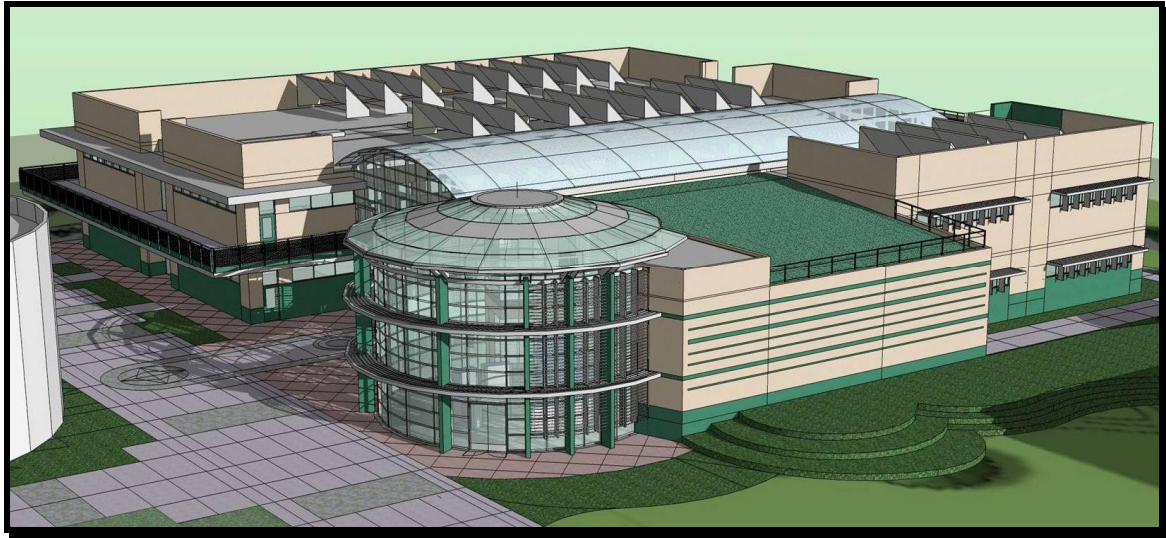


Technical Assignment #2
Building and Plant Energy Analysis Report



The Harker School - Science and Technology Building
San Jose, CA

Scott Davis
Mechanical Option

Faculty Advisor: Dr. Bahnfleth

October 28, 2007

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EXECUTIVE SUMMARY

The Harker School is one of the top K-12 schools in the state of California located in San Jose, CA. The new Science and Technology Building is a two story, 50,000 ft² located on the upper school campus(grades 9-12).

According to LEED-NC v2.2 Rating System, the Science and Technology Buildings has implemented enough sustainability and green design to get 31 points, which is good enough for official LEED certification. On top of those 31 probable points, it also is potentially eligible for 18 questionable points. Further development of the green design to get just two of those 18 points would be enough to elevate the project's status from Certified up to Silver.

Although being quite energy efficient according to LEED-NC v2.2, the building is only borderline efficient according to ASHRAE Standard 90.1 - 2004. The building envelope (save the roof) and the supply and exhaust fans are not compliant with the standard. Lighting and the other HVAC equipment all complied with the standard.

With most of the mechanical equipment being located on the roof and outside, there is very little rentable space lost due to the system, totaling a mere 1.1% of the total floor area.

The first cost of the mechanical system (including fire suppression) is \$2,658,743 (\$52.09/ft²). Carrier's Hourly Analysis Program was used to perform an energy simulation of the building. That determined that the annual cost of the running the building would be \$185,290 (\$3.342/ft²). This amount is probably higher than it actually is due to the fact that the actual system was too complex for me to perfectly simulate in HAP.

LEED-NC v2.2 ASSESSMENT

The LEED Rating System is an important tool in the modern construction industry which is used to help the construction and development of sustainable and environmentally friendly buildings. "Green design" is becoming more and more prevalent around the world as people are beginning to look into ways to take a preemptive attack on further pollution and other environmentally damaging effects that buildings may have. The LEED Rating System is in place to give everyone a clear set of instructions as to what is the standard for all the different facets of sustainable design.

Certification is classified in four different levels of compliance.

Certified: 26-32 points

Silver: 33-38 points

Gold: 39-51 points

Platinum: 52-69 points

The Harker School Science and Technology Building will be analyzed using LEED-NC v2.2. This system is used for new commercial projects or existing buildings under going major renovations such as office buildings and K-12 schools.

The LEED points will not be officially handed out until an official LEED review is completed after the building's construction is finished.

