Memorandum

To: Tony Turner, Chairman
Greenwich Central Middle School
Building Committee
Havemeyer Building
290 Greenwich Ave
Greenwich, CT 06830

From: Kemp A. Morhardt, AIA
Principal

Date: January 26, 2024

Subject: Central Middle School (CMS) – Connecticut High Performance Building Standards Summary

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The purpose of this memorandum is to provide the Building Committee with a summary of the CMS project's sustainable design initiatives/features related to Connecticut High Performance Building Standards (CT HPBS). Additionally, our team focused on modeled energy performance as it relates to Connecticut State Building Code (CSBC) energy performance requirements and how that performance relates to CT HPBS.

The entire design team has worked diligently to develop a project that is sustainable and addresses the Town's conservation initiatives and desire to provide a high performing school building that integrates into the neighborhood setting. The driving force behind the proposed siting of the building and site design is to conserve as much of the natural beauty of the existing setting as possible, while addressing the requirements of the construction program set forth in the Educational Specifications, school security/safety guidelines, recommended pedestrian and traffic safety improvements and the site logistical considerations of constructing a new building on an operational school site. The design team has conducted several coordination sessions with town staff to discuss building siting, site design, public safety, drainage, sanitary, site utilities, preservation of existing old-growth trees and the implementation of the Planning & Zoning Commissions (PZC) new landscaping regulations to develop a design that will be an asset to the community and neighborhood in which it resides for the next 50-75 years.

Referencing the CT HPBS system, the design team has incorporated several sustainable design features into the project beginning with the 18 CT HPBS prerequisite initiatives and, at the completion of Design Development (DD), an additional 34 credits as follows in the six major categories. Please refer to the attached checklist for additional details.

- 18 pre-requisite credits as detailed in the attached checklist
- 8 Credits - Energy Efficiency and Renewable Energy (16a-38k-6(a))
- 6 Credits – Indoor Environment (16a-38k-6(b))
- 2 Credits – Water Efficiency (16a-38k-6(c))
- 6 Credits – Recycling, Reuse and Sustainability (16a-38k-6(d))
- 10 Credits – Site Selection and Development (16a-38k-6(e))
- 2 Credits – Operations and Procedures/ Innovation (16a-38k-6(f))

When established the CT HPBS system was based on LEED 2009, version 3. As a result, the CT HPBS equivalent LEED certification levels are: Silver 27 points (45%); Gold 33 points (56%); Platinum 42 pts (71%). Referencing this scale, with 34 points the CMS project satisfies the CT HPBS minimum requirement of 27 points and falls at the lower end of the range of LEED Gold equivalent (LEED 2009, V3).

Specific focus has been placed on the design of a thermally efficient building envelope and the inclusion of major building HVAC, electrical and plumbing systems that are energy efficient. Also included is a rooftop photovoltaic system to generate on-site energy in pursuit of the town's interest toward a zero-net-energy building.

An energy model was prepared to analyze the project's performance considering two metrics: Energy Use Intensity (EUI) and Annual Energy Cost (AEC). The modeled project performs better than the code baseline for both metrics and therefore the design satisfies both CSBC and CT HPBS requirements. Please review the attached Energy Analysis Report for more details.

The design team is pleased with the status of sustainable initiatives put into the design thus far. We welcome the opportunity for continued enhancement of the design with additional sustainable initiatives as we complete the final phase of design. Additionally, should the Building Committee make decisions to further reduce the buildings energy use intensity and carbon footprint through the selection of a non-fossil-fuel based central plant, our team is poised to assist in that endeavor.

Enclosures:
1. CT HPBS checklist, last update dated January 12, 2024 (2 pages).
2. Greenwich Central Middle School – Design Document Energy Analysis Report, dated January 24, 2024 (11 pages).

