SOMERSET MIDDLE SCHOOL

Somerset, MA

Energy Conservation Report

Preliminary Report
14 December 2021
(based on 100% DD Set dated 11/12/2021)

PREPARED FOR

Ai3 Architects
526 Boston Post Rd
Wayland, MA
(508) 358-0790

PREPARED BY

Andelman and Lelek Engineering, Inc.
1408 Providence Highway
Norwood, MA 02062
(781) 769-8773

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EXECUTIVE SUMMARY

Andelman and Lelek Engineering, Inc. (ALE) was retained by Ai3 Architects to complete an energy performance analysis for the new Somerset Middle School in Somerset, MA. The main objective of the study was to create eQUEST models of the *proposed* building and of two *baseline* buildings, and to quantify the difference in annual energy consumption between the two models. The *baseline* buildings elements (building shell construction, mechanical systems performance, lighting system performance, etc.) are modeled to meet the requirements of ASHRAE Standard 90.1-2010 (LEED) and ASHRAE Standard 90.1-2016 with MA Amendments (MSBA).[1] This task was undertaken to evaluate the subject school building design in the context of energy efficiency requirements related to LEEDv4 certification and MSBA funding.

This is a report for the preliminary analysis conducted based on the 100% Design Development Set dated 11/12/2021 as well as emails and supplementary information received from Ai3 Architects. Because some information about the building's design is not yet finalized, ALE has made a number of assumptions during this analysis. Major assumptions are listed and explained in subsequent sections of this report. It must be stressed that any change in such assumptions can have a **dramatic** impact on the analysis results. The actual energy savings of the proposed building will therefore differ from the results presented in this report and will depend on design decisions that will be made and expressed in the final phases of construction documents preparation.

Two different sets of results are presented in this report:

- LEED analysis: Without accounting for renewable energy, the current *proposed* building achieves **28.5% energy cost savings** (36.1% site energy savings and 31.3% source energy savings) over a comparable *baseline* building that meets the requirements of ASHRAE Standard 90.1-2010. Table 1a on the following page shows the results of this study following ASHRAE 90.1-2010 Appendix G Methodology, as required by projects following LEED v4.
- MSBA analysis: Without accounting for renewable energy, the current *proposed* building achieves **29.7% site energy** (21.4% cost energy savings and 24.4% source energy savings) over a comparable *baseline* building that meets the requirements of ASHRAE 90.1-2016 with MA Amendments.[2] These results are summarized in Table 1b. The MSBA requires a minimum of 10% source energy savings for basic compliance and 20% source energy savings to be eligible to receive 2% additional reimbursement points.

The savings described in the bullet points above do not account for the project's potential renewable energy system. When information is available, renewable energy will be incorporated in the analysis.

For information on the facility and analysis methodology, please refer to subsequent sections of this report. In addition, the section *Energy Efficiency Measures Incorporated into Building Design* provides a brief description of energy conservation measures that are planned for or already incorporated into the design.

[1] MSBA: Massachusetts School Building Authority

[2] The MSBA *baseline* uses ASHRAE 90.1-2013 Appendix G methodology and ASHRAE 90.1-2016 with MA Amendments minimum requirements.

Table 1a – ASHRAE 90.1-2010 Appendix G Summary of Energy Consumption Comparison (LEED)

Performance Rating Table - Performance Rating Method Compliance

End Use	Regulated Load ? (Y/N)	Energy Type	Units of Annual Energy & Peak Demand		Baseline Design	Proposed	Percent Savings
Area Lights	Y	Electricity	Energy Use	kWh	258,726	117,667	54.5%
			Demand	kW	102	47	54.5%
Misc Equip	N	Electricity	Energy Use	kWh	258,170	258,170	0.0%
			Demand	kW	94	94	0.0%
Space Heating	Y	Electricity	Energy Use	kWh	0	10,610	-100.0%
			Demand	kW	0	7	-100.0%
Space Cooling	Y	Electricity	Energy Use	kWh	121,332	87,984	27.5%
			Demand	kW	215	188	12.6%
Pumps & Aux.	Y	Electricity	Energy Use	kWh	4,534	28,637	-531.6%
			Demand	kW	3	14	-409.0%
Vent Fans	Y	Electricity	Energy Use	kWh	263,416	152,076	42.3%
			Demand	kW	79	81	-2.2%
Domestic Hot Water	Y	Natural Gas	Energy Use	Therms	2,070	1,743	15.8%
			Demand	Therms/hr	1	1	14.3%
Exterior Usage	Y	Electricity	Energy Use	kWh	40,145	40,145	0.0%
			Demand	kW	13	13	0.0%
Misc Equip 2	N	Natural Gas	Energy Use	Therms	1,290	1,290	0.0%
			Demand	Therms/hr	2	2	0.0%
Space Heating 2	Y	Natural Gas	Energy Use	Therms	18,553	7,904	57.4%
			Demand	Therms/hr	33	16	52.1%
Total Site Energy Use (kBtu/year)					5,420,154	3,466,026	36.1%
Annual Process Energy (kBtu/year)					1,009,876	1,009,876	0.0%

