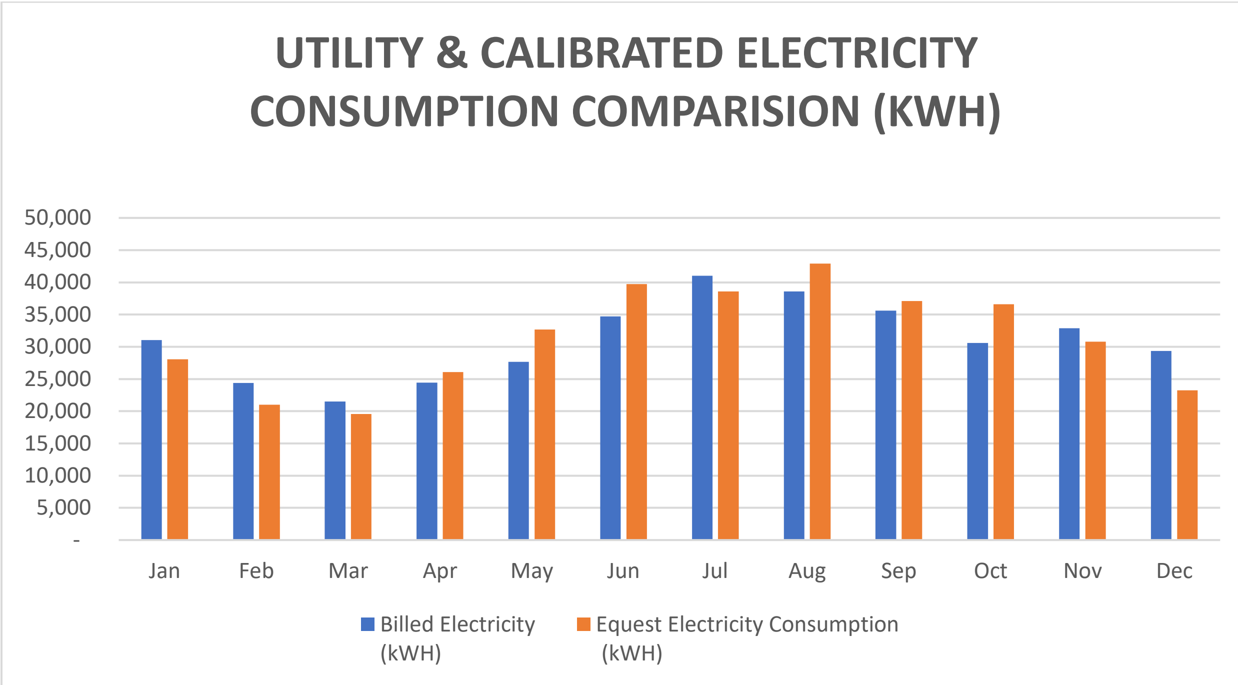
Table 9: Annual calibrated results

3 Block Building Annual Electricity Consumption Calculation	
Total Annual Electricity Consumption as per Utility Bills (kWh)	371,767
Annual Electricity Consumption as per Baseline Model (kWh)	376,399
Difference Units (kWh)	-4,632
% Variation	-1.2%

The baseline building's consumption as calculated by the eQuest energy modelling software Table 12 & 13 data and graph 1 & 2 compare the monthly electricity usage from the utility bills and the calibrated model.

Table 10: Annual utility billed & baseline consumption

3 Block Building - Monthly Electricity Consumption Comparison			
Sl. No.	**Month**	**Electricity Consumption As Per Utility Bills (kWh)**	**Electricity Consumption As Per Calibrated Model (kWh)**
1	Jan	31,022	28,079
2	Feb	24,387	20,996
3	Mar	21,507	19,576
4	Apr	24,413	26,081
5	May	27,670	32,690
6	Jun	34,716	39,723
7	Jul	41,019	38,573
8	Aug	38,611	42,919
9	Sep	35,591	37,123
10	Oct	30,593	36,592
11	Nov	32,869	30,791
12	Dec	29,368	23,256
Annual Electricity Consumption		**371,767**	**376,399**



Graph 1 : Annual utility billed & baseline result comparison

Energy Conservation Measures

The goal of this audit report is to identify potential energy efficiency opportunities, help prioritize specific measures for implementation, and provide information to the UCCI regarding financial incentives for which they may qualify to implement the recommended measures. For this audit report, most measures have received only a preliminary analysis of feasibility which identifies expected ranges of savings and costs.

This level of analysis is usually considered sufficient to demonstrate project cost-effectiveness and help prioritize energy measures. Savings are based on the RMS. Further analysis or investigation may be required to calculate more precise savings based on specific circumstances. A higher level of investigation may be necessary to support any Pay for Performance. The following sections describe the evaluated measures.

The measures below have been evaluated by the auditor and are recommended for implementation at the facility.

Table 11: Energy Conservation Measure Results

	Annual Energy Savings					Payback Analysis		
Measure Number	Measure Description	Electricity Savings (kWh)	Total Energy Savings (MMBtu)	Electric Cost Savings ($)	Total Energy Cost Savings ($)	Measure Cost	Saving ton Co2 Emission	Simple Payback (years)
ECM-1	Lighting Control	14,694	50	$3,674	$3,674	$6,649	12	2
ECM-2	Window Upgrade	14,907	51	$3,727	$3,727	$32,434	13	9
ECM-3A	BMS – Night Setback (NSB)	54,226	185	$13,557	$13,557	$40,056	46	3
ECM-3B	BMS – Fan Schedule	59,593	203	$14,898	$14,898	$18,030	51	1
ECM-3C	BMS – Optimal ON-OFF	10,130	35	$2,533	$2,533	$4,819	9	2
ECM-3D	BMS – Demand Control Ventilation (DCV)	12,569	43	$3,142	$3,142	$6,489	11	2
ECM-4	Variable frequency Drive (VFD) Installation on AHU's	24,279	83	$6,070	$6,070	$5,524	21	1
ECM-5	Condensing Unit Replacement	2,738	9	$685	$685	$2,375	2	3
ECM-6	Weatherization	73,283	250	$18,323	$18,323	$48,513	62	3
ECM-7	Solar PV (150 kW)	155,763	531	$38,941	$38,941	$327,592	132	8
Total		**422,182**	**1,440**	**$105,560**	**$105,560**	**$492,481**	**359**	**5**

Energy Conservation Measures

The Hon. Benson Ebank Block, Sybil McLaughing Block and Laymen E Scott Blocks Energy Conservation Measures (ECMs) Summary.

ECM #1 LIGHTING CONTROLS

Measure Description	This measure studies the addition of occupancy sensors to each room's lighting and daylight sensors to all rooms with exterior lighting. This will partially cut back on lighting usage during the day. Occupancy sensors turn a section of lighting fixtures and release the lights off after time of no detection. Benefits include: • Reduction the unnecessary lighting usage and building's total electricity consumption.
Operation and Maintenance Impacts	This ECM does not require any maintenance.
Design Considerations	Daylighting controls and occupancy sensors need to be implemented in sections where they are beneficial. Discussion with on-site personnel and observation of high daylight should be conducted to understand where new controls would be beneficial and not disrupt users.
Estimated Project Costs	$6,649
Annual Energy Savings	• Electricity: 14,694 (kWh) • Total Energy Savings : 50 (MMBTU)
Annual Energy Cost Savings	$3,674
Saving ton CO2 Emissions	12
Simple Payback, year	2

ECM #2 WINDOW UPGRADATION

Measure Description	New efficient windows have a low solar heat gain coefficient and visual light transmittance value. Upgraded frames with a good seal between the window frame and the wall reduce air infiltration leaks and reduce the cooling load for a building. Heat gain and heat loss through windows are responsible for 25%–30% of residential heating and cooling energy use [DOE] and upgrades will lower that number. Old Windows have many problems like: Messy or Incomplete caulking, properly opening and shutting, Condensation between the glass panes, Drafts and water damage, Glass stains and discoloration, Gaps between the windowsill and frame, uneven windows, and Repair Expenses.
Operation and Maintenance Impacts	None
Design Considerations	Window selections tips. • Look for the ENERGY STAR and NFRC labels. • In warmer climates, select windows with coatings to reduce heat gain. • Look for a low solar heat gain coefficient (SHGC). SHGC is a measure of solar radiation admitted through a window. Low SHGCs reduce heat gain in warm climates. • Look for whole-unit SHGCs, rather than center-of-glass SHGCs. Whole-unit numbers more accurately reflect the energy performance of the entire product.
Estimated Project Costs	$32,434
Annual Energy Savings	• Electricity: 14,907 (kWh) • Total Energy Savings : 51 (MMBTU)
Annual Cost Savings	$3,727
Saving ton CO2 Emissions	13
Simple Payback (years)	9

ECM #3A BUILDING MANAGEMENT SYSTEM (BMS) – NIGHT SETBACK (NSB)