CTHPB Compliance Checklist- Schools- Greenwich Central Middle School - Greenwich, CT

Mandatory Requirements

YES	?	??	NO	Section	Summary Description	LEED
Y				16a-38k-3(a)	Building Commissioning	EAp1/EAc3
Y				16a-38k-3(b)	Integrated Design Process	IDc1
Y				16a-38k-3(c)	Base Energy Performance 21% Better Than Code	EAp2
Y				16a-38k-3(d)	ENERGY STAR Products	IDc1
Y				16a-38k-3(e)	Indoor Air Quality Management Plan	IEQc3.1
Y				16a-38k-3(f)	Water Efficiency	WEp1
Y				16a-38k-3(g)	Recycling of Materials	MRp1
Y				16a-38k-3(h)	Erosion and Sedimentation Control	SSp1
Y				16a-38k-3(i)	No Smoking Policy	IEQp2
Y				16a-38k-3(j)	Integrated Pest Management Plan	IDc1
Y				16a-38k-3(k)	CFC Refrigerant Ban or Phase-out Plan	EAp3
Y				16a-38k-3(l)	Minimum Ventilation	IEQp1
Y				16a-38k-5(a)	Acoustical Standards	IEQp3
Y				16a-38k-5(b)	Properly Locate Outside Air Intakes	IEQp1
Y				16a-38k-5(c)	Electronic Ignition on Natural Gas Equipment	IDc1
Y				16a-38k-5(d)	Use of Low VOC Products	IEQc4
Y				16a-38k-5(e)	Environmental Site Assessment	SSp2
Y				16a-38k-5(f)	HEPA Vacuuming	IDc1

Building Standard Options (A minimum of 28 of the following strategies must be implemented.)

YES	?	??	NO	Section	Summary Description	LEED
8	**2**	**0**	**1**	**ENERGY EFFICIENCY AND RENEWABLE ENERGY (16a-38k-6(a))**		
				At least one measure in subsection (a) must be selected		
1				16a-38k-6(a)(1)	Energy Performance 3.5% Better Than Code	EAc1
1				16a-38k-6(a)(2)	Energy Performance 7% Better Than Code	EAc1
1				16a-38k-6(a)(3)	Energy Performance 10.5% Better Than Code	EAc1
1				16a-38k-6(a)(4)	Energy Performance 14% Better Than Code	EAc1
1				16a-38k-6(a)(5)	Energy Performance 17.5% Better Than Code	EAc1
			1	16a-38k-6(a)(6)	Energy Performance 21% Better Than Code	EAc1
1				16a-38k-6(a)(7)	On-Site Renewable Energy – 3%	EAc2
1				16a-38k-6(a)(8)	On-Site Renewable Energy – 7%	EAc2
1				16a-38k-6(a)(9)	On-Site Renewable Energy – 10%	EAc2
	1			16a-38k-6(a)(10)	Purchase Renewable Energy	EAc6
	1			16a-38k-6(a)(11)	Energy Measurement and Verification Plan	EAc5
6	**5**	**1**	**1**	**INDOOR ENVIRONMENT (16a-38k-6(b))**		
				At least two measures in subsection (b) must be selected		
1				16a-38k-6(b)(1)	Install Permanent Indoor Air Monitoring Systems	IEQc1
			1	16a-38k-6(b)(2)	Provide Increased Outdoor Ventilation	IEQc2
1				16a-38k-6(b)(3)	Building Flushout	IEQc3.2
1				16a-38k-6(b)(4)	Composite Wood and Agrifiber Products	IEQc4.4
1				16a-38k-6(b)(5)	Individual Lighting Control	IEQc6.1
		1		16a-38k-6(b)(6)	Individual Thermal Comfort Control	IEQc6.2
	1			16a-38k-6(b)(7)	Building Occupant Survey	IEQc7.2
	1			16a-38k-6(b)(8)	Daylight Contribution	IEQc8.1
	1			16a-38k-6(b)(9)	Visual Gazing – Views to the Outdoor Environment	IEQc8.2
	1			16a-38k-6(b)(10)	Mold Prevention	IEQc10
1				16a-38k-6(b)(11)	Low VOC Furniture	IEQc4.5
1				16a-38k-6(b)(12)	Isolation of Chemical Use Areas	IEQc5
	1			16a-38k-6(b)(13)	Control of Particulates at Pedestrian Entryways	IEQc5