Energy Cost and Consumption by Energy Type - Performance Rating Method Compliance

Energy Type			Baseline Design	Proposed	Percent Savings
Electricity	Usage	kWh	946,323	695,289	26.5%
	Cost	$	192,718	144,636	24.9%
	CO2	kg CO2/sf	5	4	26.5%
Natural Gas	Usage	Therms	21,913	10,937	50.1%
	Cost	$	32,962	16,696	49.3%
	CO2	kg CO2/sf	2	1	50.1%
Total Site Energy Use (kBtu/year)			5,420,154	3,466,026	**36.1%**
Total Energy Cost ($)			$225,680	$161,332	**28.5%**
Total CO2 Emissions (kg CO2 /sf)			7.1	4.7	**33.4%**

Table 1b – ASHRAE 90.1-2013 Appendix G Summary of Energy Consumption Comparison (Stretch)

Performance Rating Table - Performance Rating Method Compliance

End Use	Regulated Load ? (Y/N)	Energy Type	Units of Annual Energy & Peak Demand		Baseline Design	Proposed	Percent Savings
Area Lights	Y	Electricity	Energy Use	kWh	188,165	117,667	37.5%
			Demand	kW	102	47	54.5%
Misc Equip	N	Electricity	Energy Use	kWh	258,170	258,170	0.0%
			Demand	kW	94	94	0.0%
Space Heating	Y	Electricity	Energy Use	kWh	0	10,610	-100.0%
			Demand	kW	0	7	-100.0%
Space Cooling	Y	Electricity	Energy Use	kWh	113,368	87,984	22.4%
			Demand	kW	215	188	12.6%
Pumps & Aux.	Y	Electricity	Energy Use	kWh	4,378	28,637	-554.1%
			Demand	kW	3	14	-409.0%
Vent Fans	Y	Electricity	Energy Use	kWh	253,515	152,076	40.0%
			Demand	kW	79	81	-2.2%
Domestic Hot Water	Y	Natural Gas	Energy Use	Therms	2,070	1,743	15.8%
			Demand	Therms/hr	1	1	14.3%
Exterior Usage	Y	Electricity	Energy Use	kWh	40,145	40,145	0.0%
			Demand	kW	13	13	0.0%
Misc Equip 2	N	Natural Gas	Energy Use	Therms	1,290	1,290	0.0%
			Demand	Therms/hr	2	2	0.0%
Space Heating 2	Y	Natural Gas	Energy Use	Therms	16,689	7,904	52.6%
			Demand	Therms/hr	33	16	52.1%
Total Site Energy Use (kBtu/year)					4,931,512	3,466,026	29.7%
Annual Process Energy (kBtu/year)					1,009,876	1,009,876	0.0%

Energy Cost and Consumption by Energy Type - Performance Rating Method Compliance

Energy Type			Baseline Design	Proposed	Percent Savings
Electricity	Usage	kWh	857,741	695,289	18.9%
	Cost	$	175,200	144,636	17.4%
	CO2	kg CO2/sf	5	4	18.9%
Natural Gas	Usage	Therms	20,049	10,937	45.4%
	Cost	$	30,010	16,696	44.4%
	CO2	kg CO2/sf	2	1	45.4%
Total Site Energy Use (kBtu/year)			4,931,512	3,466,026	**29.7%**
Total Energy Cost ($)			$205,210	$161,332	**21.4%**
Total CO2 Emissions (kg CO2 /sf)			6.4	4.7	**26.7%**

FACILITY DESCRIPTION

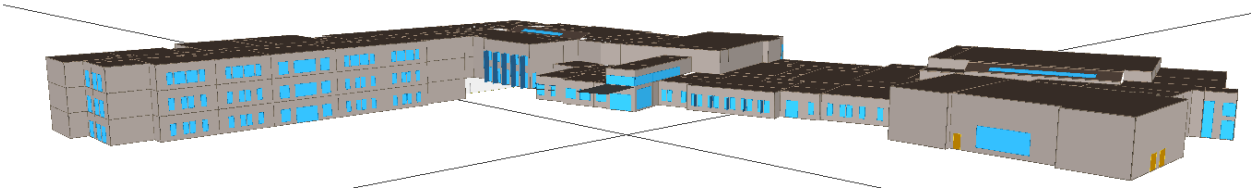


Figure 1: eQUEST model of Somerset Middle School

General

Somerset Middle School (SMS) is a new three-story school with a total area of approximately 124,000 sf. The building will serve approximately 600 students and 100 staff. The project will be located in Somerset, MA and will include classrooms (including tech/engineering classrooms), offices, a media center, a cafeteria, a kitchen, a gymnasium, an auditorium, and a variety of utility and support spaces. National Grid is the electric utility provider and Liberty Utilities is the natural gas provider for this project.

Architectural

Roof Construction:

Typical roof construction consists of PVC membrane roofing system with minimum 6" of continuous polyiso rigid insulation (R-30) and additional tapered insulation, for a total estimated assembly R-41.7. Estimated overall assembly U-value: U-0.023.