Measure Description	A Building Management System (BMS) or centralized control system can manage and monitor building systems and equipment. This will enhance efficiency, comfort, safety, and reduce energy consumption. The BMS feature implemented in this modelled study is night setback. • A night setback controls HVAC equipment to run at a lower rate during unoccupied hours. The strategy optimizes energy usage while still providing full comfort during occupied hours.
Operation and Maintenance Impacts	• Set point temperatures of cooling systems during unoccupied hours should be monitored. Setback points should reduce the load of equipment while still providing sufficient nighttime cooling for unoccupied buildings.
Design Considerations	• Designing a Building Management System with a Night Setback feature requires careful planning and consideration to ensure that it effectively optimizes energy usage while maintaining occupant comfort. • The occupant profile, operational schedule, setpoint adjustments, integration of the HVAC system, monitoring, data logging analysis, and energy efficiency optimization should all be accounted for in design.
Estimated Project Costs	$40,056
Annual Energy Savings	• Electricity: 54,226 (kWh) • Total Energy Savings : 203 (MMBTU)
Annual Cost Savings	$13,558
Saving ton CO2 Emissions	46
Simple Payback (years)	3

ECM #3B BUILDING MANAGEMENT SYSTEM (BMS) – FAN SCHEDULE

Measure Description	A Building Management System (BMS) implementation serves as a centralized control system managing and monitoring various building systems and equipment to enhance efficiency, comfort, safety, and sustainability. This BMS implementation utilizes a fan schedule feature. • The fan schedule feature optimizes the operation of fans and ventilation systems.
Operation and Maintenance Impacts	The fan schedule allows for precise control of fan operation based on occupancy and building needs. Fans can be set to operate only when necessary, reducing energy consumption. • The feature will yield benefits of improved air quality (IAQ), comfort control, humidity control, and HVAC system integration. Monitoring of fan schedule should be performed to ensure both energy reduction and satisfactory occupant comfort.
Design Considerations	Designing a building management system (BMS) with a fan schedule feature involves several considerations to ensure efficient operation, occupant comfort, and energy savings. Design must consider: • Zones • Occupancy patterns • Ventilation needs • Scheduling • Temperature set points
Estimated Project Costs	$18,030
Annual Energy Savings	• Electricity: 59,593 (kWh) • Total Energy Savings : 203 (MMBTU)
Annual Cost Savings	$14,900
Saving ton CO2 Emissions	51
Simple Payback (years)	1

ECM #3C BUILDING MANAGEMENT SYSTEM (BMS) – OPTIMAL ON-OFF

Measure Description	Continuing the additional functions of a BMS, this measure implements an optimal ON-OFF feature. • Optimal start-stop control optimizes operation of various building systems and equipment, ensuring energy efficiency, occupant comfort, and operational cost savings. • Under optimal start, cooling equipment will begin cooling at just the right time before the occupancy starts, so that setpoint will be met right at the scheduled time. On less hot mornings, cooling will start closer to occupancy hours, and on hotter mornings, cooling will start even earlier. • Optimal stop aims to shut the system down before the scheduled unoccupied time and let the building "coast" down. If the outdoor temperature is close to the set point it can shut it down or back off some time before the end of occupancy.
Operation and Maintenance Impacts	Successful implementation requires careful planning, ongoing monitoring, and proactive management to ensure the system operates as intended and delivers the expected benefits. Regular maintenance and data analysis are key components of optimizing the long-term performance of a BMS with optimal on-off control.
Design Considerations	Occupancy schedules and activities outside of normal occupant hours need to be considered.
Estimated Project Costs	$4,819
Annual Energy Savings	• Electricity: 10,130 (kWh) • Total Energy Savings: 35 (MMBTU)
Annual Cost Savings	$2,533
Saving ton CO2 Emissions	9
Simple Payback (years)	2

ECM #3D BUILDING MANAGEMENT SYSTEM (BMS) – DCV

Measure Description	Direct Control Ventilation (DCV) uses CO2 sensors to determine the required amount of make-up air provided by the mechanical system to meet the required ventilation levels. Over-ventilation can be one of the largest indirect contributors to a building's energy use. Compared to a fixed ventilation approach, DCV saves energy by eliminating the need for additional cooling and dehumidification. When integrated with the appropriate building control strategy, ventilation can be controlled zone by zone based on actual occupancy. This allows for the use of supply air from under-occupied zones to be redistributed to areas where more ventilation or cooling is needed. A CO2 control strategy can be issued to maintain any per-person ventilation. As a result, this approach is highly adaptable to changing building uses.
Operation and Maintenance Impacts	None
Design Considerations	• 400-1,000 ppm is CO2 permissible limit in school. • A VFD is required to control the speed of motors controlling intake air. • Installing VFDs usually requires a mechanical/controls contractor. • Requires pressure-independent OA dampers for non-DCV zones.
Estimated Project Costs	$6,489
Annual Energy Savings	• Electricity: 12,569 (kWh) • Total Energy Savings: 43 (MMBTU)
Annual Cost Savings	$3,143
Saving ton CO2 Emissions	11
Simple Payback (years)	2

ECM #4 VFD INSTALLATION ON INDOOR UNITS

Measure Description	Install variable frequency drive (VFD) on the indoor units. VFDs ramp up a motor for a smooth startup or to prevent a heavy load from straining the unit during startup. This is accomplished by varying the frequency of the unit's output. This results in longer lasting units longer, translating to less downtime and lower repair costs.
Operation and Maintenance Impacts	VFD maintenance ensures that the units stay safe from external factors such as water and debris, as well as faulty internal mechanics. Good maintenance practices include visual inspections, regular cleanings, connection checks, and replacing parts before they start to impede good performance. The maintenance in motors is of vital importance since it guarantees its correct operation, prevents some type of faults and even allows to increase its useful life.
Design Considerations	Consider the size of motors and VFDs. The system should be easily configured with the existing equipment. VFD drive will enable AHU capacity modulation and speed control. Items to consider for the measure's implementation: • Motor capacity • VFD compatibility with motor
Estimated Project Costs	$5,524
Annual Energy Savings	• Electricity: 24,279 (kWh) • Total Energy Savings :83(MMBTU)
Annual Cost Savings	$6,071
Saving ton CO2 Emissions	21
Simple Payback (years)	1

ECM #5 CONDENSOR UNIT REPLACEMENT

Measure Description	Replace old condensing outdoor unit with new condensing unit. A newer unit provides higher efficiency cooling.
Operation and Maintenance Impacts	Monthly filter checking will improve efficiency of the system and indoor air quality.
Design Considerations	Design considerations include unit compatibility, capacity, performance, refrigerant, and an efficiency upgrade. The COP of the new condensing unit that was modelled was 4.1.
Estimated Project Costs	$2,375
Annual Energy Savings	• Electricity: 2,738 (kWh) • Total Energy Savings: 9 (MMBTU)
Annual Cost Savings	$685
Saving ton CO2 Emissions	2
Simple Payback (years)	3

ECM #6 WEATHERIZATION

Measure Description	Weatherization means protecting a building and its interior from direct sunlight, heat, wind, and humidity by providing air sealing, insulation, moisture removal or ventilation. • In air sealing, caulk is used to fill up cracks and openings between stationary envelope components like window frames, fixed windows, and door frames. This process is called caulking. Sealing of moving envelope components like doors and operable windows using flexible strip materials is called weather-stripping. Air sealing results in a decrease in cooling load due to lower air leakage rates. • In the same measure, insulation is added to existing walls. This lowers the U value of wall reducing the heat gain coefficient for the building.
Operation and Maintenance Impacts	Annual inspection of sealant quality will monitor replacement needs.
Design Considerations	Consider the required rate of air change for academic buildings. Sealing material should be applied on clean surfaces and look coherent with framing for aesthetics. While selecting building insulation, method and ease of installation, material finishing, life cycle costs should be considered.
Estimated Project Costs	$48,513
Annual Energy Savings	• Electricity: 73,283 (kWh) • Total Energy Savings :250 (MMBTU)
Annual Cost Savings	$18,323
Saving ton CO2 Emissions	62
Simple Payback (years)	3

ECM #7 SOLAR PV INSTALLATION

Measure Description	Addition of a rooftop photovoltaic solar system. • Solar PV installations generate an emissions free source of electricity. This reduces greenhouse gas emissions, promotes energy independence, and saves on energy costs. • Rooftop solar plant with a capacity of 150 kW.
Operation and Maintenance Impacts	• Proper maintenance and monitoring are essential to ensure long-term performance, maximize energy generation, and extend the system's lifespan. Regular cleaning and inspection of equipment is highly recommended. • Monitoring through a BMS system that records solar data can be beneficial to both optimizing energy generation and academic opportunities to understand the system. Regular safety inspections ensure that the PV installation meets safety standards and poses no hazards to personnel or the environment.
Design Considerations	Designing a solar photovoltaic (PV) installation requires careful planning to ensure that the system operates efficiently, generates maximum energy, and has a long lifespan. • Mainly site assessment, system size and capacity, solar panel selection, inverter selection, mounting and racking, shading analysis, electrical design, monitoring and control, maintenance access, and environmental considerations. • A solar PV plant with a capacity of 150 kW has been modelled on the roof of the building.
Estimated Project Costs	$327,592
Annual Energy Savings	• Electricity: 155,763 (kWh) • Total Energy Savings :531 (MMBTU)
Annual Cost Savings	$38,946
Saving ton CO2 Emissions	132
Simple Payback (years)	8

On-Site Generation Measures

On-site generation measures generate power to meet electric needs of a facility.

