University of Illinois
Freer Hall

Energy Model Report
95% Construction Documents

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Introduction

This report summarizes the results of a design phase energy analysis for University of Illinois Freer Hall located in Urbana, IL. The 35,000 square foot building consists primarily of dry lab space. In addition to the large volume of lab space the project contains a single wet lab space and office space as well as conference/meeting space. The primary objective of this report is to provide an assessment of the energy conservation measures employed in the building and their impact on annual energy use and corresponding energy cost.

Figure 1: Rendering of Freer Hall

Energy Conservation Measures (EMCs)

Improved Roof

For the baseline building existing documentation shows 2 inches of rigid insulation. The resulting existing thermal properties of the roof assembly are R-11 (U-Value 0.087). Current construction documents detail 8 inches of open cell spray insulation resulting in an assembly R-Value of 30 (U-Value is 0.033). This value represents a 62% improvement over the baseline (existing) condition. This additional thermal resistance provides for less heat loss through the roof greatly reducing heating demand/consumption.

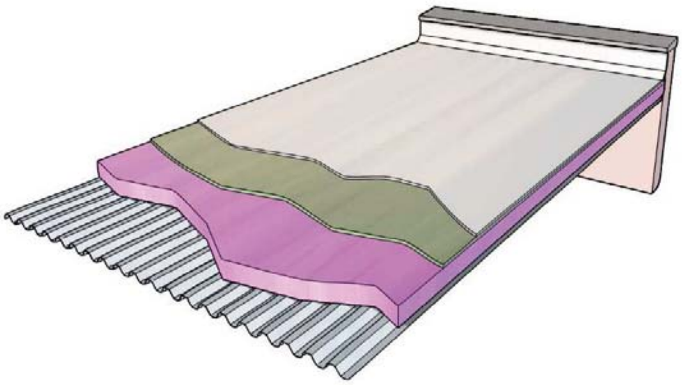


Figure 2: Continuous insulation on roof section

Improved Walls

For the baseline building existing documentation shows face brick over haydite block with no known insulation. The resulting existing thermal properties of the wall assembly are R-6 (U-Value 0.177). Current construction documents detail 2.75 inches of closed cell spray insulation resulting in an assembly R-Value of 25 (U-Value is 0.040). This value represents a 77% improvement over the baseline (existing) condition. This additional thermal resistance provides for less heat loss through the walls greatly reducing heating demand/consumption.

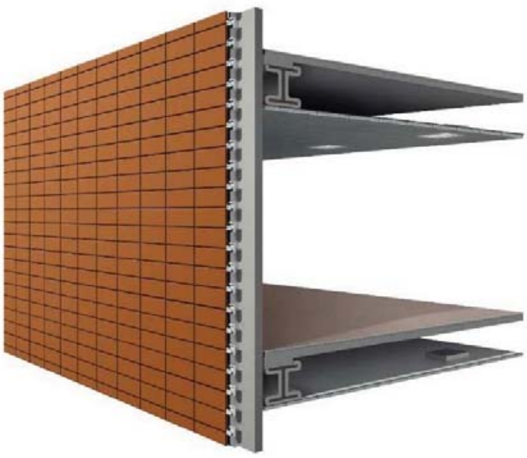


Figure 3: Above grade wall section

Improved Glazing

For the baseline building the design team has elected to reference ASHRAE 90.1 which specifies properties of unlabeled existing glazing. The resulting baseline glazing properties are a U-Value of 0.9 in conjunction with a solar heat gain coefficient (SHGC) of 0.68. Current narratives indicate new double glazing with a low E coating. The design team has assumed from this basic description that the design glass should be modeled as having an assembly U-Value of 0.4 as well as a SHGC of 0.3. These values equate to a 55% improvement in assembly U-Value and well as a 56% improvement in the glazing's SHGC. This reduction in SHGC provides lower heat gains associated with the suns radiation and consequently reduced cooling demand/consumption.

Figure 4: Glazing allowing visual light while repelling potential solar heat gains

Lighting Power Density & Controls

Lighting power densities are decreased by 20% beyond the baseline ASHRAE 90.1 2007 prescribed values. The implementation of occupancy based electric lighting controls further reduces overall annual lighting energy consumption. In addition, task lighting is utilized in multi-occupant office spaces to allow for further controllability of lighting levels.

