Allston Science and Engineering Complex

LEED Energy Model Report – Based on prior article 37 submission

14 March 2019

Executive Summary

This memo summarizes the results and major inputs of the energy model, constructed based on architectural plans that reflect the as well as those façade and mechanical design properties that have been coordinated within the design team, and serves as the LEED compliant energy model. This report is an update of one previously issued (2 March 2017) and reflects the elimination of the Wyss lab spaces and incorporates updated lab airflow rates.

Table 1 summarizes current performance relative to ASHRAE 90.1-2010 with Appendix G. The current design meets all the requirements as shown in Table 2 below.

Table 1: Summary of current performance relative to various standards

	Metric of saving	ASHRAE 90.1 Baseline	Target	Design	Status
MEPA 2010	GHG	2010	12-15%	40%	Achieved
Harvard Green Building Standards v2. (labs)	Energy use	2010	19.50%	22%	Achieved
LEED v4	Energy cost	2010	-	22%	Achieved (9 points)

Energy Model Description, Assumptions, and Input Summary

All energy models were completed in eQuest v3.65. The following pages include tables that summarize the critical inputs and assumptions.

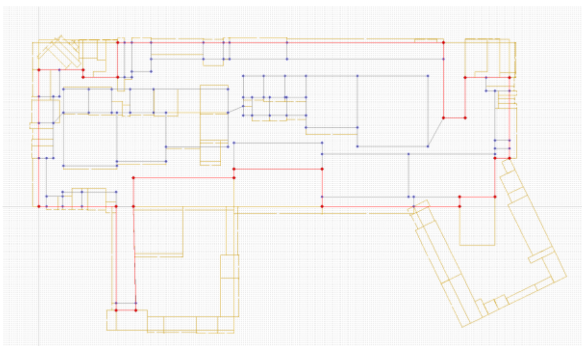

Figure 1: Thermal zoning for typical above-grade floor

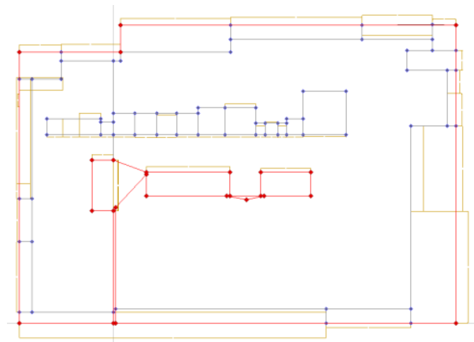

Figure 2: Thermal zoning for below-grade floor

Table 2: Area distribution per space type

Major Space Class	Area (%)
Classroom/Lecture	3%
Conference/Meeting	4%
Corridor/Transition	12%
Electrical/Mechanical	7%
Labs	23%
Lobby/Atrium	16%
Offices	25%
Workshop	2%
Other Spaces	7%

Table 3: Equipment and lighting power densities

	Equipment W/sf	**Lighting Power Density W/sf**	
	All Cases	ASHRAE 90.1-2010 Appendix G	Proposed Design
Computational	4	1.24	0.8
Lab	3	1.81	0.9
Office and Write-Up	0.75	1.11	0.8
Class / Lecture	0.5	1.24	0.8
Lobby / Atrium	0	0.64	0.65
Corridor	0	0.5	0.25
Conference	0.1	0.8	0.8
Data Room	6	0.8	0.8

*Note unfinished spaces were modelled with identical LPDs in baseline and proposed and with most likely use case.

Table 4: Envelope inputs

	ASHRAE 90.1-2010 Appendix G	Proposed Design
Window-to-Wall ratio	0.4	0.66
Glazing	SHGC 0.40	SHGC 0.28
Fenestration (Glass+Frame)	U-0.45	U-0.280
Exterior Walls	U-0.064 (R-16 overall)	U-0.036 (R-28 overall)
Roof	U-0.048 (R-20 overall)	U-0.040 (R-25 overall)
Shading	none	Varied overhang depths on lower floors and atrium; fixed exterior screen for upper floors

