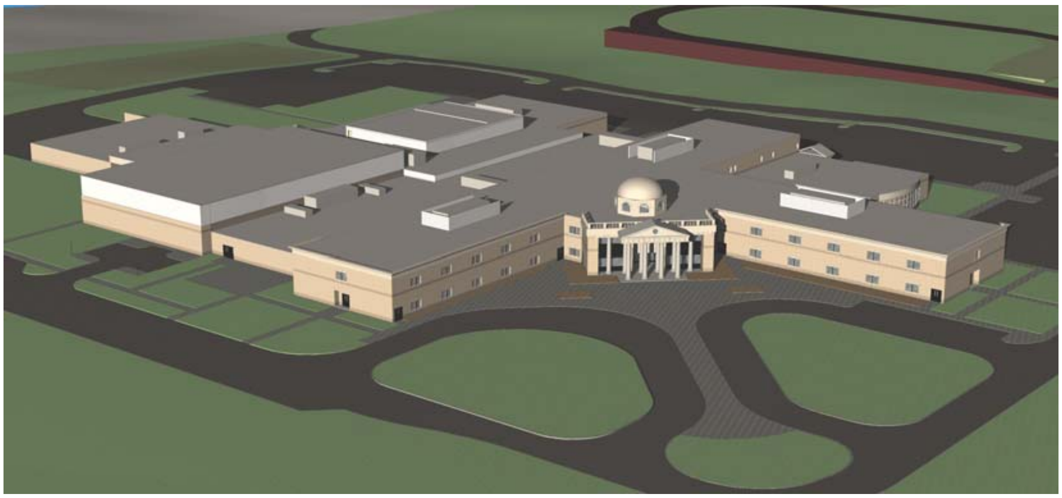
Technical Assignment 3
Mechanical System Existing Conditions Report



South Jefferson High School
Huyett Road
Charles Town, WV 25414

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Mechanical Option

Tuesday, November 21, 2006

1.0 Table of Contents

2.0 Executive Summary:

This report develops a detailed existing mechanical systems evaluation of South Jefferson High School. The analysis of the existing systems shows specific areas in which the building can be improved with possible re-design or modification.

In order to provide orientation and makeup of the building, a short summary of the general building background is provided at the beginning of the report. Followed by, information on the original mechanical systems design objectives and requirements. Next, the report shows a thorough evaluation of the existing mechanical systems including quantities and specific cut sheet values of the buildings airside and waterside equipment, and a general analysis of the mechanical systems control logic.

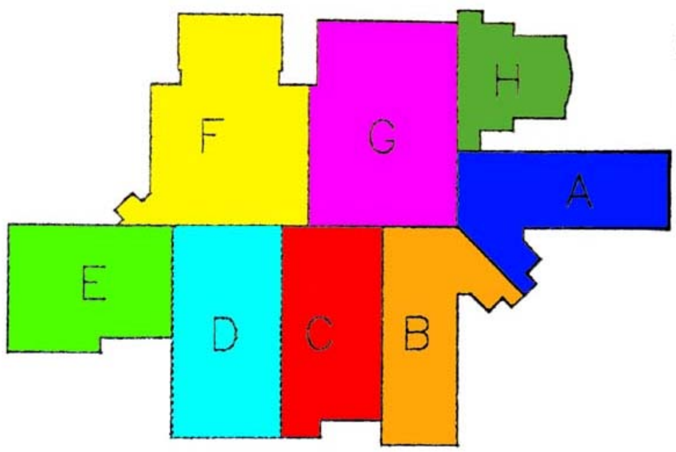
In the design ventilation requirements and design heating and cooling sections design requirements from which equipment was selected can be seen. The following sections of the report, lays out the economic cost data including mechanical system first cost and annual energy consumption and cost. Next, an evaluation of the buildings emissions and environmental impact is derived. The final section of this report, discusses the findings and potential improvement areas discovered in the mechanical systems existing conditions evaluation.

3.0 Building Background:

South Jefferson High School is a two story 232,705 s.f. secondary school utilized by 1200 students during the day, and a number of adult learners in the evening. The total capacity of the school is designed to accommodate up to 1500 students. The building is located in Charles Town, WV off of Route 1.

South Jefferson High School is broken into 8 separate zones named A thru H. The second floor is also broken into similar zones A, B, and G. The designation of each of these areas can be seen in Figure 1. The school has academic wings (1st Flr A & B, and 2nd Flr A), administration area (1st Flr A & B), and common facilities (1st Flr C thru H) for use by all students. Common facilities such as the Learning Resource Center (1st Flr G), dining (E), physical education (C & D), and creative arts (F) are accessible from the main corridors. The school's administrative offices and Student Services are located near the main entrance.

Figure 1 – South Jefferson High School Zone Designations



The Science (2nd Flr G) and Technology Center (2nd Flr B) is partially funded by a separate grant, this portion of the building includes the School's Science Department along with various technology oriented subject areas such as technology training labs, technology education, engineering, agricultural technology, and video conferencing. During regular school hours, the center supports the academic curriculum. In the evenings, the facilities will be available for continuing education classes open to the community at large.

The South Jefferson School District also plans to make the Learning Resource Center and computer facilities available to the community after normal school hours as well. Thus the community at large will have access to up-to-date facilities for instruction, research, and application that are not currently available in the School District.