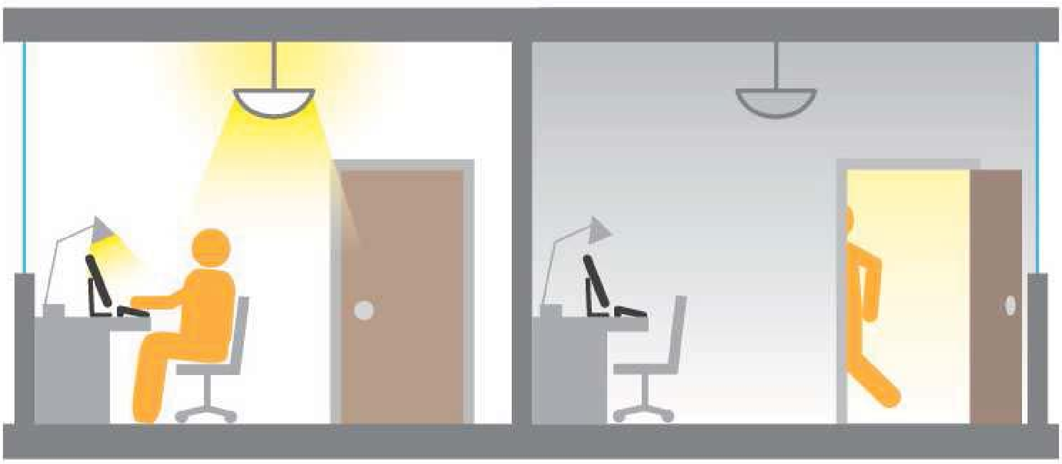


Figure 5: Occupancy sensor & task lighting schematic

Daylight Harvesting

Automatic daylighting controls are implemented in all spaces where the combined primary side lighted area equals or exceeds 250 ft^2. A photo control is located in the space which tracks the level of ambient light and adjusts the interior lighting levels accordingly. This strategy of daylight harvesting results in significant energy savings by reducing electric lighting loads and associated cooling loads.

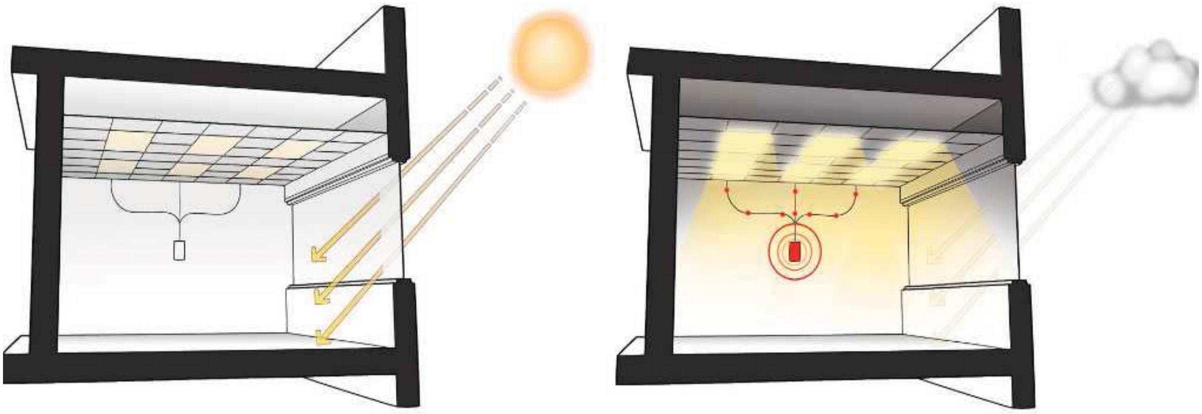


Figure 6: Daylight Harvesting

Heat Pipe

Spaces serving areas where there is potential for cross contamination between airstreams utilize a heat pipe energy recovery strategy. The heat pipe uses refrigerant as a working fluid to transfer heat from one airstream to the other thus avoiding any possibility for the airstreams to come into contact with one another. This system operates at a slightly lower efficiency then the enthalpy wheel system but is still an effective way for recovering otherwise wasted heat. This recovered heat is used to precondition the incoming outdoor air reducing the load on the main cooling and heating coils.