Category	Possible	Probable	Questionable	Declined
Sustainable Sites	14	8	1	5
Water Efficiency	5	2	0	3
Energy and Atmosphere	17	7	10	0
Materials and Resources	13	3	4	6
Indoor Environmental Air Quality	15	9	0	6
Innovation and Design Process	5	2	3	0
Totals		31	18	

Detailed breakdown located in Appendix A

As it stands now, there are 31 probable LEED points available, which will give the building a rating of LEED Certified. It is only two points short of a Silver rating, which should be fairly easy to reach as there are 18 points in question.

ASHRAE 90.1 - 2004 COMPLIANCE

BUILDING ENVELOPE

There are two different compliance paths outlined in section 5 of ASHRAE 90.1. The first is the Prescriptive Building Envelope Option. This is to be used as long as two conditions are met.

- 1) Vertical fenestration area doesn't exceed 50% of the gross wall area
- 2) Skylight fenestration area doesn't exceed 5% of the gross roof area

If either of the previously mentioned conditions are not met, then the Building Envelope Trade-Off Option is used.

Total Vertical Fenestration (SF)	Total Wall Area (SF)	Percent Fenestration
4439	17,669	25.10%

Total Skylight Fenestration (SF)	Total Roof Area (SF)	Percent Fenestration
1069	22,999	4.60%

Since both conditions are met, the Prescriptive Building Envelope Option is used.

SJ is located in climate zone 3B, so table 5.5-3 is used.

	Min. R-value Required	Actual R-value	
Roof	15	19	Complies
Walls	13	11	Does Not Comply

	Max U-value	Max SHGC	
Required	0.57	0.25	Does Not Comply
Actual	0.61	0.43	Does Not Comply

The building envelope doesn't comply with ASHRAE Standard 90.1 except for the roof.

HVAC SYSTEMS

Just as section 5, section 6 also has two different compliance paths outlined. The first is the Simplified Approach Option for HVAC Systems. In order for this to be used, three conditions must be met.

- 1) Building is two stories or less
- 2) Gross floor area is less than 25,000 ft²
- 3) Each HVAC system complies with requirements listed in 6.3.2

If any of these are not met, then the Mandatory Provisions and Prescriptive Path is used.

Since the gross floor area is greater than 25,000 ft² the Simplified Approach Option for HVAC Systems cannot be used, and the Mandatory Provisions and Prescriptive Path is used instead.

From Table 6.5.1

	Economizer Required (3B)	Cooling Capacity	Has Econmizer	
AHU-1	≥65,000Btu/hr	200+ MBH	Yes	Complies
AHU-2	≥65,000Btu/hr	200+ MBH	Yes	Complies
AHU-3	≥65,000Btu/hr	200+ MBH	Yes	Complies

From Table 6.8.1F

	Minimum Efficiency	Actual Efficiency	
Boiler, Gas Fired	75%	90%	Complies

The boiler's efficiency meets the ASHRAE requirements.

Section 6.4.1.3 states "Equipment not listed in the tables referenced in 6.4.1.1 and 6.4.1.2 may be used." The expansion tank used in the building is not specified in any of the tables referenced in those two sections, so it **complies** with the standard.

Section 6.4.3.3.2 specifies that all gravity ventilators be equipped with motorized dampers. Both gravity ventilators in the building are equipped with motorized dampers, so they **comply** with the standard.

LIGHTING

There are two compliance paths outlined in section 9 of ASHRAE 90.1. Unlike section 5 and 6, there is no correct path to be used. Either one can be used based on personal preference. The first specified is the Building Area Compliance Path. In this method, the building is looked at as a whole, using a single lighting power density from table 9.5.1.

The second specified is the Space-By-Space Method. In this one, each space is looked at individually, using the correct lighting power density from table 9.6.1 for each space.

Since this building is located at a school and is mostly classrooms, I decided to use the Building Area Compliance Path to check the compliance with ASHRAE.

LPD (Table 9.5.1)	Lit Area (ft ²)	Allowed Wattage	Actual Wattage	
1.2 W/ft ²	50,824	60,989	47,349	Complies

The actual wattage comes in below the allowed wattage for the building, so it complies with ASHRAE.

