LOWELL HIGH SCHOOL

FEASIBILITY PHASE ENERGY ANALYSIS

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01 ANALYSIS DESCRIPTION & SUMMARY

Thornton Tomasetti, Inc. (TT) has performed whole building energy analysis for Lowell High School to evaluate the relative energy performance of the proposed design cases.

The analysis presented in this report should be used for comparative analysis rather than predicting actual energy use. The energy models were created using eQuest v3.65.

The four different design options analyzed in this study are listed below:

DESIGN OPTIONS:

- Full Renovation (Full Reno)
- Addition/Renovation - Option 2 (Add/Reno 2)
- Addition/Renovation - Option 3 (Add/Reno 3)
- New Construction on Cawley Site (Cawley)

The results demonstrate that each design option can significantly reduce the overall EUI of Lowell High School from existing conditions with careful selection of Energy Conservation Measures (ECMs). The savings can be achieved with ECMs such as improved envelope, LED lighting fixtures, and high efficiency HVAC systems. New Construction at Cawley site shows the greatest Energy Use Intensity (EUI) savings from the existing building. This is due to the more efficient space layout, and a higher performance envelope than the renovation design options.

One key difference in the design options versus the existing case is the cooling load. In the design options, it is assumed that cooling will be provided to all regularly occupied spaces, while the existing building has limited functioning cooling, therefore increasing the cooling energy use from the existing building to the design option.

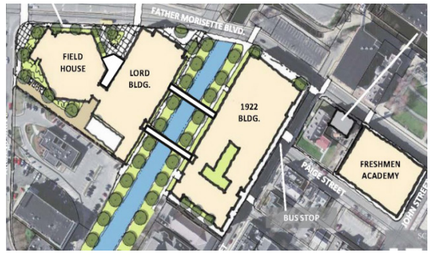
Utility bills of the existing high school were provided by the the city of Lowell, Department of Planning & Development. The existing building EUI was determined from the bills.

Another metric that is not part of this analysis but should be considered in selection of these options is the embodied carbon of new construction versus renovation and addition.

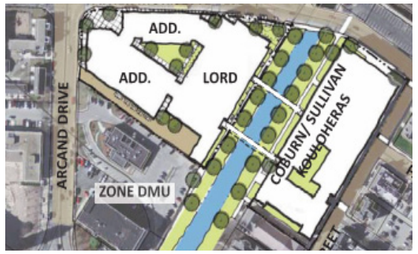
The new construction at Cawley Site performs best among all options with an EUI of 40 kBtu/sf-yr. The renovation options can achieve better performance than the existing building. However, the limited scope to envelope upgrades does not allow for a significant reduction in energy use. For the renovation options moisture issues must be considered for envelope upgrades in conjunction with energy performance.

Figure 01. Lowell High School (Existing)