2	**0**	**0**	**0**	**WATER EFFICIENCY (16a-38k-6(c))**		
				At least one measure in subsection (c) must be selected		
1				16a-38k-6(c)(1)	Reduce Total Potable Water Usage by 30%	WEc3
			N/A	16a-38k-6(c)(2)	Reduce Water Consumption for Landscaping 50%	WEc1
1				16a-38k-6(c)(3)	Eliminate Potable Water Usage for Landscaping	WEc1
			N/A	16a-38k-6(c)(4)	Reduce Total Potable Water Usage by 50%	WEc2

YES	?	??	NO	Section	Summary Description	LEED
6	**1**	**1**	**5**	**RECYCLING, REUSE AND SUSTAINABILITY (16a-38k-6(d))**		
				At least one measure in subsection (d) must be selected		
			1	16a-38k-6(d)(1)	Maintain 75% of an Existing Building Structure	MRc1.1
			1	16a-38k-6(d)(2)	Maintain 95% of an Existing Building Structure	MRc1.1
			1	16a-38k-6(d)(3)	Re-use Existing Non-Structural Building Elements	MRc1.2
1				16a-38k-6(d)(4)	Recycle or Salvage 50% of Construction and Demolition Debris	MRc2
1				16a-38k-6(d)(5)	Recycle or Salvage 75% of Construction and Demolition Debris	MRc2
		1		16a-38k-6(d)(6)	Use 5% Refurbished, Salvaged, or Reused materials	MRc3
			1	16a-38k-6(d)(7)	Use 10% Refurbished, Salvaged, or Reused materials	MRc3
1				16a-38k-6(d)(8)	Use 10% Recycled Content Materials	MRc4
1				16a-38k-6(d)(9)	Use 20% Recycled Content Materials	MRc4
1				16a-38k-6(d)(10)	Use 10% Local Materials	MRc5
1				16a-38k-6(d)(11)	Use 20% Local Materials	MRc5
			1	16a-38k-6(d)(12)	Use Building Materials Made from Short Harvest Cycle Plants	MRc6
	1			16a-38k-6(d)(13)	Use Forest Stewardship Council (FSC) Certified Wood Products	MRc7
10	**1**	**1**	**3**	**SITE SELECTION AND DEVELOPMENT (16a-38k-6(e))**		
				At least two measures in subsection (e) must be selected		
			1	16a-38k-6(e)(1)	Re-develop a Local Site	SSc2
			1	16a-38k-6(e)(2)	Select a Site with Public Transportation Access	SSc4.1
1				16a-38k-6(e)(3)	Encourage Bicycle Transportation	SSc4.2
1				16a-38k-6(e)(4)	Encourage Low-Emission Vehicle Use with Preferred Parking	SSc4.3
		1		16a-38k-6(e)(5)	Encourage Car and Van-pooling	SSc4.4
	1			16a-38k-6(e)(6)	Protect Natural Areas at the Construction Site	SSc5.1
1				16a-38k-6(e)(7)	Maximize Open Space	SSc5.2
1				16a-38k-6(e)(8)	Implement a Stormwater Management Plan Reducing Run-off by Annual Rainfall 25%	SSc6.1
1				16a-38k-6(e)(9)	Implement a Stormwater Management Plan that Treats 90% of Annual Rainfall	SSc6.2
			1	16a-38k-6(e)(10)	Reduce Heat Island Effect Through Landscaping Strategies	SSc7.1
1				16a-38k-6(e)(11)	Select Roofing Materials to Reduce Heat Island Effect	SSc7.2
1				16a-38k-6(e)(12)	Reduce Outdoor Light Pollution	SSc8
1				16a-38k-6(e)(13)	Orient Building for Daylighting and Energy Performance	EAc1
1				16a-38k-6(e)(14)	No Building in Floodplain and Sustainable Site Development	SSc1
1				16a-38k-6(e)(15)	Site Building away from External Sources of Excessive Noise	IEQp3
2	**1**	**0**	**0**	**OPERATIONS AND PROCEDURES/ INNOVATION (16a-38k-6(f))**		
				No minimum requirement for measures in subsection (f)		
1				16a-38k-6(f)(1)	Eliminate the use of CFCs, HCFCs and Halons	EAc4
1				16a-38k-6(f)(2)	Building Innovation	IDc1
	1			16a-38k-6(f)(3)	Curriculum on Sustainable Building Features	IDc1
34	**10**	**3**	**10**	Total Building Standard Optional Strategies (27 Needed for Compliance)		