4.0 Mechanical Systems Design Objectives and Requirements:

H. F, Lenz Company was the mechanical design engineer for South Jefferson High School. The influencing factors in their decision to select variable air volume roof top units and two electric boilers were first cost and ease of maintenance for the facilities staff. The amount of rooftop HVAC equipment is minimized as much as possible to ensure good access for maintenance and to maximize equipment life. The mechanical systems were also made as energy efficient as practical. All HVAC system components were designed to meet the requirements of the following codes and standards:

- International Building Code 2000
- International Mechanical Code 2003
- NFPA 101 Life Safety Code
- ASHRAE Standard 62.1-2001n
- ASHRAE Standard 90.1
- Americans with Disabilities Act
- West Virginia State Fire Code

Several energy conservation methods were incorporated by the mechanical engineer on South Jefferson High School. Savings coming in the forms of air-side economizer “free cooling”, variable volume pumping and fans, and minimizing necessary ventilation air through the use of demand based control. The design engineer also proposed energy recovery ventilators, in an alternate bid, in order to recover heat energy. The idea was negated because of other cost concerns. The architectural costs came in over budget resulting in price cuts in the mechanical design. Part of the reason that costs were coming in over budget resulted from the price increases of steel and copper at the time. These prices increase by 20 to 30 percent because of the demand for these materials in China and Indonesia. The state of West Virginia allotted cost per square foot, which is already lower than most states, was not altered to allow for higher costs even though these essential material prices were increasing.

4.1 Design Indoor and Outdoor Conditions:

ASHRAE design conditions for West Virginia are as follows:

- Cooling OA Conditions: 87 DB/75 WB
- Cooling RA Conditions: 75 DB/64 WB
- Design Heating OA Conditions: 0 DB
- Design Heating RA Conditions: 70 DB

The return air design temperatures are 70 /75 DB, heating and cooling shown consecutively, in all conditioned spaces while semi-conditioned spaces are allowed to drift 10 degrees to 60 /85 DB. This drift allows for energy savings.

The humidity levels in the Charles Town area are relatively high. No additional means of removing humidity was taken incorporated into the systems design. Only the rooftop units cooling coils provide dehumidification of the air. A desiccant or enthalpy wheel can be incorporated to help control humidity in the supply air. Controlling humidity would improve thermal comfort and indoor air quality with in the building. It has been show in studies that improving these two areas can increase performance of students and lower absenteeism. Table 1 shows humidity profile data for a variety of spaces. There are a number of rooms in need of humidity control, most being the densely populated spaces.

SYSTEM HUMIDITY PROFILES

	---- Maximum----				------------- Number of Hours at each Percentage Range -------------											
Room Description	%Rh	Mo	Hr	Day	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30 %
CORRIDOR H112	71	8	8	2	176	245	671	449	739	1,237	1,162	1,034	829	628	626	964
VICE PRIN B107	64	1	7	1	0	0	0	8	306	1,128	1,991	2,191	1,050	935	529	622
COMPUTER LAB G103	92	1	11	1	0	0	0	0	337	505	1,590	1,810	1,052	1,172	635	1,659
KEYBOARDING LAB G110	87	1	10	1	0	0	0	118	411	546	1,583	1,696	957	1,166	707	1,576
LAB CADD G116	88	1	11	1	0	0	0	0	213	548	1,516	1,829	1,067	1,086	786	1,715
BUSINESS CLASSROOM G110	100	1	14	1	0	103	462	489	757	1,842	1,602	1,049	1,009	564	374	509
PREP G118A	90	1	18	1	0	0	0	0	0	0	576	2,661	1,631	1,186	1,073	1,633
FORENSICS LAB G118	67	1	9	1	0	0	0	0	0	586	2,144	1,671	913	1,261	602	1,583
VISUAL COMM PRODN LAB G11	57	1	6	1	0	0	0	0	0	293	1,939	1,717	947	1,039	912	1,913
CONTROL ROOM G120	58	1	6	1	0	0	0	0	0	416	2,010	1,616	947	998	943	1,830
OFFICE TECH LAB G109	87	1	10	1	0	0	0	118	411	546	1,583	1,696	957	1,166	707	1,576
SCHOOL STORE G105	100	12	24	2	1,327	4	36	9	50	11	614	3,871	1,449	861	281	247
INFO TECH REPAIR LAB G124	100	1	12	1	0	0	203	479	372	1,025	1,967	1,327	935	890	642	920
OFFICE G104A	71	1	12	1	0	0	0	0	0	0	547	2,543	1,529	942	1,041	2,158
RECEPTION B103C	100	8	7	2	3,276	748	655	524	580	761	762	446	409	206	273	120
CORRIDOR D102	77	8	7	2	948	396	262	591	755	855	971	973	680	717	631	981
CORR H112	72	8	8	2	204	260	651	437	611	1,113	1,253	950	842	746	646	1,047
LOBBY B101	64	9	7	1	0	0	172	290	975	1,242	1,696	1,140	982	644	515	1,104
CORRIDOR A133	77	8	7	2	948	396	262	591	755	855	971	973	680	717	631	981
CORRIDOR B134	77	8	7	2	948	396	262	591	755	855	971	973	680	717	631	981
CORRIDOR B133 AHU3	61	8	13	8	0	0	0	806	751	1,238	1,397	1,164	936	656	725	1,087
FACILITY PLANNING B114	71	7	10	2	10	101	243	1,290	1,673	1,320	1,344	612	888	645	313	321
LOUNGE B114A	81	12	9	2	59	260	700	770	1,443	2,311	1,357	731	554	217	235	123
PHYSICS LAB G207	58	5	14	1	0	0	0	0	36	250	1,163	2,052	1,738	1,462	1,107	952
INSTRUCTOR PLANNING G101	73	1	6	1	114	288	378	537	564	1,450	1,231	918	853	591	519	1,317
CORR G125	59	1	8	2	0	0	0	74	1,747	965	118	814	4,303	680	59	0
STAGE BACKSTAGE F125	58	6	14	1	0	0	0	0	0	126	379	522	890	1,809	1,638	3,396
UNIVERSAL LAB G208	58	5	14	1	0	0	0	0	18	236	1,286	2,161	1,996	1,185	1,074	804
UNIVERSAL LAB G209	58	5	14	1	0	0	0	0	36	280	1,288	2,387	1,741	1,099	1,106	823
UNIVERSAL LAB G210	58	5	14	1	0	0	0	0	36	280	1,288	2,387	1,741	1,099	1,106	823
UNIVERSAL LAB G211	58	5	14	1	0	0	0	0	36	271	1,349	2,382	1,726	1,109	1,052	835
UNIVERSAL LAB G212	58	5	14	1	0	0	0	0	62	326	1,141	2,457	1,721	1,132	1,037	884
PREP ROOM G208A	56	1	7	1	0	0	0	0	0	0	1,179	2,288	1,695	1,832	739	1,027
PREP G210A	56	1	7	1	0	0	0	0	0	36	891	2,341	1,891	1,335	1,151	1,115
PREP ROOM G212A	56	1	7	1	0	0	0	0	0	0	552	2,064	2,241	1,584	1,359	960
UNIVERSAL LAB G213	58	5	14	1	0	0	0	0	62	326	1,141	2,457	1,721	1,132	1,037	884
MARKETING CLASSROOM G104	100	1	14	1	261	414	633	613	1,089	1,888	1,164	941	640	475	373	269
CORR G126	55	1	6	1	0	0	0	0	0	51	204	1,583	2,302	1,353	1,205	2,062
SPL ED OFFICE	88	8	7	2	1,916	544	555	666	891	672	404	810	853	488	365	596
CORR G128	54	1	1	1	0	0	0	0	0	0	0	1,458	2,219	1,183	1,037	2,863