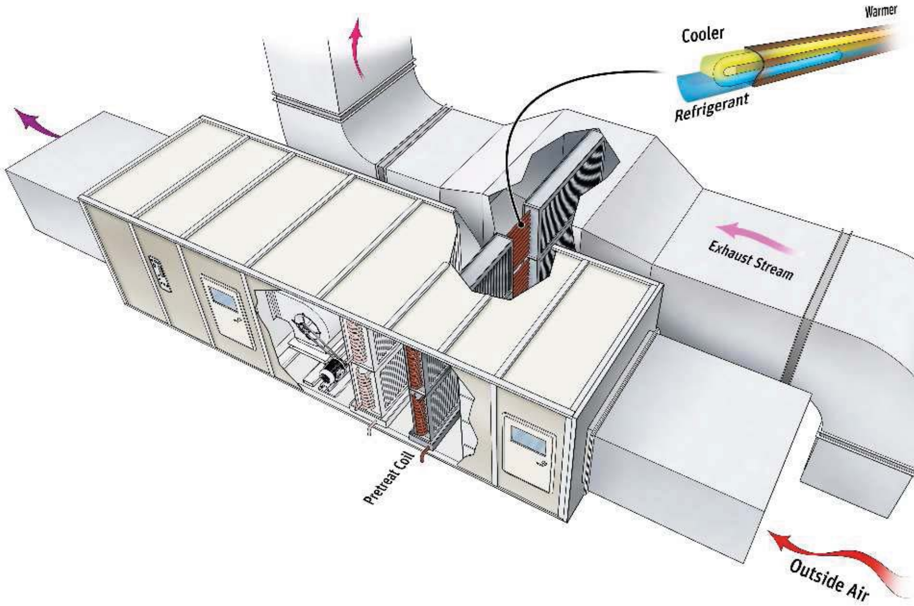


Figure 7: Heat pipe schematic

VAV Fume Hood

Better airflow management through the building as a result of unoccupied VAV shutoff in non-lab spaces in conjunction with VAV fume hoods in labs with a turn down to decrease energy associated with conditioning outside air and moving air through the building air distribution system.

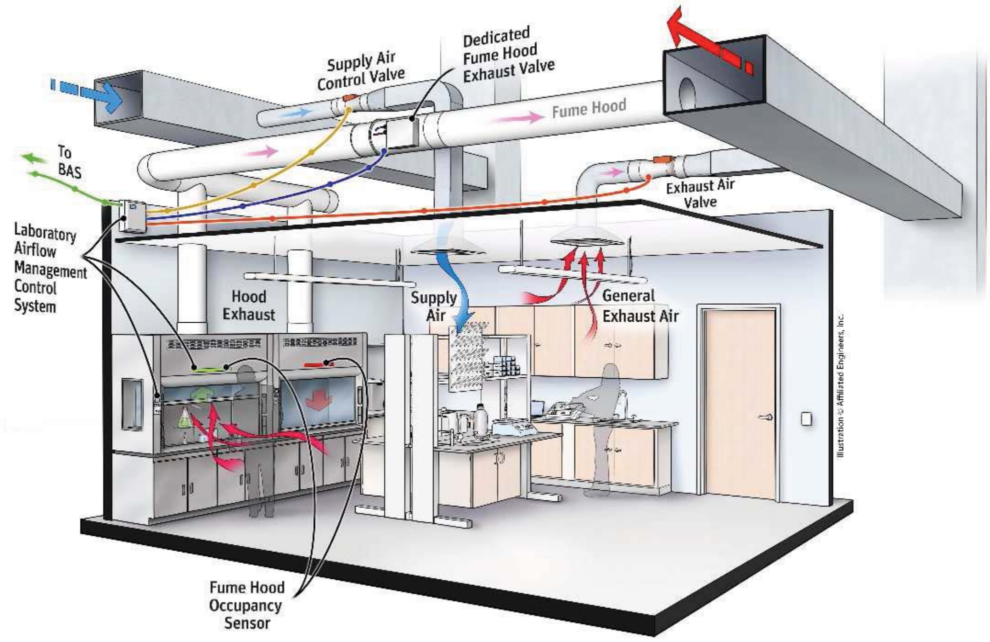


Figure 8: VAV fume hoods unoccupied turndown

Low Flow Fixtures

Low flow fixtures are being utilized throughout the project to drive down both water consumption in conjunction with domestic hot water heating energy required. A 30% reduction in flush fixtures is obtained through the implementation of 1.28 gallon per flush toilets (1.6 gpf baseline) in conjunction with 0.5 gallon per flush urinals (1.0 gpf baseline). A 35% reduction in flow fixtures is obtained though the implementation of censored 0.5 gallon per minute lavatory faucets (baseline does not contain censors).