Table 5: Mechanical system inputs

	ASHRAE 90.1-2010 Appendix G	Proposed Design
HVAC System Type	Labs: One 100% outside air system with reheat Non-labs: VAV system with reheat	Labs: One 100% outside air VAV system with reheat; chilled beams Non-labs: 100% DOAS with Radiant
Heat Recovery	50% sensible effectiveness	80% sensible effectiveness
Fan Power	Labs: 11" w.c. Non-labs: (per ASHRAE 62.1-2010) offices: 5 cfm OA/person class: 7.5 cfm OA/person	Labs: 11" w.c. Non-labs: offices: 16 cfm OA/person class: 16 cfm OA/person
Lab Design Airflow	Occupied: Hazard Level 1: 5.0 ACH Hazard Level 2: 5.5ACH Hazard Level 3: 6 ACH Unoccupied: Hazard Level 1: 5 ACH Hazard Level 2: 5.5 ACH Hazard Level 3: 6 ACH	Occupied: Hazard Level 1: 2.4 ACH Hazard Level 2: 2.7 ACH Hazard Level 3: 3.15 ACH Unoccupied: Hazard Level 1: 5 ACH Hazard Level 2: 5.5 ACH Hazard Level 3: 6 ACH
Area Weighted Average (including Peak Hood Flows):	Occupied: 6.8 Unoccupied: 5.6	Occupied: 6.8 Unoccupied: 3.15
Airside Economizer	OA temperature max 70°F	Non-lab Unit: OA temperature max 70°F
Supply Air Temperature	Reset between 55 - 60 °F based on OA DB	Reset between 55 - 60 °F based on OA DB
NonLab Space Temperature Setpoints	76 °F Cooling setpoint 7am - 6pm 70 °F Heating setpoint 7am - 6pm 80 °F Cooling setpoint 6pm - 7am 66 °F Heating setpoint 6pm - 7am	76 °F Cooling setpoint 7am - 6pm 70 °F Heating setpoint 7am - 6pm 80 °F Cooling setpoint 6pm - 7am 66 °F Heating setpoint 6pm - 7am
Lab Space Temperature Setpoints	76 °F Cooling setpoint 7am - 6pm 70 °F Heating setpoint 7am - 6pm 78 °F Cooling setpoint 6pm - 7am 68 °F Heating setpoint 6pm - 7am	76 °F Cooling setpoint 7am - 6pm 70 °F Heating setpoint 7am - 6pm 78 °F Cooling setpoint 6pm - 7am 68 °F Heating setpoint 6pm - 7am
Heating Source	ASHRAE Baseline boilers per LEED district energy modeling guidelines Option 2	Virtual plant representing steam from new ESF central plant per LEED district energy modeling guidelines Option 2
Heating Efficiency	Design efficiency 80%	78% annual average heating efficiency (provided by Harvard E&U)
HW Loop	Supply 180 °F, DT 50 °F	Supply 180 °F, DT 50 °F
Cooling Source	ASHRAE Baseline chillers per LEED district energy modeling guidelines Option 2	Virtual plant representing chilled water from new ESF central plant per LEED district energy modeling guidelines Option 2
Chiller Efficiency	Design COP 6.1	5.33 annual average cooling COP (provided by Harvard E&U)
CHW Loop	supply 44 °F, DT 12 °F	supply 44 °F, DT 10 °F
Pumps	Variable flow: HW 12 W/gpm, CHW 17 W/gpm	Variable flow: HW 11 W/gpm, CHW 11 W/gpm

Table 6: Weekday schedules – All cases

Weekdays	Non Lab Equipment Schedule	NonLab Lighting Schedule	Whole Building Occupancy Schedule	Dry Lab Equipment Schedule	Wet Lab Equipment Schedule	Lab Lighting Schedule
7am to 8am	30%	42%	80%	63%	85%	42%
8am to 9am	40%	90%	90%	65%	87%	90%
9am to 10am	50%	90%	90%	68%	88%	90%
10am to 11am	50%	90%	90%	75%	87%	90%
11am to 12pm	50%	90%	78%	91%	90%	90%
12pm to 1pm	40%	90%	78%	87%	93%	90%
1pm to 2pm	50%	90%	80%	88%	93%	90%
2pm to 3pm	50%	90%	80%	93%	94%	90%
3pm to 4pm	50%	71%	71%	100%	96%	71%
4pm to 5pm	50%	61%	41%	96%	100%	61%
5pm to 6pm	40%	50%	21%	98%	100%	50%
6pm to 7pm	30%	68%	39%	89%	95%	68%
7pm to 8pm	30%	68%	39%	84%	98%	68%
8pm to 9pm	25%	67%	29%	77%	96%	67%
9pm to 10pm	25%	29%	29%	73%	91%	29%
10pm to 11pm	25%	25%	29%	74%	88%	25%
11pm to 7am	25%	25%	23%	65%	87%	25%

Table 7: Weekend schedules – All cases

Weekends	NonLab Equipment Schedule	NonLab Lighting Schedule	Whole Building Occupancy Schedule	Dry Lab Equipment Schedule	Wet Lab Equipment Schedule	Lab Lighting Schedule
7am to 8am	30%	42%	80%	63%	85%	42%
8am to 9am	40%	90%	90%	65%	87%	90%
9am to 10am	50%	90%	90%	68%	88%	90%
10am to 11am	50%	90%	90%	75%	87%	90%
11am to 12pm	50%	90%	78%	91%	90%	90%
12pm to 1pm	40%	90%	78%	87%	93%	90%
1pm to 2pm	50%	90%	80%	88%	93%	90%
2pm to 3pm	50%	90%	80%	93%	94%	90%
3pm to 4pm	50%	71%	71%	100%	96%	71%
4pm to 5pm	50%	61%	41%	96%	100%	61%
5pm to 6pm	40%	50%	21%	98%	100%	50%
6pm to 7pm	30%	68%	39%	89%	95%	68%
7pm to 8pm	30%	68%	39%	84%	98%	68%
8pm to 9pm	25%	67%	29%	77%	96%	67%
9pm to 10pm	25%	29%	29%	73%	91%	29%
10pm to 11pm	25%	25%	29%	74%	88%	25%
11pm to 7am	25%	25%	23%	65%	87%	25%