Exterior Wall Constructions:

Typical exterior wall construction consists of stone/Masonry veneer, ½" gypsum board, air/vapor membrane, 2" continuous nailbase insulation (minimum R-12.7), 5.5" batt insulation between 6" metal studs 16" o.c. (minimum R-21, minimum equivalent continuous R-7.4), 5/8" gypsum board. Estimated overall assembly U-value: U-0.046.

Vertical Fenestration:

Typical vertical fenestration assembly performance as follows:

Storefront: assembly U-0.35
Curtainwall: assembly U-0.32

The overall building vertical glazing area is currently estimated as 13,225 sf. The overall building window-to-wall ratio is currently estimated as 21%.

Internal Loads

Occupancy:

The modeled schedule of use of the building is based on discussions with Ai3 Architects and on information provided by the Town of Somerset.

	Regular School Year			
	Weekdays	Saturday	Sunday	Holiday
Admin/Office	6:30am – 4:30pm	Unoccupied	Unoccupied	Unoccupied
Auditorium	7:30am – 4:30pm	7:30am – 4:30pm	Unoccupied	Unoccupied
Cafeteria	7:30am – 1:00pm	Unoccupied	Unoccupied	Unoccupied
Classrooms	7:55am – 2:45 pm	Unoccupied	Unoccupied	Unoccupied
Gymnasium	7:30am – 9:00pm	8:00am – 2:00pm	8:00am – 2:00pm	Unoccupied
Kitchen	6:45am – 1:15pm	Unoccupied	Unoccupied	Unoccupied
Library	7:30am – 3:30pm	Unoccupied	Unoccupied	Unoccupied
	Summer Break			
	Weekdays	Saturday	Sunday	Holiday
Admin/Office	7:00am – 3:00pm	Unoccupied	Unoccupied	Unoccupied
Auditorium	8:00am – 4:00pm	8:00am – 4:00pm	8:00am – 4:00pm	Unoccupied
Cafeteria	Unoccupied	Unoccupied	Unoccupied	Unoccupied
Classrooms	8:00am – 1:00pm	Unoccupied	Unoccupied	Unoccupied
Gymnasium	8:00am – 4:00pm	8:00am – 4:00pm	8:00am – 4:00pm	Unoccupied
Kitchen	Unoccupied	Unoccupied	Unoccupied	Unoccupied
Library	8:00am – 1:00pm	Unoccupied	Unoccupied	Unoccupied
	Vacation Breaks			
	Weekdays	Saturday	Sunday	Holiday
Admin/Office	7:00am – 3:00pm	Unoccupied	Unoccupied	Unoccupied
Gymnasium	8:00am – 12:00pm	Unoccupied	Unoccupied	Unoccupied

*All other space types are assumed to be unoccupied during Vacation Breaks.

Interior Lighting System:

The whole building lighting power density (LPD) is currently *assumed* to be 0.45 W/sf based on conversations with the design team. In future iterations of the report, when the lighting design is more detailed, the whole building LPD will be updated to more closely reflect the proposed design.

Daylighting controls are currently assumed to be compliant with ASHRAE 90.1-2016 requirements.

Equipment Loads:

The current assumed equipment loads are as follows:

- 0.75 W/sf for classrooms
- 1.5 W/sf for offices, STEM classrooms
- 0.5 W/sf for gymnasium, cafeteria, and auditorium
- 30 kW (electric peak demand) and 350 MBH (natural gas) *assumed* for kitchen
- 0.2 W/sf for all other spaces, such as lobby, corridors, etc.
- 12 kW for electric and network rooms

Exterior Lighting System

The exterior lighting load is currently assumed to be 13 kW.

Mechanical Systems

The air-side mechanical design consists of several variable air volume (VAV) roof top units (RTUs) with hot water heating and chilled water-cooling coils. Larger spaces, like the gym, cafeteria, and auditorium, have dedicated roof top units.

Air-Side System Descriptions:

System	Service	Total supply airflow (cfm)	Total outdoor airflow (cfm)[3]	Assumptions
RTU-1	Classrooms	9,000	9,000	➢ 100% outside air (OA) VAV systems with HW/CHW coils ➢ 65% effective enthalpy recovery wheels ➢ Supply fan power 0.0008 kW/cfm ➢ Return fan power 0.0006 kW/cfm ➢ Fans scheduled to operate 6am to 4pm Monday through Friday during school year; 6am to 2pm during summer, and not at all during schedule breaks[4] ➢ System will cycle on with no OA (unless economizer) during scheduled unoccupied hours ➢ Cooling DAT will reset between 55°F and 65°F based on warmest zone calling for cooling ➢ 30°F delta T available for terminal reheat (via HW coil) ➢ Hot water baseboards in all perimeter zones ➢ Minimum zone flow is set to 30%
RTU-2	Classrooms	9,000	9,000	➢ Similar to RTU-1
RTU-3	Classrooms	9,000	9,000	➢ Similar to RTU-1
RTU-4	Classrooms	7,000	7,000	➢ Similar to RTU-1
RTU-5	Media	4,800	2,100	➢ Similar to RTU-1 except as noted below: ➢ Mixed air VAV system with HW/CHW coils ➢ Fans scheduled to operate 6am to 6pm Monday through Friday during school year; 6am to 2pm during summer, and not at all during schedule breaks
RTU-6	Cafeteria	12,000	4,000	➢ Similar to RTU-5 except as noted below ➢ Fans scheduled to operate 6am to 4pm Monday through Friday during school year; no operation (except to cycle on to maintain unoccupied setpoints) during summer and scheduled breaks ➢ DCV return sensor

[3] These values are approximations and assumptions and will be updated as the design progresses and further information becomes available.