Preliminary screenings were performed to determine the potential that a generation project could provide a cost-effective solution for your facility. Before deciding to implement, a feasibility study should be conducted that would take a detailed look at existing energy profiles, siting, interconnection, and the costs associated with the generation project including interconnection costs, departing load charges, and any additional special facilities charges.

Photovoltaic

Sunlight can be converted into electricity using photovoltaics (PV) modules. Modules are racked together into an array that produces direct current (DC) electricity. The DC current is converted to alternating current (AC) through an inverter. The inverter is interconnected to the facility's electrical distribution system. The amount of unobstructed area available determines how large of a solar array can be installed. The size of the array combined with the orientation, tilt, and shading elements determines the energy produced. A preliminary screening, based on the facility's electric demand, size, location, and unshaded free area, shows that the facility has a high potential for installing a PV array.

The amount of free area, ease of installation (location), and the lack of shading elements contribute to the potential for PV at the site. In order to be cost-effective, a solar PV array needs certain minimum criteria, such as flat or south-facing rooftop or other unshaded space on which to place the PV panels. In our opinion, the facility might not meet these minimum criteria for cost-effective PV installation.

Figure 5 Solar Panel Placement of Admin Block

Figure 5 through Figure 7 portray the area and locations of the modelled solar panels on each building. The modelled areas for lines of solar panels can be seen in blue. The area has a constant Total Solar Resource Fraction or the amount of sunlight each panel would receive over the year.

Figure 6 Solar Panel Placement for The Layman E Scott Block

Figure 7 Solar Panel Placement for the Hon. Sybil McLaughin Block

The modelling analysis was conducted through Helioscope, a solar simulation tool from the Folsom Labs. Based on our simulation, a relatively small rooftop PV array might be feasible. We estimate that the available space might support up to a 150 kW solar array. Such an array might produce up 155,763 kWh per year, which could save the college up to $38,941 per year in electric purchases. Based on average costs for commercial solar installation and current CUC prices, such an installation might pay for itself in energy savings in 8 years. The available roof space needs to be properly accessed by a qualified solar installer to determine feasibility. A structural analysis of the roof may be necessary as well. Roof conditions might make available roof space smaller than we assumed, or too costly to develop, which might make a solar array not economically viable for the site.

Intelligent Building Management System Measures

Energy efficiency is one of the many benefits of incorporating IoT into buildings. IoT ecosystem includes sensors, actuators, cloud-based software and communication protocols, layered and controlled by a central building management system (BMS) that helps optimize systems, allowing them to communicate with each other and work together.

IoT ecosystem is comprised of these components:

- Devices for monitoring and controlling energy use, which ideally identify areas of high consumption, actively control energy usage and indirectly control consumption based on factors such as occupancy, time of day, or other factors
- Location-based automatic controls that optimize controls in specific rooms or sections of a building, often in relation to time-based patterns, occupancy, weather or a variety of other factors
- Cloud-computing platforms that store data and run software, such as data analytics software that evaluates data
- Software applications that implement programmed energy efficiency strategies, such as integration software that interprets and communicates data between systems

Using IoT, energy efficiency is driven by automation. With data gathered by smart sensors, a BMS can turn off lights in unoccupied rooms, reduce airflow in office buildings on weekends, or automatically close blinds when windows are exposed to direct sunlight.

Energy-Saving IoT Devices

As physical hardware, IoT devices can be used to create greater energy efficiency throughout a building's systems.

These IoT devices include:

Lighting Controls

Lighting controls are comprised of both sensors and actuators that control lighting through the use of IoT. Energy efficiency results from lowering lighting output based on certain conditions. In a recent literature review focusing on lighting and controls in office environments that use IoT, energy efficiency estimates ranged widely. Results depended upon occupant behavior, control system type, patterns of activity, and other conditions. They showed between 17-94% savings from smart controls over manually controlled systems.

Daylight Sensors

These use photocells to turn off or dim lighting based on the amount of available natural light. These photosensors can also be used to raise or lower blinds to optimize lighting. They typically achieve savings of more than 40%.

Occupancy Sensors

Sensors that automatically turn on or off lights based on whether a room is occupied use infrared or ultrasonic technology, and can also be used for managing heating and cooling as well. Occupancy sensors generated from 3-60% in savings when used in lighting systems. Another study saw a 20% reduction in energy use from such sensors in HVAC systems.

HVAC Controllers

HVAC controllers using IoT technology could reduce energy use by 24%, according to a 2011 study by Pacific Northwest National Laboratory (PNNL). Sensors measure various conditions within a building, using this data to regulate output within climate control systems. Smart controllers typically use predefined set points to determine actions and can be deployed at certain key points or throughout a building. Some more advanced sensors and controls implement machine learning (ML) algorithms to enact real-time changes.

HVAC Economizer Controls

Pulling in cool outside air to reduce the need for electrical cooling, economizers use sensors to measure either air temperature or heat and humidity to determine actions based on energy efficiency and occupant comfort. Economizers generate 57% energy savings on average, but savings can range from 22-90% depending on a variety of conditions.

Smart Thermostats

These enable remote monitoring and control of temperature within built environments. More advanced models can automatically provide analytics on energy usage that include reports showing amounts saved on a monthly basis. Two independent studies that looked at a top manufacturer of smart thermostats reported that customers saved 15% on cooling and 10-12% on heating on average.

Variable Speed Drives

These are also known as adjustable speed drives, AC drives, inverter adjustable frequency drives, or variable frequency drives. In older buildings, fans in HVAC systems normally operate on a single speed, using dampers, throttles, and valves to control airflow. As these fans only operate at full speed, this results in significant energy wastage. Variable speed drives allow fans to operate at higher or lower speeds, according to the energy needed. Typically, variable speed drives reduce energy usage for heating and cooling in buildings between 24-35%. However, a 2017 study by the American Council for an Energy-Efficient Economy (ACEEE) estimated energy use savings between 15–50% from such controls.

Sensors for Predictive Building Maintenance

Networks of IoT sensors that are connected to building systems, equipment, and other infrastructure help optimize building performance and save on energy costs. However, lowering energy expenses is just one way they promote efficiency. By proactively identifying issues before they become problems, facility managers are also able to get ahead of maintenance and avoid catastrophic system failures.

IoT sensors used to deal with maintenance issues include:

- Early fault detection sensors that alert when unseen issues show a fault is imminent
- Failure detection sensors that detect faults and disable machinery to prevent wider failures, which helps prevent injuries and downtime

While predictive maintenance offers energy efficiency indirectly, it creates savings in other areas.

According to the US Department of Energy (DOE), predictive maintenance:

- Cuts downtime by 35-40%
- Decreases breakdowns by 70-75%
- Increases productivity by 20-25%
- Offers ten times the return on investment
- Reduces maintenance costs by 25-30%

Some IoT technology can detect structural damage by measuring strain and cracks at key points. More directly, sensors used in predictive maintenance detect maintenance issues in energy-sucking systems like HVAC and lighting, reducing costs by keeping these systems working optimally.

Smart Meters

When it comes to IoT, energy efficiency in buildings is built upon metering and monitoring. Smart meters are an essential tool in tracking energy use, generally offering immediate savings of about 10%. Over time, smart meters can deliver as much as 30 percent savings when utilized properly. Smart electric submeters can also track energy consumption according to tenants, systems, or even individual plugs. Submeters additionally help identify anomalies that indicate possible maintenance issues affecting energy consumption.

Energy Efficient Best Practices

A facility energy performance can also be improved through application of many low cost or no-cost energy efficiency strategies. By employing certain behavioral and operational changes and performing routine maintenance on building systems, equipment lifetime can be extended; occupant comfort, health and safety can be improved; and energy and O&M costs can be reduced. The recommendations below are provided as a framework for developing a whole building maintenance plan that is customized to your facility. Consult with qualified equipment specialists for details on proper maintenance and system operation.

Energy Tracking with ENERGY STAR® Portfolio Manager®

You've heard it before - you can't manage what you don't measure. ENERGY STAR® Portfolio Manager® is an online tool that you can use to measure and track energy and water consumption, as well as greenhouse gas emissions 5. Your account has already been established. Now you can continue to keep tabs on your energy performance every month.

Reduce Air Leakage

Air leakage, or infiltration, occurs when outside air enters a building uncontrollably through cracks and openings. Properly sealing such cracks and openings can significantly reduce heating and cooling costs, improve building durability, and create a healthier indoor environment. This includes caulking or installing weather stripping around leaky doors and windows allowing for better control of indoor air quality through controlled ventilation.