OTHER EQUIPMENT

In this section, the minimum efficiency required of the various motors around the building are specified in 10.8

Fan Type	Required Efficiency	Actual Efficiency	
Supply 1	91%	94.50%	Complies
Supply 2	91%	72.50%	Does Not Comply
Supply 3	91%	72.50%	Does Not Comply
Exhaust 1	80%	76%	*Does Not Comply
Exhaust 2	80%	65%	*Does Not Comply
Exhaust 3	80%	66%	*Does Not Comply
Exhaust 4	80%	68%	*Does Not Comply
Exhaust 5	80%	72%	*Does Not Comply
Exhaust 6	80%	120%	*Complies
Exhaust 7	80%	52%	*Does Not Comply
Exhaust 8	80%	52%	*Does Not Comply
Exhaust 9	80%	52%	*Does Not Comply
Exhaust 10	80%	52%	*Does Not Comply
Exhaust 11	80%	52%	*Does Not Comply

*Smaller HP than lowest value specified in table; smallest value was used

LOST RENTABLE SPACE

There isn't too much rentable space lost to mechanical systems since all of the equipment is located either on the roof, outside, or above the ceiling.

Space	Area Lost (ft ²)
Elevator Shaft	143
Electrical	257
Mechanical	147
Vertical Ducts	12
Total Lost	559
Percent Lost	1.10%

As shown above, the space lost due to mechanical systems is minimal.

MECHANICAL FIRST COST

System First Cost	\$2,658,743
First Cost Per ft ²	\$52.09/ft ²

ANNUAL ENERGY CONSUMPTION AND COST

Carrier's Hourly Analysis Program was used to perform an energy analysis on the whole building. An estimate to compare the HAP findings with was not available because of the cutting edge nature of the system. As of the time of this report, there are only three or four other systems like it in the San Francisco Bay Area. Because of this, the HAP energy analysis most likely resulted in higher energy consumption than what the system will actually require in real life.

Table 1. Annual Costs

Component	Science and Technology (\$)
Air System Fans	23,853
Cooling	29,625
Heating	6,374
Pumps	0
Cooling Tower Fans	13,898
HVAC Sub-Total	73,751
Lights	64,833
Electric Equipment	46,706
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	111,539
Grand Total	185,290

Table 2. Annual Cost per Unit Floor Area

Component	Science and Technology (\$/ft²)
Air System Fans	0.430
Cooling	0.534
Heating	0.115
Pumps	0.000
Cooling Tower Fans	0.251
HVAC Sub-Total	1.330
Lights	1.169
Electric Equipment	0.842
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	2.012
Grand Total	3.342
Gross Floor Area (ft ²)	55450.0
Conditioned Floor Area (ft ²)	55450.0

More data available in Appendix B

APPENDIX A

LEED-NC v2.2 POINT SUMMARY



**LEED for New Construction v2.2
Registered Project Checklist**

Project Name: The Harker School - Science and Technology Building
Project Address: The Harker School Upper Campus, San Jose, CA

Yes ? No

8	1	5	Sustainable Sites	14 Points
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Y					
			Prereq 1	Construction Activity Pollution Prevention	Required
1			Credit 1	Site Selection	1
		1	Credit 2	Development Density & Community Connectivity	1
		1	Credit 3	Brownfield Redevelopment	1
1			Credit 4.1	Alternative Transportation, Public Transportation Access	1
1			Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
1			Credit 4.3	Alternative Transportation, Low-Emitting & Fuel-Efficient Vehicles	1
1			Credit 4.4	Alternative Transportation, Parking Capacity	1
		1	Credit 5.1	Site Development, Protect or Restore Habitat	1
	1		Credit 5.2	Site Development, Maximize Open Space	1
		1	Credit 6.1	Stormwater Design, Quantity Control	1
		1	Credit 6.2	Stormwater Design, Quality Control	1
1			Credit 7.1	Heat Island Effect, Non-Roof	1
1			Credit 7.2	Heat Island Effect, Roof	1
1			Credit 8	Light Pollution Reduction	1

Yes ? No

2		3	Water Efficiency	5 Points
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		1	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
		1	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
		1	Credit 2	Innovative Wastewater Technologies	1
1			Credit 3.1	Water Use Reduction, 20% Reduction	1
1			Credit 3.2	Water Use Reduction, 30% Reduction	1

7	10		Energy & Atmosphere	17 Points
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Y	Prereq 1	Fundamental Commissioning of the Building Energy Systems	Required
Y	Prereq 2	Minimum Energy Performance	Required
Y	Prereq 3	Fundamental Refrigerant Management	Required