[4] Please note, it is assumed that only classrooms on the first floor (lower level) will be used during summer.

System	Service	Total supply airflow (cfm)	Total outdoor airflow (cfm)[3]	Assumptions
RTU-7	Admin	4,300	1,200	➢ Similar to RTU-5 except as noted below ➢ Fans scheduled to operate 6am to 6pm Monday through Friday all year.
RTU-8	Admin	7,200	3,000	➢ Similar to RTU-7
RTU-9	Gym	13,000	3,650	➢ Similar to RTU-6 except as noted below ➢ Fans scheduled to operate 6am to 9pm Monday through Friday and 6am to 2pm weekends during school year; 7am to 4pm every day during summer; and 7am to 12pm during schedule breaks.
RTU-10	Lockers	4,000	4,000	➢ Similar to RTU-9 except as noted below ➢ Assumed 100% OA ➢ No cooling coil
RTU-11	Auditorium	13,500	2,300	➢ Similar to RTU-9 except as noted below ➢ Fans scheduled to operate 6am to 6pm Monday through Saturday during school year; 6am to 4pm daily during summer, and not at all during schedule breaks ➢ No exhaust air energy recovery wheel
RTU-12	Band/Chorus	2,400	1,600	➢ Similar to RTU-5
RTU-13	Gym Alt	2,200	1,400	➢ Similar to RTU-9

Network/ IDF/ Electric rooms are assumed to be served by split DX units. Vestibules, stairwells, and back of house spaces are served by either hot water or electric unit heaters.

Space Temperature Schedules:

The following table shows the assumed occupied/unoccupied heating and cooling temperature setpoints. The occupied/unoccupied hours are per the occupancy schedules described in the Internal Loads section.

Space Type	Occupied Heating	Occupied Cooling	Unoccupied Heating	Unoccupied Cooling
Classrooms/ Admin/ Gym/ Cafeteria	70°F	75°F	65°F	80°F
Kitchen/Vestibules	65°F	N/A	65°F	N/A
Network	N/A	85°F	N/A	85°F

Water-Side System Descriptions:

Chilled water for space cooling with be provided by a central chiller plant with one 290-ton air-cooled variable speed chiller. At standard AHRI rating conditions, the chiller's full load efficiency is 11.18 EER and the IPLV is 17.82 EER. The design chilled water supply temperature setpoint is *assumed* to be 44°F. The chilled water supply temperature setpoint is *assumed* to be reset based on outside air temperature as follows: 44°F at 91°F and above, reset linearly to 54°F at 60°F and below.

Hot water for space heating will be produced by a central boiler plant consisting of three natural gas-fired condensing boilers, each with 2,500 MBH input capacity and an *assumed* full load thermal efficiency of 95% at AHRI standard rating conditions. The design hot water supply temperature setpoint is 160°F. The hot water supply temperature setpoint is *assumed* to be reset based on outside air temperature as follows: 160°F at 0°F and below, reset linearly to 90°F at 65°F.

The hot water plant is assumed to be shut down during the warmer months.[5]

Limited information on the pumps for the chilled water and hot water systems was provided in the 100% DD set.

Domestic Hot Water Systems

The domestic hot water (DHW) loads included kitchen uses, lavatory sinks, and a few showers in the locker rooms and health instructors' offices.

The 100% DD drawings indicates that there will be two natural gas-fired water heaters with 130 gallons storage tanks with a minimum thermal efficiency of 96%.

The DHW load is assumed to be 1.0 gallons/person/day, using an assumed occupancy of 700 (600 students plus 100 faculty/staff).

Renewable Energy

It is our understanding that a PV system is under consideration; however, the contribution of PV is currently not included in the energy model.

Energy Use Intensity (EUI)