Close Doors and Windows

Ensure doors and windows are closed in conditioned spaces. Leaving doors and windows open leads to a significant increase in heat transfer between conditioned spaces and the outside air. Reducing a facility's air changes per hour (ACH) can lead to increased occupant comfort as well as significant heating and cooling savings, especially when combined with proper HVAC controls and adequate ventilation.

Ensure Lighting Controls Are Operating Properly

Lighting controls are very cost effective energy efficient devices, when installed and operating correctly. As part of a lighting maintenance schedule, lighting controls should be tested annually to ensure proper functioning. For occupancy sensors, this requires triggering the sensor and verifying that the sensor's timer settings are correct. For daylight sensors, maintenance involves cleaning of sensor lenses and confirming setpoints and sensitivity are appropriately configured.

Reduce Motor Short Cycling

Frequent stopping and starting of motors subjects rotors and other parts to substantial stress. This can result in component wear, reducing efficiency, and increasing maintenance costs. Adjust the load on the motor to limit the amount of unnecessary stopping and starting to improve motor performance.

Perform Routine Motor Maintenance

Motors consist of many moving parts whose collective degradation can contribute to a significant loss of motor efficiency. In order to prevent damage to motor components, routine maintenance should be performed. This maintenance consists of cleaning surfaces and ventilation openings on motors to prevent overheating, lubricating moving parts to reduce friction, inspecting belts and pulleys for wear and to ensure they are at proper alignment and tension, and cleaning and lubricating bearings. Consult a licensed technician to assess these and other motor maintenance strategies.

Practice Proper Use of Thermostat Schedules and Temperature Resets

Ensure thermostats are correctly set back. By employing proper set back temperatures and schedules, facility heating and cooling costs can be reduced dramatically during periods of low or no occupancy. As such, thermostats should be programmed for a setback of 5-10°F during low occupancy hours (reduce heating setpoints and increase cooling setpoints). Cooling load can be reduced further by increasing the facility's occupied setpoint temperature. In general, during the cooling season, thermostats should be set as high as possible without sacrificing occupant comfort.

Ensure Economizers are Functioning Properly

Economizers, when properly configured, can be used to significantly reduce mechanical cooling. However, if the outdoor thermostat or enthalpy control is malfunctioning or the damper is stuck or improperly adjusted, benefits from the economizer may not be fully realized. As such, periodic inspection and maintenance is required to ensure proper operation. This maintenance should be scheduled with maintenance of the facility's air conditioning system and should include proper setting of the outdoor thermostat/enthalpy control, inspection of control and damper operation, lubrication of damper connections, and adjustment of minimum damper position. A malfunctioning economizer can significantly increase the amount of heating and mechanical cooling required by introducing excess amounts of cold or hot outside air.

Check for and Seal Duct Leakage

Duct leakage in commercial buildings typically accounts for 5% to 25% of the supply airflow. In the case of rooftop air handlers, duct leakage can occur to the outside of the building, significantly increasing cooling and heating costs. By sealing sources of leakage, cooling, heating, and ventilation energy use can be reduced significantly, depending on the severity of air leakage

Perform Proper Water Heater Maintenance

At least once a year, drain a few gallons out of the water heater using the drain valve. If there is a lot of sediment or debris, then a full flush is recommended. Turn the temperature down and then completely drain the tank. Once a year check for any leaks or heavy corrosion on the pipes and valves. For gas water heaters, check the draft hood and make sure it is placed properly, with a few inches of air space between the tank and where it connects to the vent. Look for any corrosion or wear on the gas line and on the piping. If you noticed any black residue, soot or charred metal, this is a sign you may be having combustion issues and you should have the unit serviced by a professional. For electric water heaters, look for any signs of leaking such as rust streaks or residue around the upper and lower panels covering the electrical components on the tank. For water heaters over three to four years old have a technician inspect the sacrificial anode annually.

Plug Load Controls

There are a variety of ways to limit the energy use of plug loads including increasing occupant awareness, removing under-utilized equipment, installing hardware controls, and using software controls. Some control steps to take are to enable the most aggressive power settings on existing devices or install load sensing or occupancy sensing (advanced) power strips. For additional information refer to "Plug Load Best Practices Guide" http://www.advancedbuildings.net/plug-load-best-practices-guide-offices.

Replace Computer Monitors

Replacing old computer monitors or displays with efficient monitors will reduce energy use. ENERGY STAR® rated monitors have specific requirements for on mode power consumption as well as idle and sleep mode power. According to the ENERGY STAR® website monitors that have earned the ENERGY STAR® label are 25% more efficient than standard monitors.

Water Conservation

Installing low-flow faucets or faucet aerators, low-flow showerheads, and kitchen sink pre-rinse spray valves saves both energy and water. These devices save energy by reducing the overall amount of hot water used hence reducing the energy used to heat the water. The flow ratings for EPA WaterSense™ (http://www3.epa.gov/watersense/products) labeled devices are 1.5 gallons per minute (gpm) for bathroom faucets, 2.0 gpm for showerheads, and 1.28 gpm for pre-rinse spray valves. Installing dual flush or low-flow toilets and low-flow or waterless urinals are additional ways to reduce the sites water use, however, these devices do not provide energy savings at the site level. Any reduction in water use does however ultimately reduce grid level electricity use since a significant amount of electricity is used to deliver water from reservoirs to end users. The EPA WaterSense™ ratings for urinals is 0.5 gallons per flush (gpf) and toilets that use as little as 1.28 gpf (this is lower than the current 1.6 gpf federal standard).