Greenwich Central Middle School

Design Document
Energy Analysis Report

Prepared for
The S/L/A/M Collaborative
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Prepared by
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January 24, 2024

Thornton Tomasetti

TABLE OF CONTENTS

01 EXECUTIVE SUMMARY

Greenwich Central Middle School is a new school with approximately 129,000 SF area located in Greenwich, CT. The building's primary program includes classrooms, specialty classrooms, offices and conference rooms; assembly spaces such as auditorium, cafeteria, media center, and gym; and supporting spaces such as corridor, storage, and mechanical rooms.

The project is targeting compliance with Connecticut High Performance Building Standards (CTHPBS) and the 2022 Connecticut State Building Code (CSBC). CSBC is based on 2021 International Energy Conservation Code (IECC 2021) with Connecticut amendments.

Thornton Tomasetti (TT) performed a whole building energy analysis to assess the proposed design performance.

The goals of this energy analysis are as follows:

- Evaluate the energy performance of the 100% Design Development project design, dated December 13, 2023
- Assess the current design's Energy Use Intensity (EUI)
- Estimate potential Photo-Voltaic (PV) production
- Compare the current design with CSBC baseline to evaluate compliance.
- Evaluate the current design with CTHPBS criteria and evaluate compliance.

Simulations were performed to determine the CSBC code baseline and proposed design's annual energy consumption and energy cost.

Energy cost saving was used to determine compliance with the CSBC energy requirement, the results show the following:

- **The proposed design shows an EUI of 37.6 kBtu/sf-yr** without PV and **18.8 kBtu/sf-yr** with PV contribution.
- The proposed design demonstrates **21.3%** cost savings with PV as compared to the CSBC code baseline. Therefore, the project is **compliant** with the CSBC energy requirements.
- According to the 2023 CTHPBS, the project shows compliance with the IECC 2021 (CSBC energy baseline), which satisfies the energy performance requirement. Therefore, this project is **compliant** with the CTHPBC energy requirement.

Note:

The annual energy consumption and energy cost are only applicable for comparative analysis with the CSBC baseline. They are not predictions of actual energy costs of the proposed design after construction. Actual cost will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, changes in energy rates, etc.

02 ASSUMPTIONS

The following provides a summary of the major components assumed in the energy analysis. More details of input assumptions have been provided in Appendix A at the end of this report.

Envelope

The Connecticut code baseline envelope has been modeled as per IECC 2021 C407.4 requirements.

A high performance envelope can reduce heating and cooling loads, providing a comfortable interior environment for occupants. The proposed design consists of a well-insulated envelope, including R-25.5 exterior wall, R-40 roof, double-pane glazing, and a window-to-wall ratio (WWR) of 26.6%.

Internal Gains

The occupancy, equipment were modeled with space-by-space method. The values for the occupancy and equipment were modeled the same for the CT code baseline and proposed design cases. For interior lighting, the lighting power density (LPD) was modeled with IECC 2021 maximum allowed value (0.72 W/sf) in the code baseline and 0.55 W/sf in the proposed design case. The proposed LPD is 23.6% better than the code compliant LPD.