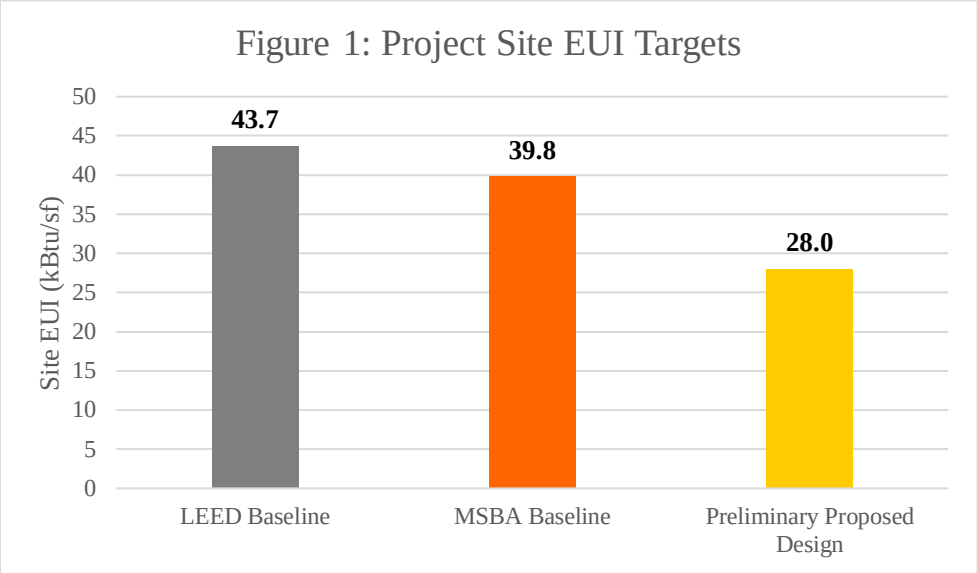
The table below describes the current estimated energy use intensity of the new Somerset Middle School building (124,000 sf). Please note that the table below does not include any contribution from renewable energy systems. Additionally, the site and source EUIs listed in the table below include exterior lighting loads; this is different from the Mass Save ZNE metric.

	Site EUI (kBtu/sf/yr)	Source EUI (kBtu/sf/yr)
Preliminary 100% DD Proposed model	28.0	62.8
Preliminary 90.1-2010 Appendix G baseline model	43.7	91.5
Preliminary 90.1-2013 Appendix G baseline model[6]	39.8	83.1

[5] This is currently modeled as shutting down the hot water loop when outside air temperature is above 65°F.

[6] ASHRAE 90.1-2013 Appendix G methodology with minimum requirements per ASHRAE 90.1-2016 with MA Amendments

Project Site EUI Targets



ANALYSIS METHODOLOGY AND BASELINE DESIGN DESCRIPTION

To analyze the future energy consumption patterns of the building and the efficiency of various energy conservation measures considered for the site, a computer model of the facility was developed and building consumption simulations were performed using the eQUEST building analysis program. eQUEST uses the latest DOE-2.3 (v3.65, build 7175) building energy analysis software as its calculating engine. This very flexible program permits modeling of a variety of building types and components, including complex building geometry, lighting systems, HVAC systems, central plant equipment, and utility rate structure.

The eQUEST model of the facility was constructed using the 100% Design Development Set dated 11/12/2021, the associated specifications, and additional information received from the design team. Providence, RI TMY3 weather data was used in the analysis.

Electric utility costs and cost savings were calculated using the National Grid G3 electric rate, while natural gas costs and cost savings were calculated using the Liberty Utilities G42 gas rate.

A list of items that differ in the two building models is provided in the table starting below. The list also provides values used in those varying components in the *proposed* and two different *baseline* building models (following both ASHRAE 90.1-2010 Appendix G and ASHRAE 90.1-2013 Appendix G). Any components not mentioned in the table are identical in all models.

Table 2 – Summary of Major Differences between Proposed and Baseline Building

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)[7]
ASHRAE 90.1 Section 5: Opaque Building Envelope			
Building Area	~124,000 sf	Same as proposed case	Same as proposed case
Building Orientation	-105° from True North	Same as proposed case + rotated 90°, 180°, and 270°	Same as proposed case + rotated 90°, 180°, and 270°
Roof Insulation	R-41.7 continuous Overall assembly U-0.023	ASHRAE 90.1-2010 Table 5.5-5 Overall assembly U-0.048 (Insulation Entirely above Deck)	ASHRAE 90.1-2016 Table 5.5-5 Overall assembly U-0.032 (Insulation Entirely above Deck)
Wall Insulation	R-12.7 + R-21 in studs Overall assembly U-0.046	ASHRAE 90.1-2010 Table 5.5-5 Overall assembly U-0.064 (Steel Framed)	ASHRAE 90.1-2016 Table 5.5-5 Overall assembly U-0.055 (Steel Framed)

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 5: Fenestration and Shading			
Fenestration	Storefront: assembly U-0.35 Curtainwall: assembly U-0.32	ASHRAE 90.1-2010 Table 5.5-5 Metal framing, curtainwall/storefront: Assembly U-0.45, SHGC 0.40 *Modeled glass: U-0.45, SHGC-0.37, VT-0.44	ASHRAE 90.1-2016 Table 5.5-5 Metal framing, curtainwall/storefront: U-0.38, SHGC 0.38
Window-to-Wall Ratio	21%	Same as proposed case	Same as proposed case

[7] ASHRAE 90.1-2013 Appendix G Methodology with minimum performance per ASHRAE 90.1-2016 with MA Amendments