Table 1 – System Humidity Profile

5.0 Mechanical Systems Summary:

The HVAC system primarily consists of multi-zone variable air volume rooftop units (RTU) serving series-style fan powered boxes at classrooms. The classroom wings have rooftop units with ductwork chased down through rated shafts for outside air to a fan powered box at each classroom. The fan powered box serve ceiling mounted diffusers.

The Gymnasium, Auditorium and Cafeteria are served with single-zone air handling units located on the roof. These units incorporate demand-based ventilation controls controls in the form of CO_2 sensors.

All heating-only equipment such as cabinet unit heaters and horizontal unit heaters are installed in mechanical spaces, entry vestibules, and similar areas. The heating-only equipment, rooftop unit heating coils, and auxiliary heating coils are served by hot water generated by two electric boilers.

5.1 Air Side Mechanical Systems:

Cooling of South Jefferson high school is done by the school's 14 packaged roof top units (RTU) with condensing units, ranging in size from 4,500 cfm to 25,500 cfm. All refrigeration coils are direct-expansion instead of chilled water. This eliminates the need for chillers in the plant and chilled water piping throughout the building. Design airflow quantities for all roof top units can be seen below in Table 2.

Symbol	Variable or Constant Volume	Supply Air (CFM)	Design Outdoor Air (CFM)	OA Percent (%)	Cooling Airflow (CFM)	Heating Airflow (CFM)	Return Airflow (CFM)
RTU-8	CV	4,500	1,200	26.7	3,337	3,337	3,337
RTU-2	VV	25,500	10,600	41.6	20,877	22,605	22,605
RTU-3	VV	13,000	3,600	27.7	10,231	3,069	10,231
RTU-4	VV	24,000	10,500	43.8	18,776	18,840	18,840
RTU-5	CV	14,000	14,000	100.0	11,273	11,276	11,276
RTU-6	VV	12,000	2,700	22.5	6,993	7,156	7,156
RTU-7	VV	15,000	6,400	42.7	12,521	12,979	12,979
RTU-1	VV	22,000	9,600	43.6	1,951	19,741	19,741
RTU-9	CV	9,000	8,000	88.9	7,950	7,950	7,950
RTU-10	CV	13,000	7,500	57.7	9,963	9,963	9,963
RTU-11	CV	6,000	4,670	77.8	3,581	3,581	3,581
RTU-12	CV	12,000	12,000	100.0	7,448	7,448	7,448
RTU-13	CV	9,500	5,500	57.9	9,375	9,375	9,375
RTU-14	CV	9,500	5,500	57.9	9,662	9,662	9,662
Totals:		**184,500**	**100,570**		**130,601**	**143,645**	**150,807**

Table 2 - Design Airflow Quantities

A central cooling plant could be useful for South Jefferson High School. If two 300 ton chillers were installed to replace the existing condensing units, the reduction in kW/ton would help save energy, reducing annual energy consumption and cost.