Photo Credit: Panoramo.com



Full Reno



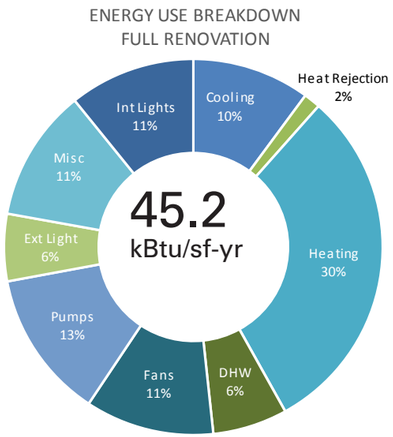
Add/Reno 2

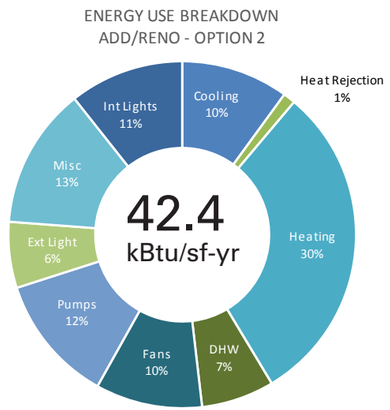
Add/Reno 3

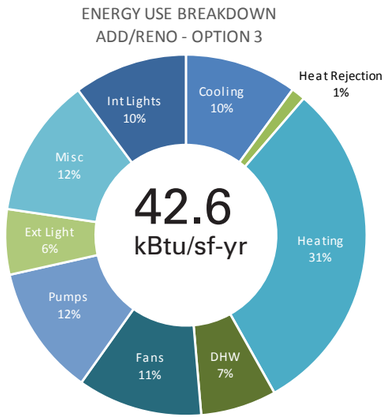
Cawley: New Construction

02 ENERGY END USE PROFILES BY SECTOR

Figure 02. shows the annual aggregate energy end-use breakdown for each of the design options. Each color in the pie charts denotes various end-uses. The largest end-use for each options is heating, followed by internal loads and cooling energy use. Although the new option has heating as the predominant load, it is smaller than the renovation options.







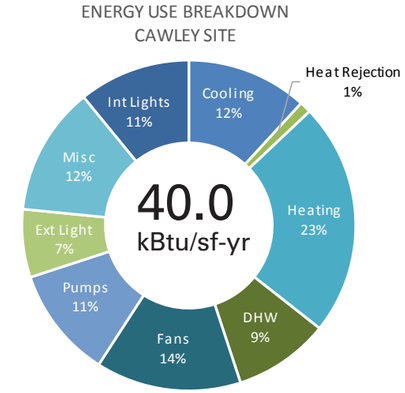


Figure 02. EUI Comparison by Design Options

03 ENERGY END USE PROFILE

Figure 03. shows the annual aggregate energy end-use breakdown for each design case. Each color in the bar chart denotes various end-uses.

The results illustrate that all the design options have a lower EUI than the existing building. The Full Reno has the least total savings, and Cawley Sity has the most compared to the existing building. The Add/Reno 2 and Add/Reno 3 options have a negligable difference in their EUI.

Note that the energy use associated with the pool is included in each case, causing the total EUI to be slightly larger then comparable buildings.