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 6: HVAC (Air-Side)			
General classrooms and administrative areas	See facility description	ASHRAE Appendix G Table G3.1.1-3 "Baseline HVAC System Types" Baseline System 5 – Packaged VAV with Reheat DX cooling, hot water (natural gas) boiler, variable air volume fan control, continuous fan operation (during occupied hours), economizer control (high limit 70°F per Table G3.1.2.6B) Equipment capacities are oversized by 15% for cooling and 25% for heating according to ASHRAE 90.1-2010 Appendix G3.1.2.2 Per G3.1.1, one system modeled per floor except as noted below	ASHRAE Appendix G Table G3.1.1-3 "Baseline HVAC System Types" Baseline System 5 – Packaged VAV with Reheat DX cooling, hot water (natural gas) boiler, variable air volume fan control, continuous fan operation (during occupied hours), economizer control (high limit 70°F per Table G3.1.2.8). Equipment capacities are oversized by 15% for cooling and 25% for heating according to ASHRAE 90.1-2013 Appendix G3.1.2.2 Per G3.1.1, one system modeled per floor except as noted below
Cafeteria, Gymnasium, Auditorium	See facility description	Per exception G3.1.1b, Baseline System 3 – Packaged Rooftop AC DX cooling, furnace heating, constant volume, continuous fan operation (during occupied hours), economizer control (high limit 70°F per Table G3.1.2.6B). Equipment capacities are oversized by 15% for cooling and 25% for heating according to ASHRAE 90.1-2010 Appendix G3.1.2.2	Per exception G3.1.1(2), Baseline System 3 – Packaged Rooftop AC DX cooling, furnace heating, constant volume, continuous fan operation (during occupied hours), economizer control (high limit 70°F per Table G3.1.2.6B). The equipment capacities are oversized by 15% for cooling and 25% for heating according to ASHRAE 90.1-2013 Appendix G3.1.2.2
Kitchen MAU	See facility description	Per exception G3.1.1b, Baseline System 3	Per exception G3.1.1(2), Baseline System 3
IDF/Electrical Rooms	See facility description	Per exception G3.1.1b, Baseline System 3	Per exception G3.1.1(2), Baseline System 3
Stairwells, storage, back of house	See facility description	Per exception G3.1.1e, Baseline System 9	Per exception G3.1.1(5), Baseline System 9

<table>
<tr><th>Item</th><th>Proposed Case (As Designed)</th><th>90.1-2010 Appendix G Baseline (LEEDv4)</th><th>90.1-2013 Appendix G Baseline (MSBA)</th></tr>
<tr><td colspan="4">ASHRAE 90.1 Section 6: HVAC (Air-Side)</td></tr>
<tr><td>Unitary Cooling Efficiency</td><td>Split systems assumed to meet minimum requirements of ASHRAE 90.1-2016 with MA Amendments</td><td>Efficiencies per table below:<table><tr><th>System</th><th>EER</th></tr><tr><td>Sys 5 - Lower Level</td><td>9.8</td></tr><tr><td>Sys 5 - Main Level</td><td>9.5</td></tr><tr><td>Sys 5 - Upper Level</td><td>9.5</td></tr><tr><td>Sys 5 - Admin</td><td>9.8</td></tr><tr><td>Sys 3 - Cafeteria</td><td>10.8</td></tr><tr><td>Sys 3 - Gym</td><td>9.8</td></tr><tr><td>Sys 3 - Auditorium</td><td>11</td></tr><tr><td>Sys 3 - Tech Class 1</td><td>11</td></tr><tr><td>Sys 3 - Tech Class 2</td><td>11</td></tr></table>System 3 units under 65 MBH: 13 SEER</td><td>Efficiencies per table below<table><tr><th>System</th><th>EER</th></tr><tr><td>Sys 5 - Lower Level</td><td>9.8</td></tr><tr><td>Sys 5 - Main Level</td><td>9.5</td></tr><tr><td>Sys 5 - Upper Level</td><td>9.5</td></tr><tr><td>Sys 5 - Admin</td><td>9.8</td></tr><tr><td>Sys 3 - Cafeteria</td><td>10.8</td></tr><tr><td>Sys 3 - Gym</td><td>9.8</td></tr><tr><td>Sys 3 - Auditorium</td><td>11</td></tr><tr><td>Sys 3 - Tech Class 1</td><td>11</td></tr><tr><td>Sys 3 - Tech Class 2</td><td>11</td></tr></table>System 3 units under 65 MBH: 14 SEER</td></tr>
<tr><td>Unitary Heating Efficiency</td><td>N/A</td><td>System 3 furnace efficiency: 80%</td><td>System 3 furnace efficiency: 80%</td></tr>
<tr><td>HVAC Air-Side Economizer Cycle</td><td>Dual enthalpy</td><td>Per G3.1.2.7, economizer must be included based on the climate (Zone 5a) for systems 3 and 5.</td><td>Per G3.1.2.7, economizer must be included based on the climate (Zone 5a) for systems 3 and 5.</td></tr>
<tr><td>Airflow Rates</td><td>See facility description</td><td>System 3 and 5: self-sized
System 5: minimum box airflow setpoint is 30% of the peak zone airflow, or minimum outside airflow, whichever is larger per G3.1.3.13

Exception: MAU is sized for 1,800 cfm like the proposed</td><td>System 3 and 5: self-sized
System 5: minimum box airflow setpoint is 30% of the peak zone airflow, or minimum outside airflow, whichever is larger per G3.1.3.13

Exception: MAU is sized for 1,800 cfm like the proposed</td></tr>
<tr><td>Ventilation (Outside Air) Airflow Rates</td><td>Current outside airflow rates are based on a combination of ASHRAE 62.1-2013 Table 6.2.2.1. and sizing information provided by the design team.</td><td>Same as proposed[8]</td><td>Same as proposed</td></tr>
</table>

[8] It is currently assumed that the design minimum outdoor air rates of the proposed design meet the minimum requirements of ASHRAE 62.1 and do not exceed requirements by more than 5%.