5.2 Boilers and Hot Water Systems:

Heating-only equipment, hot water coils in the RTU's, plus auxiliary heating coils scattered throughout South Jefferson High School are heated hydronically by two identical hot water boilers. These boilers are designed for heating by electric resistance. Electric boiler data can be seen in Table 3.

Symbol	Total KW Input	Total Load Amps	MBH Output	Steps of Control	Elect Char	EWT ºF	LWT ºF
BLR-1	1,440	1,742	4,717	16	460V/3PH/60HZ	150	180
BLR-2	1,440	1,742	4,717	16	460V/3PH/60HZ	150	180

Table 3 – Electric Boiler Data

The heating system also incorporates a primary-secondary pumping system. Two primary and two secondary (building loop) system water pumps were installed. The pumps are provided with variable frequency controllers to offer an energy-saving variable flow system. Pump data can be seen in Table 4 below.

Symbol	Type	System	GPM	FT HD	Efficiency	Motor HP	Impellar Dia.	VFD	Operation
P-1	In Line	HWS/R	310	30	74.6	5	6.875"	No	Primary Duty
P-2	In Line	HWS/R	310	30	74.6	5	6.875"	No	Primary Duty
P-3	Flr Mtd	HWS/R	750	80	78.8	25	10.750"	Yes	Secondary Duty
P-4	Flr Mtd	HWS/R	750	80	78.8	25	10.750"	Yes	Secondary Standby

Table 4 – Pump Data

5.3 Mechanical Systems Controls:

All sequences of controls for the entire building are performed by direct digital controls (DDC). This DDC system monitors all the sensors, and it is able to adjust all the set points and time delays for the equipment. The DDC system also provides start/stop, speed control, monitoring, and alarms for the variable frequency drives (VFD). A few controls can be seen in the flow diagrams in Appendix

6.0 Design Ventilation Requirements:

After following the multiple zone calculation procedure outlined in ASHRAE Standard 62.1-2004 section 6.2.2, it was determined that all roof top units at South Jefferson High School are compliant with ASHRAE 62.1-2004 ventilation requirements. In total they require approximately 89,555 cfm and have a capacity of 101,770 cfm. Ventilation values can be seen in Table 1 in section 5.1 Air Side Mechanical Systems.

7.0 Design Heating and Cooling:

Calculated HEATING capacities of the 14 roof top units were developed in the Trane TRACE 700 software and can be seen in Table 4.

Building Plant Capacities

		Peak Loads	
Plant	**System**	**Main Coil MBh**	**Preheat Coil MBh**
Heating plant - 001		3,555	2,299
	AHU-8	0	0
	AHU-2	128	566
	AHU-3	153	125
	AHU-4	51	381
	AHU-5	237	125
	AHU-6	71	96
	AHU-7	104	298
	AHU-1	112	504
	AHU-9	571	0
	AHU-10	533	0
	AHU-11	86	0
	AHU-12	147	205
	AHU-13	668	0
	AHU-14	695	0

Building peak load is 5,910.9 MBh.

Table 4 – Design Heating Loads

The total building peak heating load is for the air handling units is 5,910.9 MBh. this heating load is handled by two 4,717 MBh boilers totaling 9,434 Mbh. This is approximately 63 percent of the total boiler capacity. Additional loads of the auxiliary heating coils and heating-only equipment are not incorporated in the table above, but the boiler capacity is large enough to handle these loads. The boilers could be simulated and optimized to provide more energy efficient equipment.

Calculated cooling capacities of the packaged DX roof top units were developed in the Trane TRACE 700 software and can be seen in Figure 2.

		Peak Plant Loads		Block Plant Loads		
Plant	System	Main Coil ton	Peak Total ton	Time Of Peak mo/hr	Main Coil ton	Block Total ton
Cooling plant - 001		585.9	590.4	7/12	573.2	577.7
	AHU-8	6.4	10.9	7/12	6.4	10.9
	AHU-2	82.4	82.4	7/12	81.5	81.5
	AHU-3	30.2	30.2	7/12	30.2	30.2
	AHU-4	68.1	68.1	7/12	68.1	68.1
	AHU-5	40.7	40.7	7/12	40.7	40.7
	AHU-6	20.5	20.5	7/12	20.5	20.5
	AHU-7	49.3	49.3	7/12	47.5	47.5
	AHU-1	72.7	72.7	7/12	72.7	72.7
	AHU-9	37.1	37.1	7/12	36.6	36.6
	AHU-10	42.2	42.2	7/12	42.2	42.2
	AHU-11	10.0	10.0	7/12	4.5	4.5
	AHU-12	32.6	32.6	7/12	32.6	32.6
	AHU-13	46.1	46.1	7/12	44.4	44.4
	AHU-14	47.6	47.6	7/12	45.4	45.4
Building totals		585.9	590.4		573.2	577.7

Building peak load is 590.4 tons.
Building maximum block load of 577.7 tons occurs in July at hour 12 based on system simulation.

Table 5 – Design Cooling Load

The total peak load cooling tonnage is 590.4 tons. This load is handled completely by the roof top units condensing units. Potential for a central plant exists in which the condensing units could be replaced by two 300 ton chillers. This would result in a significant annual energy savings, but would also reduce rentable space of the building.

8.0 Mechanical System First Cost:

The data and information required for the mechanical system first cost was provided by Turner Construction Company, who is the construction manager for the South Jefferson High School project.