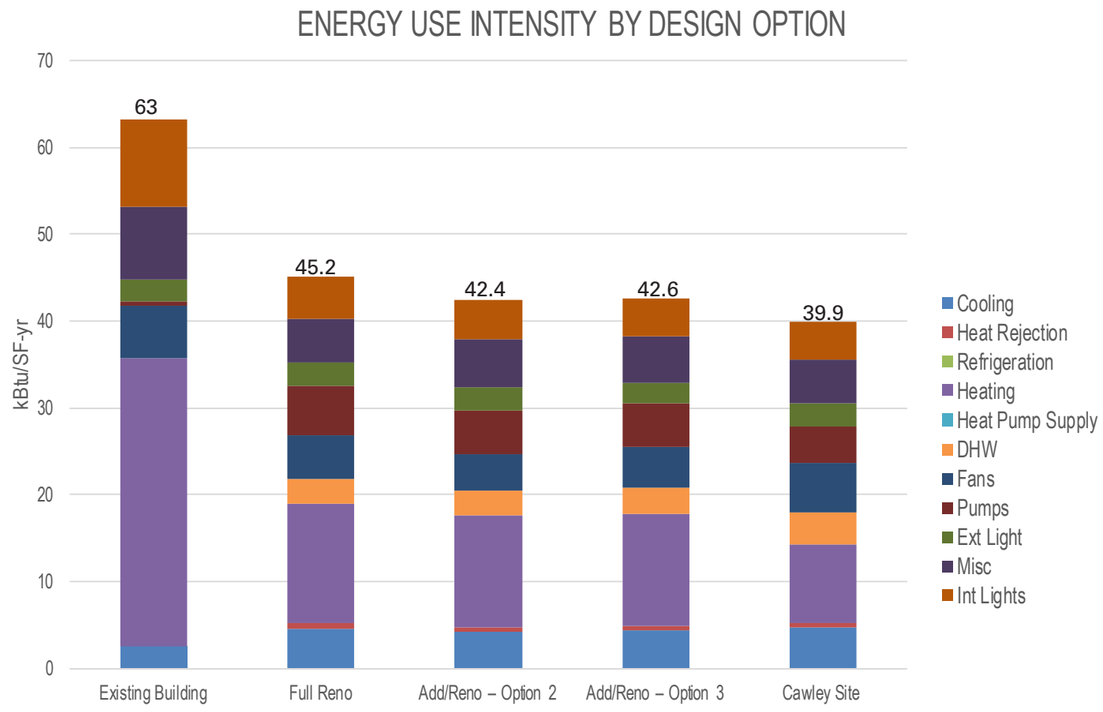


Figure 03. Annual Energy Use Profile by Design Options

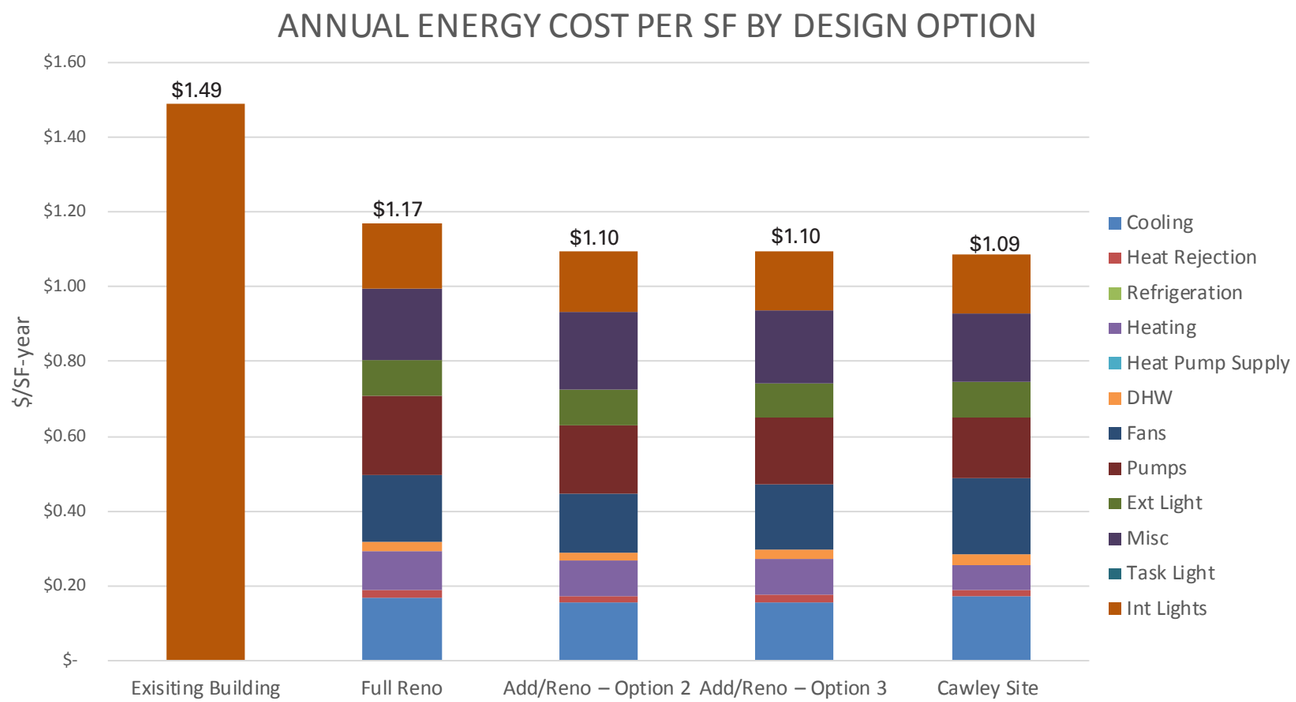


Figure 04. Annual Energy Cost Profile by Design Options

04 ENERGY COST PROFILE BY SYSTEM

The energy cost breakdown demonstrates the relative cost of energy per design option against the existing building. Figure 04. highlights the reduction of energy cost for each design option from the existing building.The Cawely site design has the greatest savings, due to the improved envelope and space layout.