Figure 9: Low flow water fixtures

Model Input Parameters

Annual computer simulations were carried out using ASHRAE 90.1-2007 Appendix G Performance Rating Method and Trane Trace energy analysis software. Basic building space use characteristics, lighting systems, ventilating and air conditioning systems, electric plug load, etc. were used to create representative models. The computer models used an hourly weather data file generated from measured data for University of Illinois (Bondville-Surfrad) (ASHRAE climate zone 5A).

Building Area by Space Type		
Space Type	Area (ft^2)	Percentage (%)
Dry Laboratory	9,108	26.4
Corridor	6,437	18.6
Office Space - Enclosed	3,255	9.4
Classroom	2,445	7.1
Wet Laboratory	2,096	6.1
Stairs	2,027	5.9
Office Space - Open Plan	2,178	6.3
Active Storage	848	2.5
Mechanical/Electrical	4,646	13.5
Kitchen (Cooking)	544	1.6
Reception Areas	375	1.1
Toilets-Public	310	0.9
Conference/Meeting	261	0.8

Lighting Power Density		
Space Type	Proposed	Baseline
Dry Laboratory	1.12	1.40
Corridor	0.40	0.50
Office Space - Enclosed	1.10	1.10
Classroom	1.12	1.40
Wet Laboratory	1.12	1.40
Stairs	0.48	0.60
Office Space - Open Plan	1.10	1.10
Active Storage	0.48	0.60
Mechanical/Electrical	1.20	1.50
Kitchen (Cooking)	0.96	1.20
Reception Areas	0.88	1.10
Toilets-Public	0.72	0.90
Conference/Meeting	1.04	1.30

A 10% reduction in lighting use for the implementation of occupancy sensors is used in both the baseline and the proposed buildings as prescribed by ASHRAE 90.1-2007.

Equipment Power Density		
Space Type	Proposed	Baseline
Dry Laboratory	3	3
Corridor	0	0
Office Space - Enclosed	1	1
Classroom	1	1
Wet Laboratory	6	6
Stairs	0	0
Office Space - Open Plan	1.5	1.5
Active Storage	0	0
Mechanical/Electrical	5	5
Kitchen (Cooking)	3	3
Reception Areas	0.5	0.5
Toilets-Public	0	0
Conference/Meeting	0.5	0.5

Ventilation Requirements		
Space Type	Proposed	Baseline
Dry Laboratory	10 cfm/person + 0.18 cfm/sf	10 cfm/person + 0.18 cfm/sf
Corridor	0 cfm/person + 0.06 cfm/sf	0 cfm/person + 0.06 cfm/sf
Office Space - Enclosed	5 cfm/person + 0.06 cfm/sf	5 cfm/person + 0.06 cfm/sf
Classroom	10 cfm/person + 0.12 cfm/sf	10 cfm/person + 0.12 cfm/sf
Wet Laboratory	10 cfm/person + 0.18 cfm/sf	10 cfm/person + 0.18 cfm/sf
Stairs	0 cfm/person + 0 cfm/sf	0 cfm/person + 0 cfm/sf
Office Space - Open Plan	5 cfm/person + 0.06 cfm/sf	5 cfm/person + 0.06 cfm/sf
Active Storage	5 cfm/person + 0.06 cfm/sf	5 cfm/person + 0.06 cfm/sf
Mechanical/Electrical	0 cfm/person + 0 cfm/sf	0 cfm/person + 0 cfm/sf
Kitchen (Cooking)	7.5 cfm/person + 0.12 cfm/sf	7.5 cfm/person + 0.12 cfm/sf
Reception Areas	5 cfm/person + 0.06 cfm/sf	5 cfm/person + 0.06 cfm/sf
Toilets-Public	0 cfm/person + 0 cfm/sf	0 cfm/person + 0 cfm/sf
Conference/Meeting	5 cfm/person + 0.06 cfm/sf	5 cfm/person + 0.06 cfm/sf