The data shows the results of four independent cost estimates, three being mechanical contractor bids and one from the construction manager. The initial mechanical system costs range from $4.78 million to the low bid of $4.22 million.

These total first cost were then calculated into the price per square foot. The cost per square foot was found to be $20.98/sf for the lowest mechanical contractor bid, as is shown in Figure 2.

Figure 2 – HVAC System First Cost

Mechanical System First Cost		
Company	**Bid**	**$/SF**
CM Estimate	$4,324,601.00	$21.49
Bid 1	$4,780,000.00	$23.76
Bid 2	$4,245,000.00	$21.10
Bid 3	$4,222,200.00	$20.98

These values fall within the allotted limit to mechanical systems of the project's budget of the. Here it can also be seen that the mechanical cost is approximately 13% of the total $33 million cost.

A breakdown of all the various components in the construction manager's mechanical cost estimate has also been included in Appendix C.

In a redesign or modification of South Jefferson High School a thorough cost estimate of alternate or modified systems must be calculated. More energy efficient systems typically cost more initially but will save the owner money in the long run,

9.0 Annual Energy Consumption:

Since South Jefferson High School is currently under construction utility values from the site are not available. All energy consumption values will be obtained from an energy model.

H.F. Lenz Co. did not perform an energy analysis on South Jefferson High School. Instead the design engineer reviewed possible systems with the owner, showing energy data from other similar projects. The mechanical system was selected on the basis that it was familiar to the maintenance staff.

To perform the energy analysis calculations, Trane Trace 700 was used to model South Jefferson High School. Weather data was taken from ASHRAE Handbook of Fundamentals – 2005, with the nearest city to Charles Town, WV being Martinsburg, WV. All conditioned spaces, equipment, and systems, were entered into the Trane TRACE model in accordance to design.

Results of the annual energy consumption calculations can be seen in Figure 3.

Figure 3 –HVAC Annual Energy Cost Estimation (Btu)

	Fuel	Energy 10^6 Btu/yr	Cost $/yr	Cost Percent %	Peak kBtuh
Lighting -Conditioned	Elect.	1520.1	$53,087.52	25	672
Space Heating	Elect.	723.2	$25,255.66	12	3255
Space Cooling	Elect.	952.3	$33,257.84	16	2071
Pumps	Elect.	45.3	$1,582.04	1	11
Heat Rejection	Elect.	131.0	$4,575.00	2	844
Fans - Conditioned	Elect.	1702.0	$59,440.14	28	844
Receptacles - Conditioned	Elect.	917.8	$32,052.97	15	466
Total Building - Consumption		**5991.7**	**$209,251.17**	100.00	

Annual Cooling Cost per SF: $0.15/yr/sf

A significant amount (25%) of the annual energy consumption is conditioning of lighting. If a lower watt per square foot values were maintained for lighting the energy savings would considerably help annual energy costs. A summary of the total lighting fixture wattage calculation is provided in Appendix B.

Although it was proposed, no energy recovery was used for South Jefferson High School. Energy recovery would impact the annual energy costs and should be considered for possible redesign or modification of the system.

10.0 Emissions:

South Jefferson High School will have no on-site energy emissions because of all electric utility usage. Emissions will be located back at the utility source's site. Emissions were found by using the Environmental Protection Agency's Energy Star Target Finder tool. Annual energy values were approximated resulting in emission rates that are also approximate. Figure 4 show results for source energy usage using the Energy Star analysis software.

Figure 4 – Source energy usage for various Energy Star targets

DESIGN ENERGY PERFORMANCE RESULTS

Energy	DESIGN	ENERGY STAR
EPA Energy Performance Rating (1 – 100)	68	75
Percent Energy Reduction (%)[2]	17	21
Site Energy Use Intensity (kBtu/sf/yr)	30.1	28.8
Total Annual Site Energy (kBtu)	7,000,000	6,703,197
Total Annual Energy Cost ($)	$ 200,410	$ 191,913
Pollution Emissions (1000 lbs/yr)		
CO_2	4,354	4,129

Target Energy Performance Results (estimated)

Energy	Design	Target	Top 10%
Energy Performance Rating (1-100)	68	80	90
Energy Reduction (%)	17	27	41
Source Energy Use Intensity (kBtu/Sq. Ft./yr)	90.6	79.9	64.7
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	30.1	26.5	21.5
Total Annual Source Energy (kBtu)	21,091,000.1	18,600,867.2	15,059,532.4
Total Annual Site Energy (kBtu)	7,000,000.0	6,173,537.1	4,998,185.3
Total Annual Energy Cost ($)	$ 200,410	$ 176,748	$ 143,098

Method to improve the environmental impact of South Jefferson High School should be considered in redesign or modification. CO_2 emissions could be reduced by lowering kW per ton values of equipment. Fuel-oil could also be taken into consideration as an alternate fuel source. It would be more efficient than running electricity but would cause on-site emissions. Other alternative fuel sources are not currently available to the site.