Model Input Parameter	Full Renovation	Add/ Reno 2	Add/ Reno 3	Cawley
Utility				
Electric Rates	0.125 $/KWH			
Natural Gas Rates	0.75 $/therm			
Number of Floors	4 Floors	5 floors	5 floors	4 floors
Flr to Flr Height	14FT	14FT	14FT	14FT
Climate Zone	5A			
Model Input Parameter	**Full Renovation**	**Add/ Reno 2**	**Add/ Reno 3**	**Cawley**
Building Envelope (Construction Assemblies)				
Roofs Construction/Exterior insulation/Additional insulation	Existing- Assembly: U-0.063	Existing- Assembly: U-0.063 Addition- Assembly: U-0.032 Insulation: R-30	Existing- Assembly: U-0.063 Addition- Assembly: U-0.032 Insulation: R-30	Assembly: U-0.032 Insulation: R-30
Walls (Above Grade) construction/Exterior insulation/Additional Insulation/Interior insulation	Existing- Assembly: U-0.109	Existing- Assembly: U-0.109 Addition- Assembly: U-0.09 Insulation: R-11.4	Existing- Assembly: U-0.109 Addition- Assembly: U-0.09 Insulation: R-11.4	Assembly: U-0.055 Insulation: R-13 + R-10 c.i.
Ground Floor construction/insulation	Unheated Assembly: F-0.520	Unheated Assembly: F-0.520	Unheated Assembly: F-0.520	Unheated Assembly: F-0.520
Perimeter Zone Infiltration	0.038 CFM/SF of exterior wall	0.038 CFM/SF of exterior wall	0.038 CFM/SF of exterior wall	0.038 CFM/SF of exterior wall
Core Zone Infiltration	0.001 CFM/SF	0.001 CFM/SF	0.001 CFM/SF	0.001 CFM/SF
Vertical fenestration Area (% of Wall area)	1922 Building/Lord/Freshman: 40% Gymnasium: 0%	1922 Building/Lord: 40% Gymnasium: 0%	1922 Building/Lord: 40% Gymnasium: 0%	40% Gymnasium: 0%
Vertical Glazing U-factor (Assembly)	Existing: U-1.3	Existing: U-1.3 Addition: U-0.5	Addition: U-0.5	U-0.5
Vertical Glazing SHGC	0.4	0.4	0.4	0.4
Shading Devices	No	No	No	No
Building Operation Schedule				
Occupancy	4,019 Students	4,019 Students	4,019 Students	4,019 Students
Schedule	Typical school year: 90% occupancy 8am-4pm Summer & Breaks: 15% occupancy 8am-4pm, 4 days/wk	Typical school year: 90% occupancy 8am-4pm Summer & Breaks: 15% occupancy 8am-4pm, 4 days/wk	Typical school year: 90% occupancy 8am-4pm Summer & Breaks: 15% occupancy 8am-4pm, 4 days/wk	Typical school year: 90% occupancy 8am-4pm Summer & Breaks: 15% occupancy 8am-4pm, 4 days/wk
Annual Days of Operation	365	365	365	365