Table 8: Utility Costs

Utility cost (FY16)

Gas	$/MMBTU
Fuel	14.15
Total	**14.15**

Electric	$/kWh
Delivery	0.0381
Supply	0.0973
C&O	0.0266
Total	**0.162**

Lab Airflows

During occupied periods, lab air change rates have a prescribed minimum flow rate that sets a lower bound on ai flow rates. Lab spaces also contain fume hoods whose exhaust flows can exceed the baseline air flow rate. The laboratories were assumed to operate at peak fume hood loads for 2.5 hours per day, while remaining at the prescribed minimum ventilation rate during the rest of the occupied time, except in certain cases, where the minimum equipment exhaust rate still exceeded the base line rate. The air change rates listed in the table above represents the area and time weighted average of all laboratory exhaust rates for occupied and unoccupied periods. Spaces that will most likely be laboratory spaces but are currently planned for fit-out were modelled with base case airflow rates and LPDs in the proposed model, resulting in no claimed energy savings for these spaces.

Air change rate during unoccupied periods differ between the baseline and proposed model in accordance with section 6.5.7.2(a) of ASHRAE 90.1 , which states that lab air systems must incorporate variable exhaust or heat recovery system with greater than 50% effectiveness. The baseline model includes heat recovery and therefore, the unoccupied ventilation rate for each lab space is the greater the prescribed minimum occupied ventilation rate or the minimum equipment exhaust rate. The building as designed and modelled during in the proposed case, reduces lab airflow during un occupied time to approximately half of the design rate to levels that were determined in conjunction with the relevant facility managers and regulatory bodies.

Thermal Zoning

Detailed zone take-offs were simplified by combining like zones while maintaining characteristics essential to accurately represent building and zone performance such as façade area to floor area ratios and orientations. This simplification allowed for time efficient changes as the design was updated and is the reason that the energy model zoning diagrams do not “look” like the actual building design

Note that the underground area that is not planned for fit-out is not included in the energy models and no energy savings are being taken for these spaces. Furthermore, since there is no energy consumption in these spaces, their areas are not added to the total GSF indicated in Table 2 of this report, which would have given a misleading estimation of annual Energy Use Intensity (EUI). Underground areas for which fit-out and programming is planned have been included in the model.

Post-processing tools

Merge spreadsheet – The modelling software did not allow for outside air rates to be varied when using induction units representing the planned chilled beams. The merge spreadsheet combines energy model results for occupied ACH (parametric run #3) and unoccupied ACH (Baseline run) on an hourly basis. Hourly values for all end-uses are merged with an excel macros script, to capture energy consumed during occupied hours and unoccupied hours.

Results Files

Proposed Case:	6.8 ACH (Occupied average lab ACH) and 3.15 ACH (Unoccupied average lab ACH)
Baseline Case:	6.8 ACH (Occupied average lab ACH) and 5.6 ACH (Unoccupied average lab ACH)

Konvekta Cooling Adjustment – The project includes an advanced heat recovery system with evaporative exhaust cooling system manufactured by Konvekta AG of Switzerland. This system allows for heat recovery from all exhaust streams and additionally can cooling incoming air by adiabatically cooling the exhaust air before it travels through a heat recovery coil. The savings associated with this system were applied to the energy model results using performance data determined and supplied by Konvekta AG who use a proprietary implementation of DOE2 simulation software to determine overall system efficacy based on project specific parameters. The results from that investigation are included.

Simulation Output Summary

Consolidated Report Tables – includes GHG emissions factors, utility rates and equipment efficiency. A summary of these calculations is shown in Tables 9 and 10 below.

Table 9: Summary of final site energy calculations from Consolidated Report Tables

		ASHRAE 2010 with Appendix G	Proposed Design
Heating Usage	MMBTU	5943	5876
Gas Consumption	MMBTU	10885	8637
Chilled water Usage	MMBTU	15654	8834
Cooling Electricity	MMBTU	included in Elec.	1657
Electricity Usage	MMBTU	40079	29642

Table 10: Summary of GHG emissions, site energy, and energy cost calculations from Consolidated Report Tables

		ASHRAE 2010 with Appendix G	Proposed Design	Savings
GHG emissions from heating	tons CO2	579	360	
GHG emissions from cooling	tons CO2	included in Elec.	154	
GHG emissions from electricity	tons CO2	4815	2744	
Total annual GHG emissions	tons CO2	5394	3258	40%
Annual Energy Use	MMBtu	50964	39936	22%
Annual Energy Use	kBtu/sf	104	82	
Energy Cost Elec.	$	1,902,390	1,485,661	
Energy Cost Gas	$	154,023	122,208	
Energy Cost Total	$	2,056,413	1,607,870	22%
Energy Cost	$/sf	4.21	3.29	