HVAC Parameters		
Parameter	Proposed	Baseline
Cooling Setpoint	-	-
Occupied Zones	Lab: 72°F Office: 75°F	Lab: 72°F Office: 75°F
Unnocupied Zones	85°F	85°F
Heating Setpoint	-	-
Occupied Zones	Lab: 72°F Office: 70°F	Lab: 72°F Office: 70°F
Unnocupied Zones	60°F	60°F
Economizer	AHU-1,2,3	AHU-1,2,3
Economizer Shut-off	70°F	70°F

Air Distribution System	AHU-5 (West VAV non labs): 20% OA Multizone VAVR AHU-6 (East VAV non labs): 20% OA Multizone VAVR DOA-1 (Labs DOAS): 100% OA Multizone VAVR FCUs: CHW units serving IDF spaces	AHU-Level 0: VAV w/reheat (ASHRAE 90.1-2010 System # 7) AHU-Level 1: VAV w/reheat (ASHRAE 90.1-2010 System # 7) AHU-Level 2: VAV w/reheat (ASHRAE 90.1-2010 System # 7) AHU-Level 3: VAV w/reheat (ASHRAE 90.1-2010 System # 7) AHU-Level 4: VAV w/reheat (ASHRAE 90.1-2010 System # 7) FCUs: Fan Coil Unit serving the Mechanical and Electrical rooms (ASHRAE 90.1-2010 System # 3)
Supply Air Reset	Yes	Yes
Cooling	5°F	5°F
Heating	None	None
Energy Recovery	AHU-5: None AHU-6: None DOA-1: Total heat pipe (50% Effectiveness)	AHU-Level 0: Not required AHU-Level 1: Not required AHU-Level 2: Not required AHU-Level 3: Not required AHU-Level 4: Not required
Design Fan Power	AHU-5: SF 19.6 BHP, RF 9.6 BHP, EF 0.5 BHP AHU-6: SF 27.2 BHP, RF 15.1 BHP DOA-1: SF 8.6 BHP. EF 7.4 BHP	AHU-Level 0: SF 6.5 BHP AHU-Level 1: SF 14.0 BHP AHU-Level 2: SF 14.2 BHP AHU-Level 3: SF 4.9 BHP AHU-Level 4: SF 3.7 BHP
Cooling Plant	District Chilled Water	District Chilled Water
Heating Plant	District Steam	District Steam

Rate Structure		
Fuel Source	Proposed	Baseline
Electricity	University of Illinois Rate - 0.0859 $/kWh	Same as Proposed
Purchased Chilled Water	University of Illinois Rate - 1.548 $/therm ($15.48 / MBTU)	Same as Proposed
Purchased Steam	University of Illinois Rate - 2.313 $/therm ($19.37 / klb)	Same as Proposed