Mechanical Systems

The HVAC systems in code baseline are selected by following the HVAC systems map per section C407.4.

In the proposed case, roof mounted dedicated outdoor air systems (DOAS) provides dehumidified ventilation air to classrooms (which are conditioned by chilled beams). Cafe, kitchen and gym are served by a dedicated packaged air source heat pump providing a mixture of outdoor air and return air to provide cooling, heating and ventilation. Data and electric room are cooled by split cooling only system.

Hot water and chilled water are provided by a high-efficiency gas-fired boiler and air-cooled chillers. Low temperature chilled water is provided to the air handling units for cooling while warmer chilled water is provided to the chilled beams to prevent condensation and sweating of the coils.

Domestic Hot Water

Domestic hot water (DHW) will be provided by gas-fired water heaters. Water will be heated up to 140°F to supply kitchen fixtures and custodial sinks, and 120°F to serve general use fixtures.

Utility Costs

Natural Gas Flat Rate	Electricity Flat Rate
1.2372 ($/Therm)	0.2695 ($/kWh)

03 ENERGY MODELING RESULTS

Energy Use Intensity (EUI) is a normalized metric that shows a building's annual energy use per square-foot. Connecticut Code baseline has a site EUI of 47.1 kBtu/sf-yr. The proposed design shows a site EUI of **37.6 kBtu/sf-yr**.

The building's roof has potential to fit approximately 400-550 kW (dc) of PV array. 400 kW of PV is estimated to produce 518 MWh of electricity per year, which is equivalent to 13.7 EUI and is estimated to supply 60% of the building's annual electricity energy use. 550 kW of PV is estimated to produce 712 MWh of electricity per year, which is equivalent to 18.8 EUI and is estimated to supply 83% of the building's annual electricity energy use. With 550 kW of PV array, the proposed EUI is reduced to **18.8 kBtu/sf-yr.** The EUI breakdown is shown as Figure 1.

Heating and cooling energy has been reduced with a high performance envelope, and the use of high efficiency boiler, chiller and energy recovery.

In addition, the overall lighting power density of the proposed design is 23.6% lower than the baseline, which contributes to significant energy savings.

Compliance with the CSBC energy requirement is based on energy cost saving. The energy cost savings are shown on this page in Figure 2.

The proposed design shows an 17.1% cost savings with respect to CT code baseline without PV. As per the requirement of C407.2, the reduction of energy cost of the proposed design associated with on-site renewable energy shall be no more than 5% of the total proposed energy cost. Therefore, with PV array, the annual energy costs for proposed design is reduced by 5% and the cost saving from code baseline is increased to **21.3%.**

The building design's energy performance exceeds the minimum energy requirement of CSBC and CTHPBS.