<table>
<tr><th>Item</th><th>Proposed Case (As Designed)</th><th>90.1-2010 Appendix G Baseline (LEEDv4)</th><th>90.1-2013 Appendix G Baseline (MSBA)</th></tr>
<tr><td colspan="4">ASHRAE 90.1 Section 6: HVAC (Air-Side)</td></tr>
<tr><td>Fan Power</td><td>See facility description</td><td>ASHRAE 90.1-2010 fan power calculated using Section 6.5.3.1.1 pressure drop allowances.
<table>
<tr><th>System</th><th>Supply (kW/cfm)</th><th>Return (kW/cfm)</th></tr>
<tr><td>Sys 5 - Lower Level</td><td>0.000761</td><td>0.000685</td></tr>
<tr><td>Sys 5 - Main Level</td><td>0.000740</td><td>0.000666</td></tr>
<tr><td>Sys 5 - Upper Level</td><td>0.000722</td><td>0.000650</td></tr>
<tr><td>Sys 5 - Admin</td><td>0.000713</td><td>0.000642</td></tr>
<tr><td>Sys 3 - Cafeteria</td><td>0.000555</td><td>0.000499</td></tr>
<tr><td>Sys 3 - Gym</td><td>0.000502</td><td>0.000452</td></tr>
<tr><td>Sys 3 - Auditorium</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class 1</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class 2</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class X</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>MAU (Kitchen)</td><td>0.000546</td><td>0.000491</td></tr>
</table>
The smaller system 3 units have a supply fan power of 0.00074 kW/cfm.
The unit heaters (system 9) have a supply fan power of 0.0003 kW/cfm.</td><td>ASHRAE 90.1-2016 fan power calculated using Section 6.5.3.1-2 pressure drop allowances.
<table>
<tr><th>System</th><th>Supply (kW/cfm)</th><th>Return (kW/cfm)</th></tr>
<tr><td>Sys 5 - Lower Level</td><td>0.000767</td><td>0.000690</td></tr>
<tr><td>Sys 5 - Main Level</td><td>0.000750</td><td>0.000675</td></tr>
<tr><td>Sys 5 - Upper Level</td><td>0.000732</td><td>0.000659</td></tr>
<tr><td>Sys 5 - Admin</td><td>0.000719</td><td>0.000647</td></tr>
<tr><td>Sys 3 - Cafeteria</td><td>0.000555</td><td>0.000499</td></tr>
<tr><td>Sys 3 - Gym</td><td>0.000506</td><td>0.000455</td></tr>
<tr><td>Sys 3 - Auditorium</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class 1</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class 2</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>Sys 3 - Tech Class X</td><td>0.000546</td><td>0.000491</td></tr>
<tr><td>MAU (Kitchen)</td><td>0.000546</td><td>0.000491</td></tr>
</table>
The smaller system 3 units have a supply fan power of 0.00074 kW/cfm.
The unit heaters (system 9) have a supply fan power of 0.0003 kW/cfm.</td></tr>
<tr><td>Exhaust Air Energy Recovery</td><td>See facility description</td><td>The systems which require exhaust air energy recovery per ASHRAE 90.1-2010 6.5.6.1 are noted below.
1. Sys 5 - Lower Level
2. Sys 5 - Main Level
3. Sys 5 - Upper Level
4. Sys 5 - Admin

The systems with exhaust air energy recovery are modeled with enthalpy wheels with 50% heat recovery effectiveness.</td><td>The systems which require exhaust air energy recovery per ASHRAE 90.1-2016 6.5.6.1 are noted below.
5. Sys 5 - Lower Level
6. Sys 5 - Main Level
7. Sys 5 - Upper Level
8. Sys 5 - Admin

The systems with exhaust air energy recovery are modeled with enthalpy wheels with 50% heat recovery effectiveness.</td></tr>
</table>