Appendix – A

3D MODEL IMAGES

Figure 8 : South Elevation

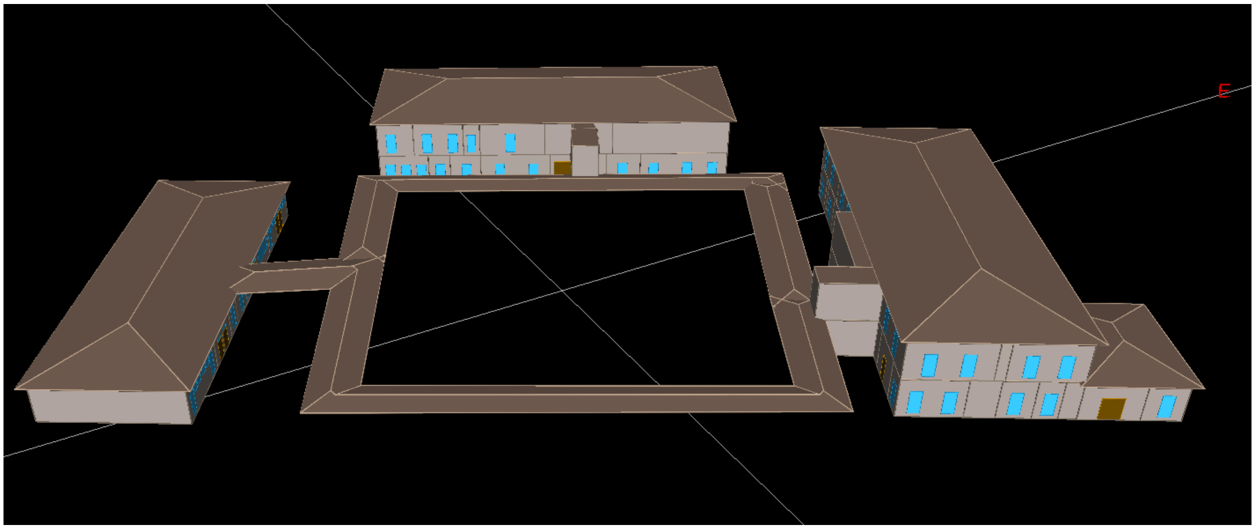


Figure 9: East Elevation

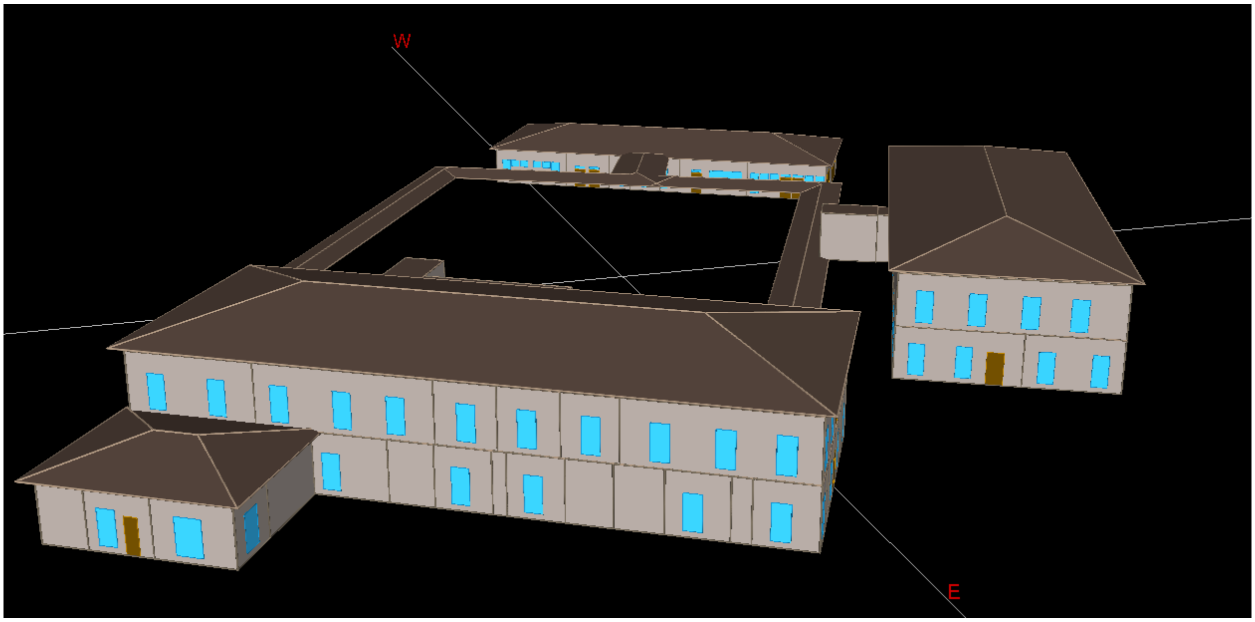


Figure 10: North Elevation

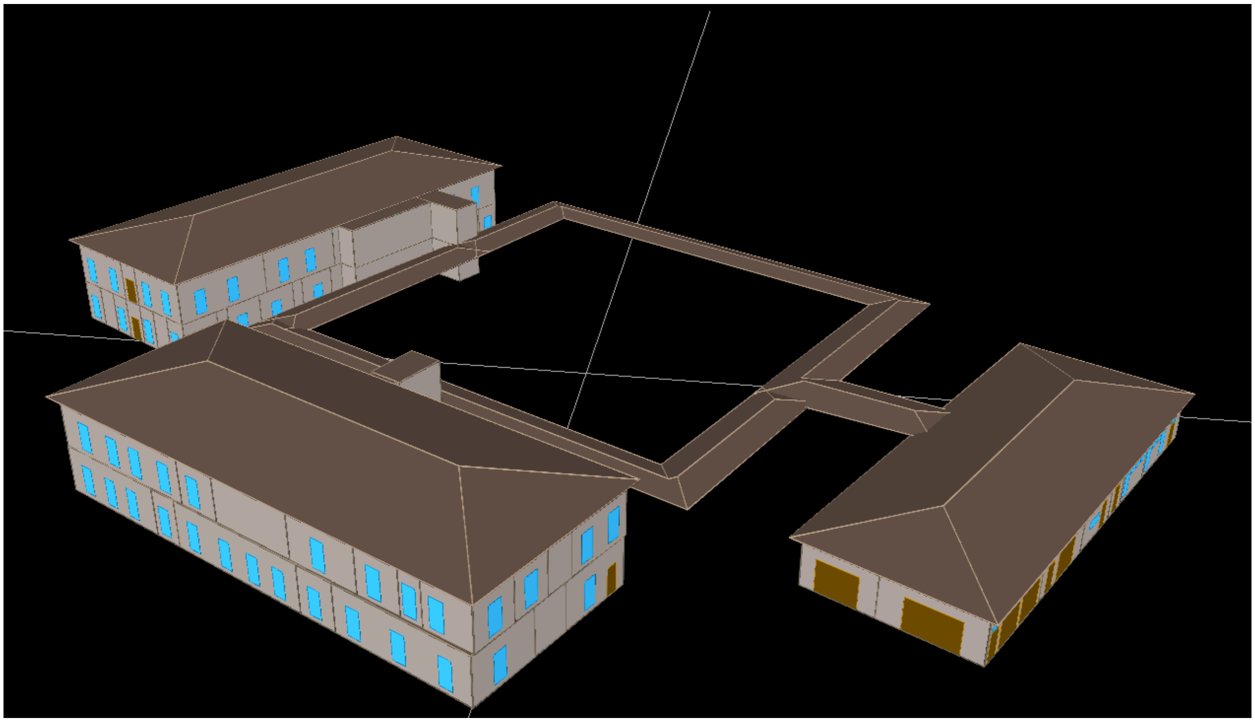
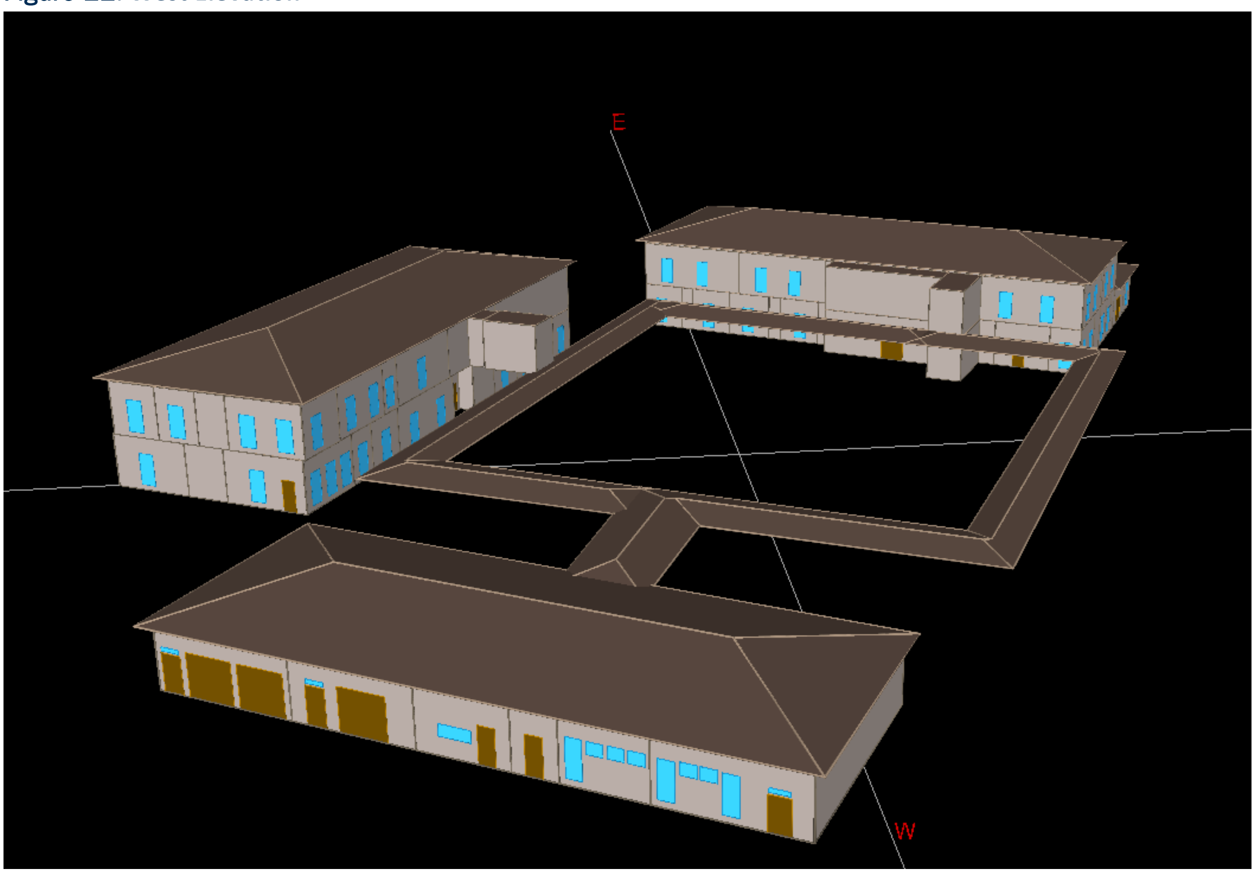


Figure 11: West Elevation



Appendix - B

ENERGY MODEL INPUTS AND REFERENCE

Table 12: Input parameters

Building Information	
Project Name	Hon. Benson Ebank Block + Sybil McLaughing block + Laymen E Scott block
Client Name	Dr. Robert Robertson
Site Address	168 Olympic Way, PO Box 702 Grand Cayman,KY1-1107, Cayman Islands
Construction year	2004
Building typology	University
No. stories	One Story, two stories
Built-up area (sq. ft)	30,295
Utility Data	
Billed Electricity Consumption (kWh)	371,767
Reference	
Weather file	CYM_SI_Grand.Cayman-East.End.783830_TMYx.2007-2021.BIN
Schedule (Refer "to schedule" sheet)	Default schedule of University/School by NREL
Exterior wall U-Value (Btu/h-ft2-F)	0.58 (ASHRAE 2004)
Roof U-Value (Btu/h-ft2-F)	0.034 (ASHRAE 2004)
Glass U-value (Btu/h-ft2-F)	1.47
SC & VLT of glass	SC:0.60 & VLT: 0.8
Window/Glass	With Blinder
Occupancy	370 persons in total
Lighting Load	
LPD (W/sq. ft./kW)	0.53 W/Sq. ft. (as measured at site)
Equipment Load	
EPD (W/sq. ft./kW)	1.63 W/Sq. ft. (as measured at site)
Cooling System	
Type of cooling system	Mini-Split-Unit
EER /COP	AS per HVAC Sheet

ASHRAE EPIDEMIC TASK FORCE

ASHRAE EPIDEMIC TASK FORCE

Core Recommendations for Reducing Airborne Infectious Aerosol Exposure

The following recommendations are the basis for the detailed guidance issued by ASHRAE Epidemic Task Force. They are based on the concept that within limits ventilation, filtration, and air cleaners can be deployed flexibly to achieve exposure reduction goals subject to constraints that may include comfort, energy use, and costs. This is done by setting targets for equivalent clean air supply rate and expressing the performance of filters, air cleaners, and other removal mechanisms in these terms.