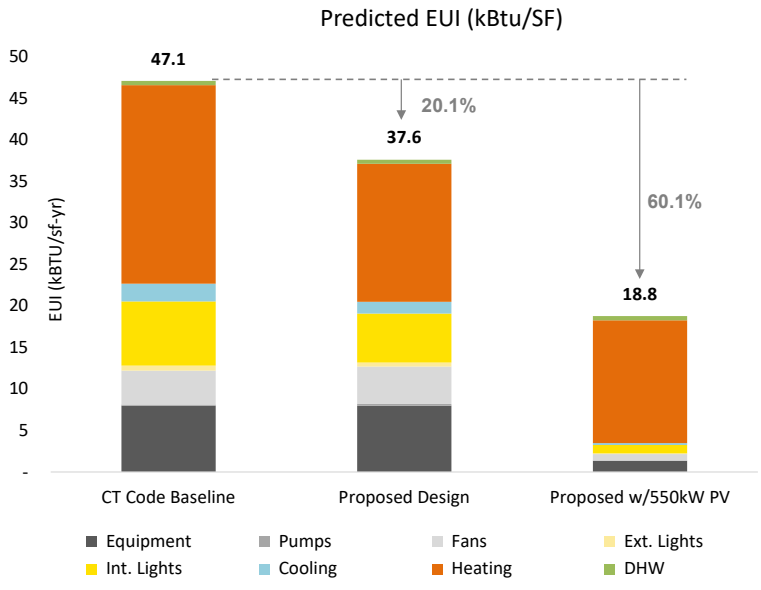

Fig 1. Annual Energy Use Intensity Breakdown

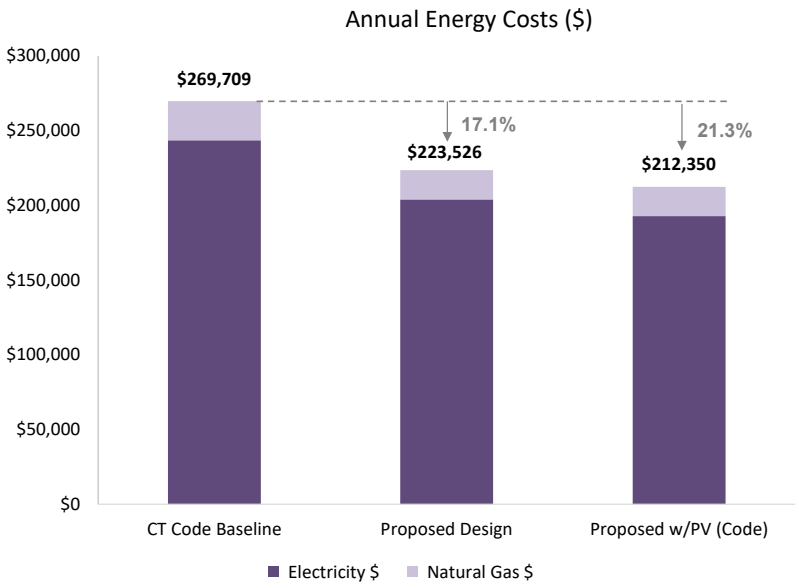

Fig 2. Annual Energy Cost Comparison

04 DISCUSSION & CONCLUSION

The building's roof has potential to fit approximately 400-550 kW (dc) of PV array. 550 kW of PV is estimated to produce 712 MWh of electricity per year, which is equivalent to 18.8 EUI. With 550 kW of PV panels, the proposed design achieves an EUI of **18.8 kBtu/sf-yr** and a cost saving of **21.3%** from CSBC baseline, which exceeds with CSBC energy requirement.

According to the 2023 CTHPBS, project shows compliance with the 2021 International Energy Conservation Code (CSBC energy baseline) satisfies the energy performance requirement. Therefore, this project **exceeds** the CTHPBC energy requirement.

APPENDIX A: ENERGY ANALYSIS INPUTS

General Information	
Weather File	Climate Zone: 5A USA_NY_White.Plains-Westchester.County.AP.72503 _TMY3
Utility Rates	Electricity: $0.2925/kWh; Gas: $1.24/Therm

Opaque Construction	CSBC Baseline	Proposed
Roofs Construction	R-30, U-0.032	R-40 assembly, U-0.025
Walls Construction	R-13+R-10 c.i., U-0.055	R-25.5 assembly, U-0.039
Slab-on-Grade Construction	R-15 for 24" below (F-0.52)	4' horizontally and 4' vertically around the perimeter frost walls and 3" insulation full height vertical insulation around the basement retaining walls (F-0.36)
Fenestration	**CSBC Baseline**	**Proposed**
Window to Wall Ratio	26.6%	26.6%
Glazing Properties (Assembly)	U-0.36, SHGC-0.38	Curtainwall: U-0.335, SHGC-0.227 Windows: U-0.307, SHGC - 0.242
Infiltration	**CSBC Baseline**	**Proposed**
Infiltration rate	0.4 cfm/sf @75Pa	0.4 cfm/sf @75Pa
Lighting (W/sf)	**CSBC Baseline**	**Proposed**
Whole building	0.72	0.55
Plug Loads (W/sf)	**CSBC Baseline**	**Proposed**
Cafe	0.1	Same as the Baseline
Classroom	0.65	
Corridor	0	
Data	10	
Gym	0.1	
Kitchen	7.5	
Library	0.5	
Mech	0.5	
Office	0.73	
RestRM	0	
Stairs	0	
Storage	0	