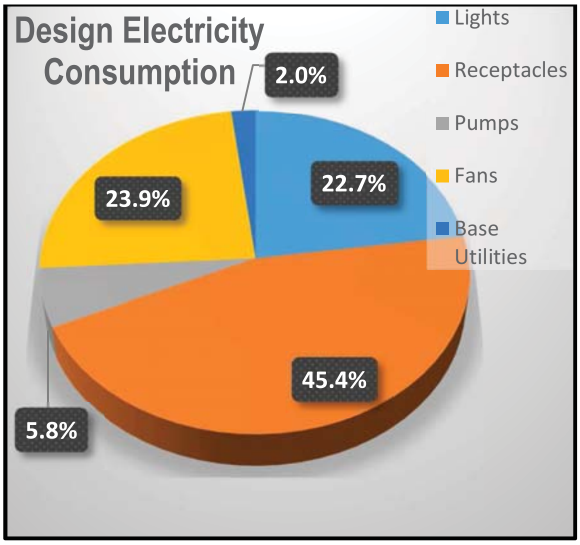
Results

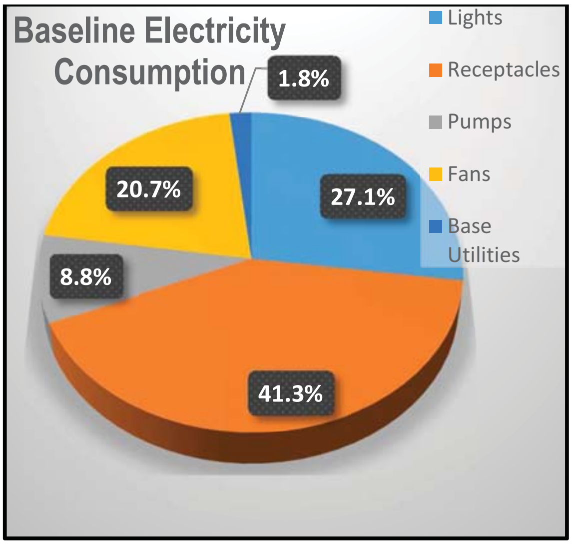
		Design Model				Baseline Model			
Building Area	34,615	Annual Energy Consumption		Annual Energy Cost		Annual Energy Consumption		Annual Energy Cost	
		(MMBtu)	(kBtu/sf)	($)	($)	(MMBtu)	(kBtu/sf)	($)	($)
Electricity	Space Cooling	0	73	28,149	53,385	0	93	30,947	68,760
	Space Heating	2				3			
	Lights	254				333			
	Receptacles	508				508			
	Pumps	65				108			
	Fans	268				255			
	Heat Rejection	0				0			
	Base Utilities	22				22			
District Steam	Space Heating	377		10,589		809		21,575	
	Process Steam	81				124			
District Chilled Water	Space Cooling	946		14,644		1,049		16,239	
	Process CHW	0				0			
Natural Gas	Space Heating	0		0		0		0	
	SHW	0				0			
	Process Steam	0				0			

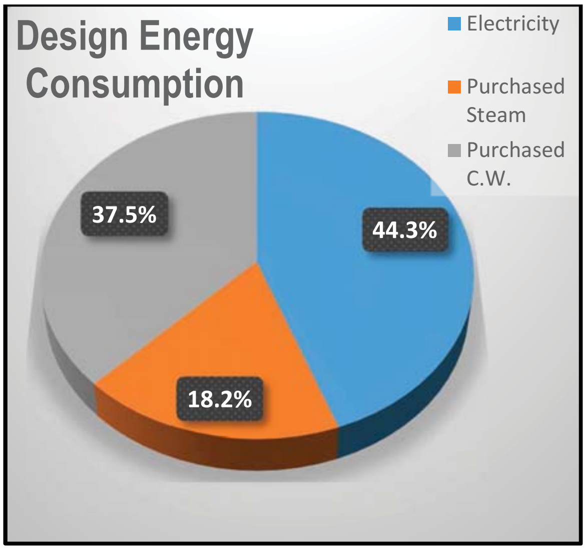
Overall annual energy consumption in the proposed building is 22.4% lower than the ASHRAE 90.1-2007 baseline building and Energy Use Intensity (EUI) is reduced by 20 kBtu/sf. Energy cost saving is estimated at $15,375 per year. The proposed building requires 51% less space heating energy in addition to 10% less space cooling energy. Further, annual lighting energy use is 24% lower compared to the ASHRAE 90.1 2007 baseline. Costs associated with district steam are reduced by 51% from $21,575 in the baseline to $10,589 in the proposed design. Costs associated with district chilled water are reduced by 10% from $16,238 in the baseline to $14,646 in the proposed design. Costs associated with electricity are reduced by 9% from $30,947 in the baseline to $28,149 in the proposed design.