1. *Public Health Guidance* – Follow all current regulatory and statutory requirements and recommendations, including vaccination, wearing of masks and other personal protective equipment, social distancing, administrative measures, circulation of occupants, hygiene, and sanitation.

2. *Ventilation, Filtration, Air Cleaning*
   2.1 Provide and maintain at least required minimum outdoor airflow rates for ventilation as specified by applicable codes and standards.
   2.2 Use combinations of filters and air cleaners that achieve MERV 13 or better levels of performance for air recirculated by HVAC systems.
   2.3 Only use air cleaners for which evidence of effectiveness and safety is clear.
   2.4 Select control options, including standalone filters and air cleaners, that provide desired exposure reduction while minimizing associated energy penalties.

3. *Air Distribution* - Where directional airflow is not specifically required, or not recommended as the result of a risk assessment, promote mixing of space air without causing strong air currents that increase direct transmission from person-to-person.

4. *HVAC System Operation*
   4.1 Maintain temperature and humidity design set points.
   4.2 Maintain equivalent clean air supply required for design occupancy whenever anyone is present in the space served by a system.
   4.3 When necessary to flush spaces between occupied periods, operate systems for a time required to achieve three air changes of equivalent clean air supply.
   4.4 Limit re-entry of contaminated air that may re-enter the building from energy recovery devices, outdoor air, and other sources to acceptable levels.

5. *System Commissioning – Verify that HVAC systems are functioning as designed.*

Figure 7: ASHRAE epidemic task force

Appendix - C

MONTHLY ECMS SAVING DETAILS

CALIBRATION RESULTS

Table 13: Calibrated Electricity Utility Details

Month	Billed Electricity (KWh)	eQuest Calibrated Electricity consumption (kWh)	ECM 1 Lighting Control (KWh)	ECM 2 Window Upgradation (KWh)	ECM 3A BMS - Night Setback (NSB) (KWH)	ECM 3B BMS - Fan Control (KWH)	ECM 3C BMS - Optimal On-Off (KWH)	ECM 3C BMS - Demand Control Ventilation (DCV) (KWH)	ECM 4 VFD Installation (KWH)	ECM 5 Condensing Unit Replacement (KWH)	ECM 6 Weatherization(KWH)	ECM 7 Solar PV(KWH) (150 KW)
Jan	31,022	28,079	26,708	26,969	24,495	27,082	27,185	27,630	26,524	27,859	23,515	16,392
Feb	24,387	20,996	20,006	20,130	18,232	19,536	20,360	20,643	19,875	20,835	17,569	11,518
Mar	21,507	19,576	18,747	18,485	16,897	17,200	18,974	19,207	18,523	19,433	16,336	10,393
Apr	24,413	26,081	25,042	24,681	22,146	21,587	25,221	25,306	24,536	25,896	21,001	13,762
May	27,670	32,690	31,525	31,240	27,587	25,955	34,139	31,473	30,619	32,462	26,121	18,064
Jun	34,716	39,723	38,299	38,270	33,450	31,871	38,328	38,050	37,062	39,443	31,351	23,669
Jul	41,019	38,573	37,254	36,903	33,212	29,753	37,328	36,816	35,859	38,302	30,459	22,682
Aug	38,611	42,919	41,518	41,551	36,906	33,977	41,347	41,051	39,804	42,614	33,867	25,455
Sep	35,591	37,123	35,866	35,865	31,881	29,543	35,730	35,483	34,403	36,858	29,299	22,193
Oct	30,593	36,592	35,243	35,363	30,937	30,389	35,216	35,272	34,007	36,322	29,090	22,955
Nov	32,869	30,791	29,410	29,701	26,136	27,775	29,818	30,039	28,848	30,558	25,102	19,366
Dec	29,368	23,256	22,087	22,334	20,294	22,138	22,623	22,860	22,060	23,079	19,406	14,187
Total	**371,767**	**376,399**	**361,705**	**361,492**	**322,173**	**316,806**	**366,269**	**363,830**	**352,120**	**373,661**	**303,116**	**220,636**
Saving on Baseline (KWh)		**(4,632)**	**14,694**	**14,907**	**118,137**	**54,226**	**10,130**	**12,569**	**24,279**	**2,738**	**73,283**	**155,763**
Saving on Baseline (%)			**4%**	**4%**	**31%**	**16%**	**14%**	**3%**	**6%**	**1%**	**19%**	**41%**

Appendix - D

LIGHTING POWER DENSITY (LPD) CALCULATION SHEET

Table 14: Lighting Power Density Calculation Sheet Laymen E Scott

Location	Floor	Equipment Type	Code	Qty	Lighting Control	Lamp Type	Lamp Label	Watts/Lamp	Lamps/Fixture	Total wattage	Area	LPD (W/ft2)
Studio	1	Fixture	LED-T8E-1L-4ft-2P	14	Wall Switch 1	LED - Linear Tubes	T8 Equiv	32	27	864	610	1.42
Library	1	Fixture	LED-22W-2L-D/I-SM-4P	4	Wall Switch 1	LED - Lamps	-	22	27	594	355	1.67
Office	1	Fixture	LF-T8-32W-3L-4ft-2P	9	Wall Switch 1	Linear Flourescent	T8	32	9	288	188	1.53
Electrical Workshop	1	Fixture	LED-Strip-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	Strip	20	36	720	617	1.17
Corridor	1	Fixture	LED-22W-2L-D/I-SM-4P	1	Wall Switch 1	LED - Lamps	-	22	6	132	117	1.13
Corridor	1	Fixture	LED	2	Wall Switch 1	LED - Fixtures	-	20	3	60	126	0.48
Facility	1	Fixture	LED-T8E-2L-4ft-2P	2	Wall Switch 1	LED - Linear Tubes	T8 Equiv	20	6	120	161	0.75
Nursing Lab	1	Fixture	LED-T8E-1L-4ft-2P	6	Wall Switch 1	LED - Linear Tubes	T8 Equiv	17	12	204	460	0.44
Restroom	1	Fixture	LF-T8-17W-2L-2ft-2P	1	Wall Switch 1	Linear Flourescent	T8	17	6	102	161	0.63
Library Storage	1	Fixture	LF-T12(e)-40W-3L-4ft-CV-SM-4P-IS	6	Wall Switch 1	Linear Flourescent	T12	40	9	360	283	1.27
Mechanical Workshop	1	Fixture	CFL-15W-1L	5	Wall Switch 1	CFL	-	15	42	630	1028	0.61

Table 15: Lighting Power Density Calculation Sheet Benson Lighting

Location	Floor	Equipment Type	Code	Qty	Lighting Control	Lamp Type	Lamp Label	Watts/Lamp	Lamps/Fixture	Total wattage	Area	LPD (W/ft2)
Asst director	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	117.2	0.34
Director	1	Fixture	LF-T8(m)-32W-2L-4ft-PR-RE-HW-IS	1	Wall Switch 1	Linear Flourescent	T8	32	2	64	117.2	0.55
Registration Manager office	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	83.5	0.48
Accounts	1	Fixture	LED-22W-2L-D/I-SM-HW	3	Wall Mounted Occupancy Sensor 1	LED - Lamps	-	22	2	132	117.2	1.13
Accounts	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	91.4	0.44
deputy manager	1	Fixture	LED-A2x2-20W	1	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	20	91.4	0.22
electronics lab (T8)	1	Fixture	LED-A2x4-40W-D/I-SM-HW	18	Bi-level Wall Switch 1	LED - Fixtures	Ambient 2x4	40	1	720	245.2	2.94
female bathroom	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	230.95	0.17
hospitality (T12)	1	Fixture	LED-22W-2L-D/I-SM-HW	10	Wall Switch 1	LED - Lamps	-	22	2	440	784	0.56
male bathroom	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	230.95	0.17
Ms Rene	1	Fixture	LF-T8(m)-32W-2L-4ft-PR-RE-HW-IS	1	Wall Switch 1	Linear Flourescent	T8	32	2	64	142.6	0.45
recruiting	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	117.2	0.34
Registration office	1	Fixture	LED-A2x2-20W	2	Wall Switch 2	LED - Fixtures	Ambient 2x2	20	1	40	142.6	0.28
Registration office	1	Fixture	LED-A2x4-40W-D/I-SM-HW	10	Wall Switch 1	LED - Fixtures	Ambient 2x4	40	1	400	142.6	2.81