APPENDIX A: ENERGY ANALYSIS INPUTS

Occupancy (ppl/1000sf)	CSBC Baseline	Proposed
Cafe	100	Same as the Baseline
Classroom	35	
Corridor	0	
Data	0	
Gym	7	
Kitchen	20	
Library	10	
Mech	0	
Office	5	
RestRM	0	
Stairs	0	
Storage	0	
Airflow	**CSBC Baseline**	**Proposed**
Cafe	7.5 cfm/ppl + 0.18 cfm/sf	Same as the Baseline
Classroom	10 cfm/ppl + 0.12 cfm/sf	
Corridor	0 cfm/ppl + 0.06 cfm/sf	
Data	0 cfm/ppl + 0 cfm/sf	
Gym	20 cfm/ppl + 0.18 cfm/sf	
Kitchen	7.5 cfm/ppl + 0.12 cfm/sf + 0.7 cfm/sf exhaust	
Library	5 cfm/ppl + 0.12 cfm/sf	
Office	5 cfm/ppl + 0.06 cfm/sf	
RestRM	0 cfm/ppl + 0 cfm/sf	
Stairs	0 cfm/ppl + 0.06 cfm/sf	
Storage	10 cfm/ppl + 0.06 cfm/sf	
Mech	0 cfm/ppl + 0 cfm/sf	
Service Hot Water	**CSBC Baseline**	**Proposed**
HW Type	Gas-fired water heater	Gas-fired water heaters
Efficiency	80%	80%
DHW supply temp	140°F	140°F to kitchen fixtures; 120°F to general use fixtures
Pump control	Constant speed	Constant speed
Pump power	1/2 HP	1/2 HP

APPENDIX A: ENERGY ANALYSIS INPUTS

HVAC (Air-Side)	CSBC Baseline	Proposed
HVAC Type 1	Sys3 -PVAV w/ PFP boxes	DOAS
Serving Location	Classrooms	Classrooms
Cooling Source	DX Cooling, 9.5 EER	DX cooling (COP: 3.6)
Heating Source	Electric resistance, 100% Eff	DX heating (COP: 3.2)
Fan Power	AHU: 2.2 W/cfm; Fan Parallel Boxes: 0.35 W/cfm	2.2 W/cfm
Fan Control	AHU: Variable speed; Fan Parallel Boxes: Constant speed	Variable Speed
Energy Recovery	Total Energy Wheel - 50% efficiency	Total Energy Wheel - 78% sensible; 72% latent
DCV	No	Yes
Economizer	Fixed Dry-bulb 70°F	Fixed Dry-bulb 70°F
Supply air temp	AHU: 55-60°F; Reheat: 95°F	55 - 68°F warmest
HVAC Type 2	Chilled beams	Chilled beams
Serving Location	Classrooms	Classrooms
Cooling Source	CHW	CHW
Heating Source	HW	HW
Fan Control	Constant speed	Constant speed
Fan Power	0	0
Supply air temp	55°F	55°F
HVAC Type 3	Sys3 -PVAV w/ PFP boxes	RTU-1
Serving Location	Gym	Gym
Cooling Source	DX Cooling, 10 EER	DX Cooling (COP: 3.6)
Heating Source	Electric resistance, 100% Eff	DX Heating (COP: 3.2)
Economizer	Fixed Dry-bulb 70°F	Fixed Dry-bulb 70°F
DCV	No	No
Energy Recovery	Total Energy Wheel - 50% efficiency	Total Energy Wheel - 78% sensible; 72% latent
Fan Control	Variable speed	Variable speed
Fan Power	0.88 W/cfm	0.88 W/cfm
Supply air temp	55-95°F	55-95°F