Model Input Parameter				
HVAC (Air-Side)	**Full Renovation**	**Add/ Reno 2**	**Add/ Reno 3**	**Cawley**
Primary HVAC Type	Full Air Conditioning Variable Air Volume Displacement System in classrooms Overhead ventilation system in: • Gym • Locker rooms • Auditorium and stage • Admin and media • Kitchen, Custodial Support, Receiving • Cafeteria • Studios • Pool • Corridors	Full Air Conditioning Variable Air Volume Displacement System in classrooms Overhead ventilation system in: • Gym • Locker rooms • Auditorium and stage • Admin and media • Kitchen, Custodial Support, Receiving • Cafeteria • Studios • Pool • Corridors	Full Air Conditioning Variable Air Volume Displacement System in classrooms Overhead ventilation system in: • Gym • Locker rooms • Auditorium and stage • Admin and media • Kitchen, Custodial Support, Receiving • Cafeteria • Studios • Pool • Corridors	Full Air Conditioning Variable Air Volume Displacement System in classrooms Overhead ventilation system in: • Gym • Locker rooms • Auditorium and stage • Admin and media • Kitchen, Custodial Support, Receiving • Cafeteria • Studios • Pool • Corridors
Cooling Source	1992: (2) 215 ton high efficiency water cooled chillers Lord: (2) 270 ton high efficiency water cooled chillers Freshman: DX cooling	1992: (2) 215 ton high efficiency water cooled chillers Lord: (2) 310 ton high efficiency water cooled chillers	1992: (2) 215 ton high efficiency water cooled chillers Lord: (2) 310 ton high efficiency water cooled chillers	High efficiency central chilled water cooling plant - (3) 310 ton water cooled chillers
Heating Source	1922 Building: High efficiency gas-fired condensing boiler plant (3) 5,000 MBH boiler Lord:(3) 5,000 MBH output boilers Freshman: (2) two gas fired 2,000 MBH boilers	1922 Building - High efficiency gas-fired condensing boiler plant (3) 5400 MBH Lord:(3) 5400 MBH output boilers	1922 Building - High efficiency gas-fired condensing boiler plant (3) 5400 MBH Lord:(3) 5400 MBH output boilers	High efficiency gas-fired condensing boiler plant (5) 4500 MBH
Seasonal Thermostat setpoints				
- Heating (occupied/unoccupied)	70 F ; 60 F	70 F ; 60 F	70 F ; 60 F	70 F ; 60 F
- Cooling (occupied/unoccupied)	75 F ; 85 F	75 F ; 85 F	75 F ; 85 F	75 F ; 85 F
Outside Air System				
Heat Recovery Device Type	Enthalpy Wheel	Enthalpy Wheel	Enthalpy Wheel	Enthalpy Wheel
Effectiveness	74%	74%	74	74%
Domestic Water Heating	**Full Renovation**	**Add/ Reno 2**	**Add/ Reno 3**	**Cawley**
Heater Fuel	Gas	Gas	Gas	Gas
Tank Volume	5,500 gal	5,500 gal	5,500 gal	5,500 gal
Supply water Temp	135F	135F	135F	135F
Lighting	**Full Renovation**	**Add/ Reno 2**	**Add/ Reno 3**	**Cawley**
Lighting Power Density (LPD) for all activity areas	0.5 W/SF: Classroom 0.6 W/SF: Gymnasium 0.5 W/SF: Office 0.6 W/SF: Library 0.4 W/SF: Corridor 0.6 W/SF: Kitchen 0.65 W/SF: Dining 0.63 W/SF: Auditorium	0.5 W/SF: Classroom 0.6 W/SF: Gymnasium 0.5 W/SF: Office 0.6 W/SF: Library 0.4 W/SF: Corridor 0.6 W/SF: Kitchen 0.65 W/SF: Dining 0.63 W/SF: Auditorium	0.5 W/SF: Classroom 0.6 W/SF: Gymnasium 0.5 W/SF: Office 0.6 W/SF: Library 0.4 W/SF: Corridor 0.6 W/SF: Kitchen 0.65 W/SF: Dining 0.63 W/SF: Auditorium	0.5 W/SF: Classroom 0.6 W/SF: Gymnasium 0.5 W/SF: Office 0.6 W/SF: Library 0.4 W/SF: Corridor 0.6 W/SF: Kitchen 0.65 W/SF: Dining 0.63 W/SF: Auditorium
Daylighting Controls	Continuous dimming in classroom spaces	Continuous dimming in classroom spaces	Continuous dimming in classroom spaces	Continuous dimming in classroom spaces
Miscellaneous	**Full Renovation**	**Add/ Reno 2**	**Add/ Reno 3**	**Cawley**
Miscellaneous equipment	Classrooms - 0.85 W/sf Core/transition spaces - 0.165 - 0.316 W/sf	Classrooms - 0.85 W/sf Core/transition spaces - 0.165 - 0.316 W/sf	Classrooms - 0.85 W/sf Core/transition spaces - 0.165 - 0.316 W/sf	Classrooms - 0.85 W/sf Core/transition spaces - 0.165 - 0.316 W/sf