small conference	1	Fixture	LED-A2x2-20W	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	40	250.3	0.16
Student life training	1	Fixture	LED-A2x4-40W-D/I-SM-HW	12	Wall Switch 1	LED - Fixtures	Ambient 2x4	40	1	480	91.4	5.25
T11 computer lab	1	Fixture	LED-22W-2L-D/I-SM-HW	1	Wall Switch 1	LED - Lamps	-	22	2	44	632.9	0.07
B038	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	1958.7	0.04
Deputy to President	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	234.3	0.38
IT office	2	Fixture	LED-A2x2-20W	1	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	20	103.9	0.19
Mr Paul	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	107.3	0.82
Mr Simon office	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	65.8	1.34
Mr Wright	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	107.3	0.82
Ms Singh	2	Fixture	LED-22W-2L-D/I-SM-HW	1	Wall Switch 1	LED - Lamps	-	22	2	44	142.6	0.31
Admissions Coordinator	2	Fixture	LED-22W-2L-D/I-SM-HW	1	Wall Switch 1	LED - Lamps	-	22	2	44	95.9	0.46
chief financial officer	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	228.9	0.38
Corner office	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	141.8	0.62
Hallway	2	Fixture	LED-22W-2L-D/I-SM-HW	14	Wall Switch 1	LED - Lamps	-	22	2	616	380	1.62
IT	2	Fixture	LED-22W-2L-D/I-SM-HW	1	Wall Switch 1	LED - Lamps	-	22	2	44	103.9	0.42
IT room	2	Fixture	LED-22W-2L-D/I-SM-HW	1	Wall Switch 1	LED - Lamps	-	22	2	44	103.9	0.42
Marketing	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	146.61	0.60
Kitchen	2	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	68.2	1.29

Office	2/ HR managers	Fixture	LED-A2x2-20W	1	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	20	127.8	0.16
male restroom	-	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	171.95	0.51
pres conference room	-	Fixture	LED-A2x2-20W	1	Wall Switch 1	LED - Fixtures	Ambient 2x2	20	1	20	351.4	0.06
president	-	Fixture	LED-22W-2L-D/I-SM-HW	2	Wall Switch 1	LED - Lamps	-	22	2	88	171.95	0.51

Table 16: Lighting Power Density Calculation Sheet Sybil McLaughlin Lighting

Location	Floor	Equipment Type	Code	Qty	Lighting Control	Lamp Type	Lamp Label	Watts/Lamp	Lamps/Fixture	Total wattage	Area	LPD (W/ft2)
Copy Room	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	2	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	88	160
Janitor	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
Main Corridor	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	6	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	264	518
Men’s	1	Fixture	LED-DNR-10W-1L-CA-RE-HW	2	Wall Switch 1	LED - Fixtures	Downlight Recessed	10	1	10	20	40
C0015	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	3	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	132	250
C002	1	Fixture	LED-T8E-22W-4L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	4	88	88	160

C003	1	Fixture	LED-T8E-22W-4L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	4	88	88	160
C004	1	Fixture	LED-T8E-22W-4L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	4	88	88	160
C005	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C006	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C007	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C008	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C009	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C010	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C011	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C012	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C013	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85

C014	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
C018-23	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	6	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	264	518
C036	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	2	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	88	160
C037-048	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	12	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	528	1036
Corridor 18-23	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	2	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	88	173
Director of teaching	1	Fixture	LED-A2x2-22W-2L-HW	3	Wall Switch 1	LED - Fixtures	Ambient 2x2	22	2	44	132	259
Faculty lounge	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	5	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	220	432
female bathroom	1	Fixture	LED-A2x2-22W-2L-HW	2	Tri-level Wall Switch 1	LED - Fixtures	Ambient 2x2	22	2	44	88	173
IT Department	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	8	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	352	691
ladies	1	Fixture	LED-DNR-10W-1L-CA-RE-HW	2	Wall Switch 1	LED - Fixtures	Downlight Recessed	10	1	10	20	40
male bathroom	1	Fixture	LED-T8E-1L-2ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	10	1	10	10	20

Mechanical C025	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
Restroom - Male	1	Fixture	LED-A2x2-22W-2L-HW	2	Wall Switch 1	LED - Fixtures	Ambient 2x2	22	2	44	88	150
Vestibule	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
B1	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B2	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B3	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B4	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B5	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B6	2	Fixture	LED-T8E-2L-4ft-2P	9	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	396	700
B7	2	Fixture	LED-T8E-2L-4ft-2P	12	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	528	900
female restroom	2	Fixture	LED-T8E-1L-2ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	1	22	22	40

female restroom	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	80
hallway	2	Fixture	LED-T8E-2L-4ft-2P	8	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	352	691
IT Room	2	Fixture	LED-T8E-2L-4ft-2P	4	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	176	346
janitor	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
male restroom	2	Fixture	LED-T8E-1L-2ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	1	22	22	45
male restroom	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
office	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
storage	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
Copy Room	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	2	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	88	160
Janitor	1	Fixture	LED-T8E-22W-2L-4ft-CV-RE-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	85
male restroom	2	Fixture	LED-T8E-1L-2ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	1	22	22	45

male restroom	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
office	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87
storage	2	Fixture	LED-T8E-2L-4ft-2P	1	Wall Switch 1	LED - Linear Tubes	T8 Equiv	22	2	44	44	87

EQUIPMENT LIST

Table 17: EPD list for Laymen E. Scott

Equipment Details Building B									
Floor	**Location**	**Equipment Type**	**Model number**	**Make**	**Qty**	**Power Consumption (W)**	**Total Power Consumption (W)**	**Area (ft2)**	**EPD(W/ft2)**
1	Studio	Computer		Apple	1	150	150	610	0.98
1	Studio	Computer		LG	1	150	150		
1	Studio	Computer		HP	1	150	150		
1	Studio	Printer		HP	1	150	150		
1	Nursing Lab	Television	UN75TU700F	Samsung	1	94	94	460	0.20
1	Library	Computers		Dell	2	150	300	586.4	1.02
1	Library	Printer		HP	2	150	300		
1	Office	Computer		HP	3	150	450	277.2	3.25
1	Office	Server			1	300	300		
1	Office	Printer		HP	1	150	150		
1	Restroom	Exhaust Fan			1	40	161	231	0.70
1	Electrical Workshop	Television	70up7070pue	LG	1	225	225	617	0.36
1	Mechnanical Workshop	Drill machine			1	746	746	1028	4.62

1	Mechnanical Workshop	Air conditioners			2	1000	2000		
1	Mechnanical Workshop	Compressors			2	1000	2000		

Table 18: EPD list for Benson Ebanks Block

Equipment Details Building A									
Floor	Location	Equipment Type	Model number	Make	Qty	Power Consumption (W)	Total Power Consumption (W)	Area (ft2)	EPD(W/ft2)
1	Open Office	Monitor			6	32	192	1427	1.67
	Open Office	CPU			6	160	960		
1	Open Office	IP telephone		Cisco	6	6.3	37.8		
1	Open Office	Water dispenser			1	3	3		
1	office room	Monitor			6	32	192		
1	office room	CPU			6	160	960		
1	office room	IP telephone		Cisco	6	6.3	37.8		
1	Classroom 2	Class room active panel	VTP2-75-4K	promethean	1	300	300	662.5	0.54
1	Classroom 2	LED TV			1	60	60		
1	Computer Room	Laptops		Lenovo	7	45	315	245.2	1.28
1	Faculty Room	Monitor			2	32	64	593.3	0.84
1	Faculty Room	CPU			2	160	320		
1	Faculty Room	Printer			2	50	100		
1	Faculty Room	IP telephone			2	6.3	12.6		
1	Faculty Room	Water dispenser			1	3	3		
1	Conference Room	LCD TV			1	120	120	250.3	0.49
1	Conference Room	IP telepone			1	3	3		
1	T12	LED TV			1	50	50	784	0.48
1	T12	Projector			1	327	327		