APPENDIX A: ENERGY ANALYSIS INPUTS

HVAC (Air-Side)	CSBC Baseline	Proposed
HVAC Type 5	Sys3 -PVAV w/ PFP boxes	RTU-2
Serving Location	Cafe, kitchen	Cafe, kitchen
Cooling Source	DX Cooling, 10 EER	DX cooling (COP: 3.6)
Heating Source	Electric resistance, 100% Eff	DX heating (COP: 3.2)
Fan Power	0.88 W/cfm	0.88 W/cfm
Fan Control	Variable Speed	Variable Speed
Energy Recovery	Total Energy Wheel - 50% efficiency	Total Energy Wheel - 78% sensible; 72% latent
DCV	No	No
Economizer	Fixed Dry-bulb 70°F	Fixed Dry-bulb 70°F
Supply air temp	55 - 95°F	55 - 95°F
HVAC Type 6		Dedicated packed air source heat pump
Serving Location	-	Cafe
Cooling Source	-	DX Cooling (COP: 5)
Heating Source	-	DX Heating (COP: 3)
Fan Control	-	Variable speed
Fan Power	-	0.88 W/cfm
Energy recovery	-	Total Energy Wheel - 75% efficiency
DCV	-	Yes
Economizer	-	Fixed Dry-bulb 70°F
Supply air temp	-	55 - 105°F
HVAC Type 8	System 11 - Packaged rooftop air conditioner	Unit heaters
Serving Location	Stairs, storage	Stairs, storage
Heating Source	Gas Furnace (80% eff)	HW Loop
Cooling Source	DX Cooling (COP: 13 SEER)	N/A
Economizer	Yes	No
DCV	No	No
Energy Recovery	Total Energy Wheel - 50% efficiency	N/A
Fan Control	Constant speed	Constant speed
Fan Power	0 W/cfm	0 W/cfm
Supply air temp	95°F	95°F

APPENDIX A: ENERGY ANALYSIS INPUTS

HVAC (Air-Side)	CSBC Baseline	Proposed
HVAC Type 9	System 9 - Packaged rooftop heat pump	Ductless split units
Serving Location	Data, Tel, Security	Data, Tel, Security
Heating Source	DX heating (COP: 14.3 SEER)	DX heating (COP: 3.6)
Cooling Source	DX Cooling (COP: 13 SEER)	DX Cooling (COP: 3.9)
Economizer	Yes	N/A
DCV	N/A	N/A
Energy Recovery	N/A	N/A
Fan Control	Constant speed	Constant speed
Fan Power	1.3 W/cfm	1.3 W/cfm
Supply air temp	55°F - 105°F	55°F - 105°F
HVAC (Water-Side)	**CSBC Baseline**	**Proposed**
System Description	Gas-fired boiler + air-cooled chiller	Gas-fired boiler+air-cooled chiller
Efficiency	Boiler: 80% eff; Chiller: 10 EER	boiler: 96% eff; Chiller: COP 4
Chilled water supply temp	44°F	To ERU, AHU, FCU: 40°F; To chilled beams: 55°F;
Hot water supply temp	180°F	180°F
Temp Reset	Chilled water: 44/56°F Hot water: 130/180°F	Chilled water: 44/56°F Hot water: 130/180°F
Pump Control	Variable speed	Variable speed
Pump Power	Chiiled water loop: 7.5 W/gpm; Hot water loop: 7.5 W/gpm	Chiiled water loop: 7.5 W/gpm; Hot water loop: 7.5 W/gpm

ENERGY MODEL DISCLAIMER

The results from the energy model must be used for comparative evaluations of energy optimization measures with the assumptions indicated in this report. The results should not be construed as an absolute prediction of future building energy use as usage schedules, weather patterns and system functions may change during operation.