11.0 Discussion:

There are many areas in which redesign or modification of the South Jefferson High School mechanical systems reduce cost, energy, thermal comfort, indoor air quality, or emissions. The current trend in the industry is to make buildings sustainable and as green as possible. Taking this into consideration the most feasible route in potential redesign or modification of the buildings mechanical systems is reducing annual energy costs. This approach will most likely result in a higher first cost of the mechanical system, but payback from energy savings will help future costs and provide the school district with additional money to improve other aspects of concern. If the energy consumption is reduced the building and source emissions should come down. After energy savings, the improvement of thermal comfort and indoor air quality should be looked at in redesign or modification. If this is done, enhanced performance by students will ensure the schools longevity and possibly allow for additional government funding,

12.0 References:

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APPENDIX A: Energy Model Data

Schedules:

- Regular school hours were assumed to be 7am to 5pm and between the months of August to June
- Administrative offices and classrooms follow regular school hours
- Cafeteria was assumed to be fully occupied between 11am and 1pm
- Gymnasium and Technology/Adult learning areas were assumed to have extended hours until 8pm and occupancy year round

Note: Utilization schedules were designed with the designer's best judgment, because no utilization data was provided.

Electricity Cost:

Demand Charge

First 3,000 kVA .... $7.923 per kVA

Next 14,000 kVA .... $7.456 per kVA

Additional kVA .... $7.104 per kVA

Energy Charge

All kW .... $0.02198 per kW

Loads:

People: Varies depending on activity level

Computers

Kitchen Equipment

Receptacle

Lighting

Miscellaneous Loads

HVAC Annual Energy Cost Estimation (kW)

	Fuel	Energy 10^6 Btu/yr
Lighting -Conditioned	Elect.	445515.83
Space Heating	Elect.	211948.03
Space Cooling	Elect.	279103.17
Pumps	Elect.	13276.671
Heat Rejection	Elect.	38393.904
Fans - Conditioned	Elect.	498827.67
Receptacles - Conditioned	Elect.	268991.79
Total Building - Consumption		1756057.1

APPENDIX B: Lighting Power Calculations

Section 1: Allowed Lighting Power Calculation

A	B Floor Area	C Allowed Watts / ft2	D Allowed Watts
School/University	232705	1.2	279246
		Total Allowed Watts =	279246

Section 2: Actual Lighting Power Calculation

A Fixture ID : Description / Lamp / Wattage Per Lamp / Ballast	B Lamps/ Fixture	C # of Fixtures	D Fixture Watt.	E (C X D)
Linear Fluorescent 1: RF-1: 3 - 32W T8 / Other / Electronic	3	500	96	48000
Linear Fluorescent 2: RF-2: 2 - 32W T8 / Other / Electronic	2	317	64	20288
Linear Fluorescent 3: RF-3: 3 - 32W T8 / Other / Electronic	3	160	96	15360
Linear Fluorescent 4: RF-4: 2 - 26W TRT / Other / Electronic	2	35	52	1820
Linear Fluorescent 5: RF-5: 3 - 32W T8 / Other / Electronic	3	118	96	11328
Linear Fluorescent 6: RF-6: 3 - 32W T8 / Other / Electronic	3	41	96	3936
Linear Fluorescent 7: RF-7: 2 - 26W TRT / Other / Electronic	2	90	52	4680
Linear Fluorescent 8: RF-8: 2 - 26W TRT / Other / Electronic	2	43	52	2236
Linear Fluorescent 9: RF-9: 2 - 26W TRT / Other / Electronic	2	53	52	2756
Linear Fluorescent 10: RF-10: 3 - 26W TRT / Other / Electronic	3	12	78	936
Linear Fluorescent 11: RF-11: 2 - 32W T8 / Other / Electronic	2	14	64	896
Linear Fluorescent 12: RF-12: 3 - 32W T8 / Other / Electronic	3	37	96	3552
Linear Fluorescent 13: RF-13: 4 - 32W T8 / Other / Electronic	4	7	128	896
Linear Fluorescent 14: RF-14: 6 - 32W T8 / Other / Electronic	6	53	192	10176
Linear Fluorescent 15: SF-1: 2 - 32W T8 / Other / Electronic	2	1	64	64
Linear Fluorescent 16: SF-2: 3 - 32W T8 / Other / Electronic	3	8	96	768
Linear Fluorescent 17: SF-3: 1 - 26W TRT / Other / Electronic	1	1	26	26
Linear Fluorescent 18: WSF-1: 1 - 26W TRT / Other / Electronic	1	3	26	78
Incandescent 1: WSI-1: 100W INCAND / Incandescent 100W	1	1	100	100
Linear Fluorescent 19: DF-1: 2 - 32W T8 / Other / Electronic	2	122	64	7808
Linear Fluorescent 20: DF-2: 3 - 32W T8 / Other / Electronic	3	17	96	1632
Linear Fluorescent 21: DF-3: 2 - 32W T8 / Other / Electronic	2	68	64	4352
Linear Fluorescent 22: DF-4: 3 - 32W T8 / Other / Electronic	3	12	96	1152
Linear Fluorescent 23: DF-5: 5 - 54W T5 / Other / Electronic	5	34	270	9180
Linear Fluorescent 24: DF-6: 1 - 32W TT / Other / Electronic	1	12	32	384
HID 1: DI-1: 500W QUARTZ / Other / Magnetic	1	32	500	16000
HID 2: DI-2: 250W QUARTZ / Other / Magnetic	1	22	250	5500
HID 3: RMH-1: 100W MH/100W QUARTZ / Metal Halide 100W / Magnetic	1	14	200	2800
HID 4: RMH-2: 100W MH / Metal Halide 100W / Electronic	1	15	100	1500
HID 5: RMH-3: 100W MH / Metal Halide 100W / Electronic	1	33	100	3300
HID 6: WMH-1: 175W MH/100W QUARTZ / Metal Halide 175W / Electronic	1	15	275	4125
HID 7: WMH-2: 175W MH / Metal Halide 175W / Electronic	1	26	175	4550
HID 8: SL-1: 400W MH / Metal Halide 400W / Magnetic	1	1	400	400
HID 9: SL-2: 100W MH / Metal Halide 100W / Electronic	1	1	100	100
Linear Fluorescent 1 copy 1: RF-1: 3 - 32W T8 / Other / Electronic	3	237	96	22752