***Note for EAc1:** All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

6	4	6	Credit 1	Optimize Energy Performance	1 to 10
				10.5% New Buildings or 3.5% Existing Building Renovations	1
				14% New Buildings or 7% Existing Building Renovations	2
				17.5% New Buildings or 10.5% Existing Building Renovations	3
				21% New Buildings or 14% Existing Building Renovations	4
				24.5% New Buildings or 17.5% Existing Building Renovations	5
				6 28% New Buildings or 21% Existing Building Renovations	6
				31.5% New Buildings or 24.5% Existing Building Renovations	7
				35% New Buildings or 28% Existing Building Renovations	8
				38.5% New Buildings or 31.5% Existing Building Renovations	9
				42% New Buildings or 35% Existing Building Renovations	10
3	3	3	Credit 2	On-Site Renewable Energy	1 to 3
				2.5% Renewable Energy	1
				7.5% Renewable Energy	2
				12.5% Renewable Energy	3
1	1	1	Credit 3	Enhanced Commissioning	1
1	1	1	Credit 4	Enhanced Refrigerant Management	1
1	1	1	Credit 5	Measurement & Verification	1
1	1	1	Credit 6	Green Power	1

continued...

Yes	?	No	3	4	6	Materials & Resources	13 Points
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Y	Y	Y	Y	Prereq 1	Storage & Collection of Recyclables	Required
			1	Credit 1.1	Building Reuse , Maintain 75% of Existing Walls, Floors & Roof	1
			1	Credit 1.2	Building Reuse , Maintain 100% of Existing Walls, Floors & Roof	1
			1	Credit 1.3	Building Reuse , Maintain 50% of Interior Non-Structural Elements	1
1				Credit 2.1	Construction Waste Management , Divert 50% from Disposal	1
1				Credit 2.2	Construction Waste Management , Divert 75% from Disposal	1
			1	Credit 3.1	Materials Reuse , 5%	1
			1	Credit 3.2	Materials Reuse , 10%	1
1				Credit 4.1	Recycled Content , 10% (post-consumer + ½ pre-consumer)	1
	1			Credit 4.2	Recycled Content , 20% (post-consumer + ½ pre-consumer)	1
	1			Credit 5.1	Regional Materials , 10% Extracted, Processed & Manufactured Regionally	1
			1	Credit 5.2	Regional Materials , 20% Extracted, Processed & Manufactured Regionally	1
	1			Credit 6	Rapidly Renewable Materials	1
	1			Credit 7	Certified Wood	1

Yes	?	No	9	6	Indoor Environmental Quality	15 Points
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Y	Y	Y	Y	Prereq 1	Minimum IAQ Performance	Required
			Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
1	1	1		Credit 1	Outdoor Air Delivery Monitoring	1

1			Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan , During Construction	1
1			Credit 3.2	Construction IAQ Management Plan , Before Occupancy	1
1			Credit 4.1	Low-Emitting Materials , Adhesives & Sealants	1
1			Credit 4.2	Low-Emitting Materials , Paints & Coatings	1
1			Credit 4.3	Low-Emitting Materials , Carpet Systems	1
1			Credit 4.4	Low-Emitting Materials , Composite Wood & Agrifiber Products	1
		1	Credit 5	Indoor Chemical & Pollutant Source Control	1
		1	Credit 6.1	Controllability of Systems , Lighting	1
		1	Credit 6.2	Controllability of Systems , Thermal Comfort	1
1			Credit 7.1	Thermal Comfort , Design	1
		1	Credit 7.2	Thermal Comfort , Verification	1
		1	Credit 8.1	Daylight & Views , Daylight 75% of Spaces	1
		1	Credit 8.2	Daylight & Views , Views for 90% of Spaces	1
Yes	?	No			

2	3		Innovation & Design Process	5 Points
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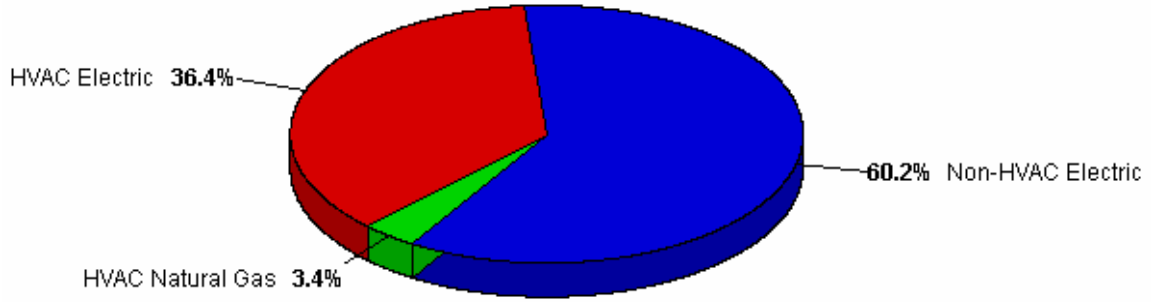
1			Credit 1.1	Innovation in Design : Provide Specific Title	1
	1		Credit 1.2	Innovation in Design : Provide Specific Title	1
	1		Credit 1.3	Innovation in Design : Provide Specific Title	1
	1		Credit 1.4	Innovation in Design : Provide Specific Title	1
1			Credit 2	LEED® Accredited Professional	1
Yes	?	No			