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 6: HVAC (Air-Side)			
Demand Controlled Ventilation	See facility description	The systems which require demand-controlled ventilation (DCV) per ASHRAE 90.1-2010 6.4.3.9 are noted below. 1. Sys 3 - Cafeteria 2. Sys 3 - Gym 3. Sys 3 - Auditorium	The systems which require demand-controlled ventilation (DCV) per ASHRAE 90.1-2016 6.4.3.8 are noted below. 1. Sys 3 - Cafeteria 2. Sys 3 - Gym 3. Sys 3 - Auditorium
SA Temperature Setpoint Reset Parameters	See facility description	Per G3.1.3.12, system 5 air temperature for cooling shall be reset higher by 5°F under minimum cooling load conditions. During occupied hours: 55°F DAT at 55°F OAT reset linearly to 60°F DAT at 50°F OAT. During unoccupied hours: 55°F DAT at 80°F OAT reset linearly to 70°F DAT at 55°F OAT.	Per G3.1.3.12, system 5 air temperature for cooling shall be reset higher by 5°F under minimum cooling load conditions. During occupied hours: 55°F DAT at 55°F OAT reset linearly to 60°F DAT at 50°F OAT. During unoccupied hours: 55°F DAT at 80°F OAT reset linearly to 70°F DAT at 55°F OAT.
Equipment Capacities	Equipment capacities in this iteration are self-sized by eQuest based on load.	Per G3.1.2.2, cooling capacities are oversized by 15% and heating capacities are oversized by 25%.	The equipment capacities are oversized by 15% for cooling and 25% for heating according to ASHRAE 90.1-2013 Appendix G3.1.2.2
Fan System Operation	See facility description	Per G3.1.2.5, the fans operate continuously when the spaces are occupied, and cycle (no outside air) during unoccupied hours.	Per G3.1.2.5, the fans operate continuously when the spaces are occupied, and cycle (no outside air) during unoccupied hours.

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 6: HVAC (Water-Side)			
Boiler Plant	See facility description	Per G3.1.3.2, two natural gas fired boilers with natural draft of equal size are modeled. The boilers stage with load. Boilers have 80% thermal efficiency.	Per G3.1.3.2, two natural gas fired boilers with natural draft of equal size are modeled. The boilers stage with load. Boilers have 80% thermal efficiency.
Hot Water Supply Temp. Setpoint Reset	See facility description	Per G3.1.3.3, the hot water supply temperature setpoint is 180°F (return is 130°F), and per G3.1.3.4 a hot water supply temperature reset schedule is assigned based on outdoor dry bulb temperature: 180°F HW supply temperature setpoint at 20°F outside air temperature reset linearly to 150°F HW supply temperature at 50°F outside air temperature.	Per G3.1.3.3, the hot water supply temperature setpoint is 180°F (return is 130°F), and per G3.1.3.4 a hot water supply temperature reset schedule is assigned based on outdoor dry bulb temperature: 180°F HW supply temperature setpoint at 20°F outside air temperature reset linearly to 150°F HW supply temperature at 50°F outside air temperature.
Hot Water Pumps	See facility description	Per G3.1.3.5, the hot water pump power is modeled as 19 W/gpm. The pump is single speed that "rides the curve".	Per G3.1.3.5, the hot water pump power is modeled as 19 W/gpm. The pump is single speed that "rides the curve".

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 7: Service Water Heating			
Domestic Hot Water Heater	See facility description	Per Table G3.1 Section 11, the energy source of the proposed system is natural gas, therefore the baseline system uses natural gas.	Per G3.1.1-2, gas storage water heater with 80% Et

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
ASHRAE 90.1 Section 9: Lighting			
Interior Lighting System Wattage Density	0.50 W/sf (design target)	Per ASHRAE 90.1-2010 Table 9.5.1, 0.99 W/sf (building area method)	ASHRAE 90.1-2016 w/ MA Amendments School/University 0.72 W/sf (building area method)
Occupancy /Daylight Sensors	Currently, same as baseline.	Meets the minimum daylighting requirements of ASHRAE 90.1-2010	Meets the minimum daylighting requirements of ASHRAE 90.1-2016
Exterior Lighting	13 kW	Currently assumed same as proposed	Currently assumed same as proposed

Item	Proposed Case (As Designed)	90.1-2010 Appendix G Baseline (LEEDv4)	90.1-2013 Appendix G Baseline (MSBA)
Miscellaneous			
Equipment Loads	See facility description	Same as proposed	Same as proposed
Electric Rate Schedules	National Grid G3	Same as proposed	Same as proposed
Gas Rate Schedules	Liberty Utilities G42	Same as proposed	Same as proposed
Renewable Energy	Currently not included.	TBD	TBD

ENERGY EFFICIENCY MEASURES INCORPORATED INTO BUILDING DESIGN

Based on the 100% Design Development Set and discussions with the project team, it appears that a number of energy efficiency measures and technologies will be incorporated into the building design. The ones listed below are accounted for in the *proposed* building model presented in this report. Please see the previous table, "Summary of Major Differences Between Proposed and Baseline Buildings", for specific performance parameters compared to the LEED and MSBA baselines.

1. Building envelope features:
    - Roof and wall insulation surpassing baseline performance requirements
    - Fenestration assembly U-value surpassing the baseline performance requirements
2. High efficiency interior lighting system currently *assumed* to be 0.5 W/sf on average
3. Exhaust air energy recovery with effectiveness *assumed* to be above code minimum
4. Demand controlled ventilation based on CO_2 controls in spaces where not required by code
5. High efficiency air-cooled chiller
6. High efficiency condensing natural-gas fired boilers
7. High efficiency condensing natural-gas fired water heaters
8. Low flow sinks and showerhead