Note: Calculated using the COMcheck Software Version 3.3.1 Lighting Application Worksheet

APPENDIX C: Breakdown – Mechanical First Cost

060 HVAC			
060-015 Air Side Equipment			
15730.000 Unitary Air Conditioning Equipment			
Ductless Split System @ Data Rooms	7 ea	3,335.74	23,350
15730.000 Unitary Air Conditioning Equipment			**23,350**
15830.000 Fans			
Exhaust Fans	1 alw	7,500.00	7,500
Allowancew for special exhaust at Science and Shops	1 alw	10,000.00	10,000
15830.000 Fans			**17,500**
060-015 Air Side Equipment			**40,850**
060-020 Cooling Equipment			
15620.000 Packaged Water Chillers			
Water chillers, recip, int air cooled cond, 100 ton cooling	1 ea	106,235.56	106,236
Water Chiller, recip, air cooled cond. 250 ton cooling	2 ea	116,032.41	232,065
15620.000 Packaged Water Chillers			**338,300**
15720.000 Air Handling Units			
Air-Handling Unit 1, 2, & 4, 30,000 CFM	3 ea	103,392.98	310,179
Air-Handling Unit 7, 28,000 CFM	1 ea	97,362.75	97,363
Air-Handling Unit 5, 25,000 CFM	1 ea	87,302.29	87,302
Air-handling Unit 12, 18,000 CFM	1 ea	63,272.06	63,272
Air-Handling Unit 3, 16,000 CFM	1 ea	56,181.38	56,181
Air-Handling Unit 6 & 10, 10,000 CFM	2 ea	35,151.14	70,302
Air-Handling Unit 9, 8000 CFM	1 ea	28,120.92	28,121
Air Handling Unit 11, 7500 CFM	1 ea	26,090.69	26,091
Air-Handling Unit 13, 14, 15, & 16 6000 CFM	4 ea	21,090.69	84,363
Air-Handling Unit 8, 4500 CFM	1 ea	15,060.46	15,060
15720.000 Air Handling Units			**838,235**
060-020 Cooling Equipment			**1,176,535**
060-025 Heating Equipment			
15130.000 Pumps			
Heating hot water supply/return pumps	2 ea	5,870.83	11,742
Chilled water supply/return pumps	5 ea	5,870.82	29,354

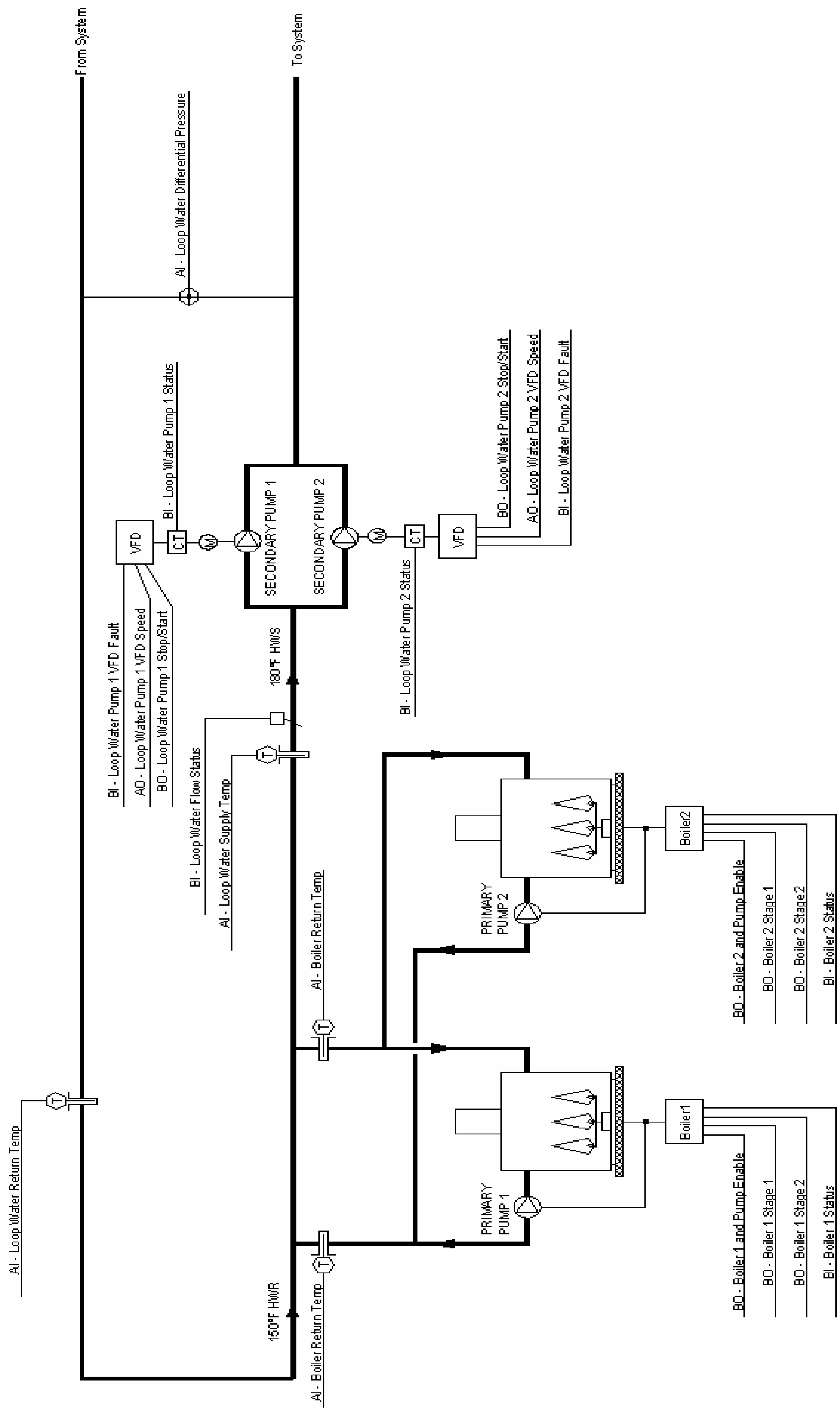
APPENDIX C: Breakdown – Mechanical First Cost (Cont'd)