31	18	20	Project Totals (pre-certification estimates)	69 Points
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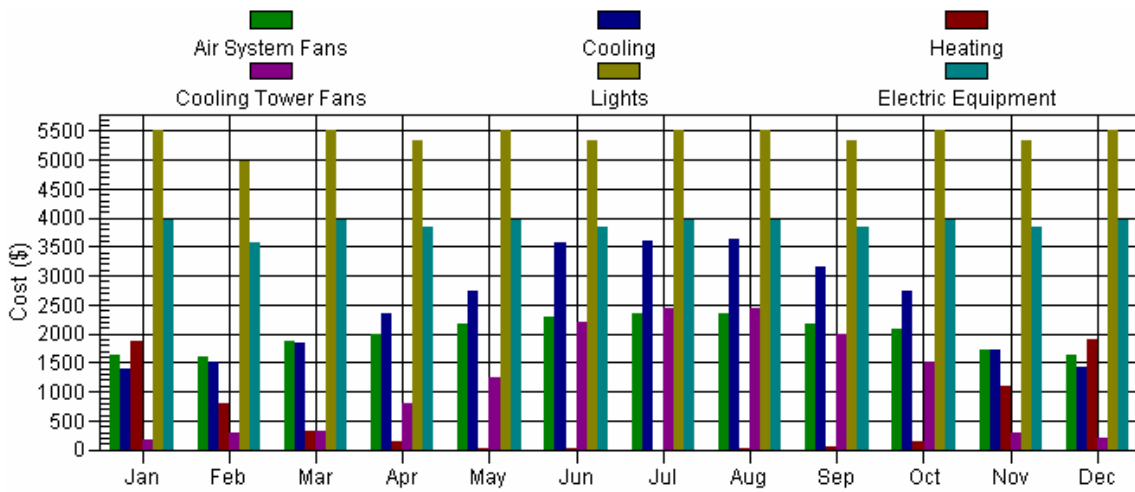
Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

APPENDIX B

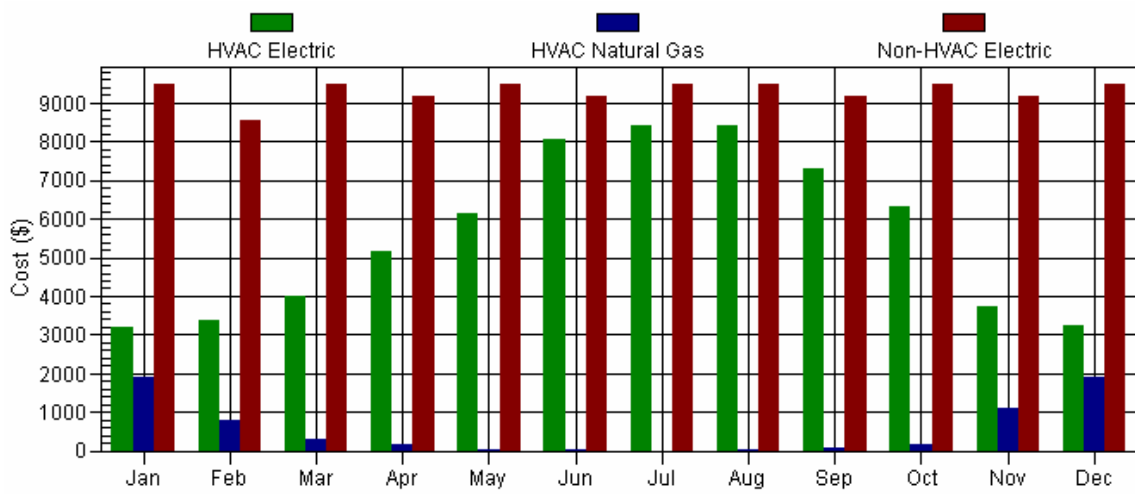
MISCELLANEOUS COST DATA



Annual Cost by Energy Type



Monthly Cost by System Component



Monthly Cost by Energy Type