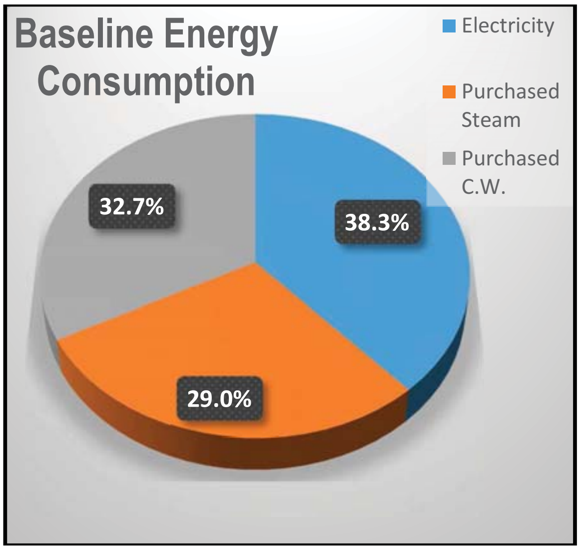
Currently, given the 22.4% annual energy cost reduction over the ASHRAE 90.1-2007 baseline building, 6 points may be achieved towards LEED (V3) Energy and Atmosphere credit 1.

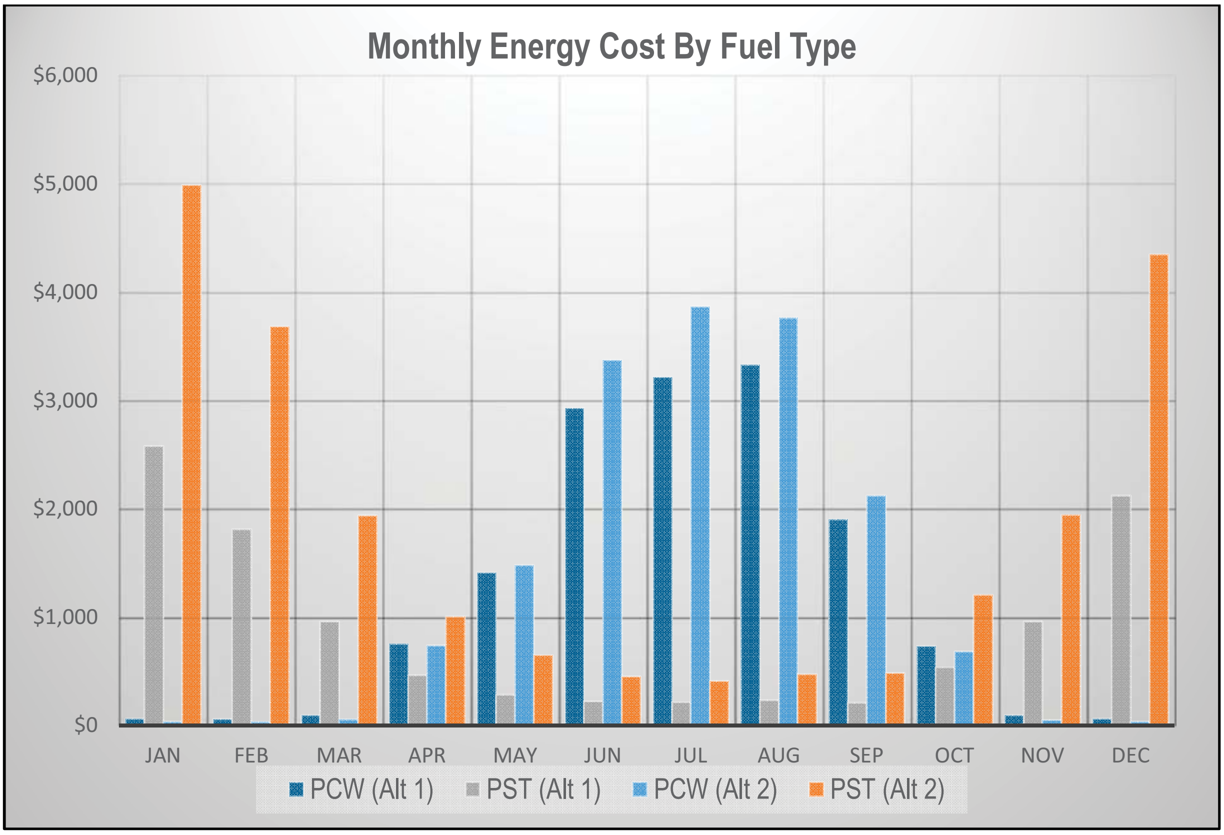
Supplemental Graphs










Monthly Energy Cost By Fuel Type
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
PCW (Alt 1)
PST (Alt 1)
PCW (Alt 2)
PST (Alt 2)