15130.000 Pumps			**41,096**
15510.000 Heating Boilers and Accessories			
Boilers, Electric 1000 KW	3 ea	25,810.89	77,433
Expansion Tank	4 ea	2,102.64	8,411
Air Separator	1 ea	1,820.73	1,821
Chemical Feeder/Treatment	1 ls	10,000.00	10,000
Boilers, Control Panel	1 ea	6,888.17	6,888
Dom. H.W. Storage Heater (350 Gal.)	2 ea	2,077.51	4,155
15510.000 Heating Boilers and Accessories			**108,707**
15760.000 Terminal Heating and Cooling Units			
VAV Fan Powered Boxes	105 ea	1,406.05	147,635
15760.000 Terminal Heating and Cooling Units			**147,635**
15770.000 Floor-Heating and Snow-Melting Equipment			
Cabinet Unit Heaters, with fan, 120V, surf mtd, 2,250 W	5 ea	1,189.18	5,946
Horizontal Unit Heaters, with fan, 120V, ceiling mtd,	6 ea	1,189.18	7,135
15770.000 Floor-Heating and Snow-Melting Equipment			**13,081**
060-025 Heating Equipment			**310,519**
060-030 Ductwork			
15810.000 Ducts			
Duct, rect, incl ftg, supports	250,000 lb	5.09	1,273,606
Duct accessories, fire damper	10 ea	215.51	2,155
Duct accessories, volume damper	50 ea	275.08	13,754
Duct accessories, motorized damper	1 ea	515.51	516
Duct accessories, Specialties	1 ls	19,620.51	19,621
Floor Penetrations - cutting, patching and firestopping	1 ls	9,620.51	9,621
15810.000 Ducts			**1,319,271**
15850.000 Air Outlets and Inlets			
Diffusers, Grilles and Registers	1,150 ea	153.21	176,186
Louvers	1 ls	10,000.00	10,000
Roof Ventilator, base, damper&bird scr, sta mushroom, 42" orifice dia	16 ea	1,267.65	20,282

APPENDIX C: Breakdown – Mechanical First Cost (Cont'd)

15850.000 Air Outlets and Inlets			**206,468**
060-030 Ductwork			**1,525,740**
060-035 HVAC Piping			
15105.000 Pipes and Tubes			
Pipe, HWS & HWR with fittings and supports	12,500 lf	38.00	475,000
Pipe, Refrigerant with fittings and supports	1,500 lf	38.00	57,000
Pipe, CWS & CWR with fittings and supports	9,875 lf	38.00	375,250
15105.000 Pipes and Tubes			**907,250**
060-035 HVAC Piping			**907,250**
060-040 HVAC Insulation			
15080.100 Duct Insulation			
Duct Insulation	1 ls	50,000.00	50,000
Piping Insulation	1 alw	15,000.00	15,000
Insulation Equipment	1 ls	5,000.00	5,000
15080.100 Duct Insulation			**70,000**
060-040 HVAC Insulation			**70,000**
060-045 Testing, Balancing & Commissioning			
15950.000 Testing, Adjusting, and Balancing			
Test & balance	180 hr	125.00	22,500
15950.000 Testing, Adjusting, and Balancing			**22,500**
060-045 Testing, Balancing & Commissioning			**22,500**
060-050 HVAC Controls			
15935.000 Building Systems Controls			
Building Systems Controls	1 ls	460,000.00	460,000
15935.000 Building Systems Controls			**460,000**
060-050 HVAC Controls			**460,000**
060-060 HVAC Miscellaneous			
15050.000 Basic Mechanical Materials and Methods			
Hvac mech equip, concrete pads	1 ls	5,000.00	5,000
Hvac mech equip, Comb. Starters & Disc. Switches	12 ea	1,200.00	14,400
15050.000 Basic Mechanical Materials and Methods			**19,400**
060-060 HVAC Miscellaneous			**19,400**
060 HVAC	**232,705 sf**	**19.48**	**4,532,793**

APPENDIX D: Heating Plant Flow Diagram



APPENDIX E: Air Side Flow Diagram