1	Computer Lab	Monitor			16	32	512	632.9	5.37
1	Computer Lab	CPU			16	160	2560		
1	Computer Lab	Projector			1	327	327		
2	Classroom	Projector	EB-X49 XGA	Epson	2	327	654	1958.7	0.33
2	Admissions coordinator	LCD Monitor	Latitude E7440	Dell	2	65	130	95.9	3.51
2	Admissions coordinator	IP telepone	7960G	Cisco	1	6.3	6.3		
2	Admissions coordinator	CPU	Vostro 420 Tower	Dell	1	200	200		
2	Assistant Registrar	IP telepone	7911	Cisco	1	12	12	95.9	3.57
2	Assistant Registrar	CPU	Vostro 420 Tower	Dell	1	200	200		
2	Assistant Registrar	LCD Monitor	Latitude E7440	Dell	2	65	130		
2	Employee Store room	Shredders	60 CP5	Intimus	1	550	550	103.9	5.29
2	Chief financial Officer	LED Monitor	HP24UH	HP	2	32	64	228.9	2.24
2	Chief financial Officer	CPU			1	200	200		
2	Chief financial Officer	IP telepone	7960G	Cisco	1	6.3	6.3		
2	Chief financial Officer	LED Monitor	HP24UH	HP	1	32	32		
2	Chief financial Officer	CPU	Pavilion 550-126	HP	1	160	160		
2	Chief financial Officer	Printer			1	50	50		
2	Assistant Accountant	CPU			1	200	200	107.3	4.48
2	Assistant Accountant	IP telepone	7960G	Cisco	1	6.3	6.3		
2	Assistant Accountant	LED Monitor			2	32	64		
2	Assistant Accountant	CPU			1	160	160		

2	Assistant Accountant	Printer			1	50	50		
2	Assistant Accountant 1	IP telepone	7960G	Cisco	1	6.3	6.3	65.8	4.26
2	Assistant Accountant 1	LED Monitor			2	32	64		
2	Assistant Accountant 1	CPU			1	160	160		
2	Assistant Accountant 1	Printer			1	50	50		
2	Deputy Registrar	IP telepone	7960G	Cisco	1	6.3	6.3	65.8	4.26
2	Deputy Registrar	LED Monitor			2	32	64		
2	Deputy Registrar	CPU			1	160	160		
2	Deputy Registrar	Printer			1	50	50		
2	Registrar	IP telepone	7960G	Cisco	1	6.3	6.3	142.6	1.97
2	Registrar	LED Monitor			2	32	64		
2	Registrar	CPU			1	160	160		
2	Registrar	Printer			1	50	50		
2	Ex. Ass. To the President	Shredders	60 CP5	Intimus	1	550	550	127.8	6.25
2	Ex. Ass. To the President	IP telepone	7960G	Cisco	1	6.3	6.3		
2	Ex. Ass. To the President	LED Monitor			1	32	32		
2	Ex. Ass. To the President	CPU			1	160	160		
2	Ex. Ass. To the President	Printer			1	50	50		
2	President	IP telepone	7960G	Cisco	1	6.3	6.3	234.3	1.20
2	President	LED Monitor			2	32	64		
2	President	CPU			1	160	160		
2	President	Printer			1	50	50		
2	President Conference Room	IP telepone			1	3	3	351.4	0.01

2	Corridor	Multifunctional Printer	3500I	Kyocera Taskalfa	1	1440	1440	341	5.54
2	Corridor	Comb binder	C210E	GBC	1	450	450		
2	Open office	Monitor			5	40	200	1037.38	1.03
2	Open office	CPU			5	160	800		
2	Open office	Printer			1	50	50		
2	Open office	IP telepone	7960G	Cisco	3	6.3	18.9		
2	Open office	Water dispenser			1	3	3		

Table 22: EPD list for Sybil McLaughlin Block

Equipment Details Building C									
Floor	**Location**	**Equipment Type**	**Model number**	**Make**	**Qty**	**Power Consumption (W)**	**Total Power Consumption (W)**	**Area (ft2)**	**EPD(W/ft2)**
1	Office (Typical)	Computer (typical)			1	150	150	150	2
1	Office (Typical)	Printer (typical)			1	150	150		
1	Lounge	Dishwasher	CG	Champion	1	3000	3000	668	6.59431138
1	Lounge	Microwave	MO1108SST	Avanti	1	1000	1000		
1	Lounge	Refrigerator	WRT318FMDW06	Whirlpool	1	105	105		
1	Lounge	Computers		Dell	2	150	300		
2	Class Room (Typical)	Television		Samsung	1	94	94	500	0.888
2	Class Room (Typical)	Projector		Optomo	1	300	300		
2	Class Room (Typical)	Speaker		Majority	1	50	50		
2	Computer Lab	Computer		Dell	15	150	2250	532	6.04323308
2	Computer Lab	Exhaust Fan			1	40	40		
2	Computer Lab	Television			1	225	225		
2	Computer Lab	Projector		Optomo	1	300	300		

2	Computer Lab	Printer		HP	1	150	150		
2	Computer Lab	3D Printer	I3mk3	Prusa	1	250	250		

HVAC SYSTEM LIST

Table 19: HVAC Sheet for Layman E Scott Block

Zone	System type	Model Number	Cooling Capacity	EER		Make	Year of Manufactured
Studio	Condensing Unit	CWI18CD	18000 BTU/hr	11	3.2	ComfortStar	NA
Nursing Lab	Condensing Unit	GMX160182HWE	18000 BTU/hr	12.8	3.75	Goodman	2021
Library	Condensing Unit	LM12C1	12,000 BTU/hr	10	2.9	Lennox	NA
Office	Condensing Unit	NA	NA	NA		NA	NA
Storage	Split DX	GSX160182cUE	18,000 BTU/hr	12.8	3.75	GOODMAN	2019
Corridor	Condensing Unit	NA	NA	NA		NA	NA
Mechanical Workshop	Condensing Unit	RA1636AJ1NA	36000 btu/HR	0		RHEEM	2020
0	0	NA	NA	NA		NA	NA
0	0	0	0	0		0	2018

Table 20: HVAC Sheet for Benson Ebanks Block

Zone	System type	Model Number	Quantity	Cooling Capacity	EER		Make	Year of Manufactured
Classroom	Condensing Unit	GSXC160601	4	60000 BTU/hr	12.8	3.75	Goodman	2019
Classroom	Condensing Unit	RA1460CJNARA14	2	60000 BTU/hr	12.8	3.75	Goodman	-

Table 21: HVAC Sheet for Sybil

Zone	System type	Model Number	Cooling Capacity	EER	Make	Year of Manufactured
Classroom B1	Condensing Unit	LI024C0-210P432	22000	16	Lennox	NA
Classroom B2	Condensing Unit	LI024C0-210P432	22,000	11.73719	Lennox	2021
Classroom B3	Condensing Unit	LI024CI-170P432	22000	10.91968	Lennox	NA
Director house	Split DX	RGWI-CW18C2AR	18,000 BTU/hr	12.8	Rheem	2019
IT ROOM	Condensing Unit	GSX160601FF	60000	16	Goodman	2019
Offices	Condensing Unit	GSX160601FF	60000	16	GOODMAN	2020

Appendix – E

ESTIMATED COSTING PER ECMS

Table 26: Estimation Project Cost Details

S N	ECM			Total (Material + Labor)
1	**Lighting Controls**	**Unit**	**Quantity**	**$6,649**
	Daylighting Sensor	Each	39	$4.036
	Occupancy Sensor	Each	34	$2,613
2	**Window Upgrade**			**$32,434**
	New Glass Window	Area (ft^2)	3,012	$32,434
3A	**BMS – Night Setback (NSB)**			**$40,056**
	Control Software	Points	39	$2,338
	Start-up Labor / hr.	EA	4	$600
	Controller , 128 Point	EA	2	$133
	Communications Cable/ LF	EA	390	$1,747
	Space Temperature	EA	39	$12,911
	Space Humidity	EA	39	$22,327
3B	**BMS – Fan Schedule**			**$18,030**
	Control Software	Points	39	$2,338
	Start-up Labor / hr	EA	6	$900
	Controller , 128 Point	EA	2	$133
	Communications Cable/ LF	EA	390	$1,747
	Space Temperature	EA	39	$12,911
3C	**BMS – Optimal On-Off**			**$4,819**
	Control Software	Points	39	$2,338
	Start-up Labor / hr	EA	4	$600
	Controller , 128 Point	EA	2	$133
	Communications Cable/ LF	EA	390	$1,747
3D	**BMS-Demand Control Ventilation (DCV)**			**$6,489**
	CO2 Sensor	EA	12	$3,098

	Motorised Damper , 12" x 12"	EA	12	$3,101
	Control Software	Points	12	$290
4	**VFD Installation**			**$5,524**
	Motors , 1.15 service factor	KW	2	$1,828
	VFD	KW	2	$1,460
	Panel for VFD	EA	1	$2,236
5	Condensing Unit Replacement			$2,375
	Condenser unit	EA	1	$1,700
	Refrigerant Pipe	Ft	75	$675
6	**Weatherization**			**$327,592**
	Air Sealing	SqFt	3,012	$2,614
	Wall Insulation (R-5.7)	SqFt	21,016	$45,899
7	**Solar PV Installation**			**$327,592**
	Solar Panels - Hanwha Q Cell Q.Peak DUO XL -G10.3/BFG (485W)	KW	160.9	$327,592

NEWYORK ENGINEERS

Grand Cayman Campus –

The Hon. Benson Ebanks Block (Administration Building), The Layman E. Scott Block, The Hon. Sybil McLaughin Block,168 Olympic Way, PO Box 702 Grand Cayman, Cayman Islands KY1-1107