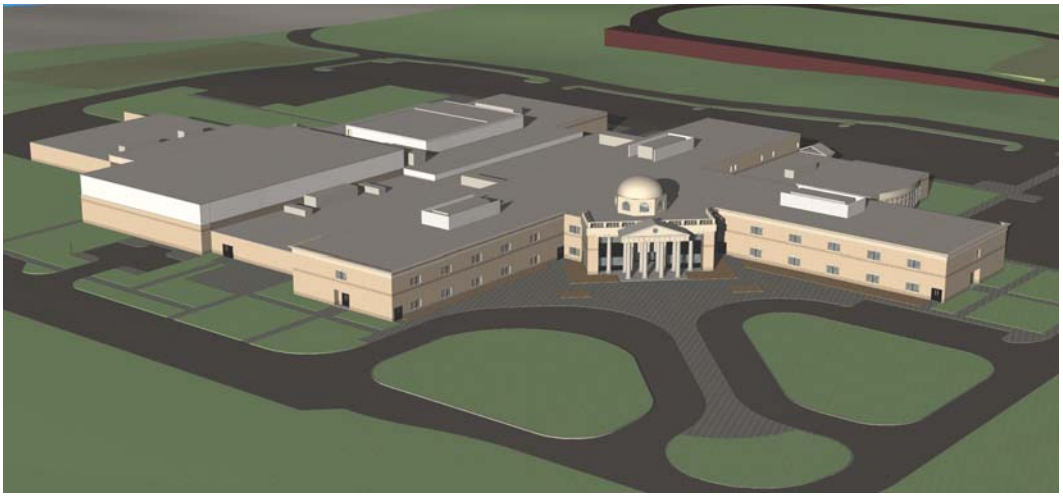
Technical Assignment 2

Building and Plant Energy Analysis Report



South Jefferson High School

Huyett Road
Charles Town, WV 25414

Prepared for Dr. Jelena Srebric
The Pennsylvania State University

By
Jonathon Gridley
Mechanical Option

Friday, October 27, 2006

Table of Contents

Executive Summary:

This report develops a detailed energy analysis of South Jefferson High School. Several different approaches to examining the buildings energy compliance are employed.

The U.S. Green Building Council's LEED for New Construction version 2.2 rating system is used to look at all possible green aspects of South Jefferson High School. Although it was not designed to meet the LEED criteria, the evaluation shows it would be possible to receive 28 out of a possible 69 points obtaining enough points for the building to be LEED Certified.

ASHRAE Standard 90.1-2004 is another non-mechanical energy performance baseline to help building energy efficiency. South Jefferson complies with the envelope, lighting, and mechanical system criteria.

The total amount of lost rentable space was determined to be less than 7% of the total building floor area. The mechanical system first cost was calculated next. At a total cost of almost $4.22 million, this equates to $20.98 per square foot.

Trane's TRACE 700 was used as the energy modeling software to calculate the design loads and perform an energy analysis on South Jefferson High School. The results of this energy analysis showed that the building would use 1,756,057 kWh of energy each year.

Finally, an emissions analysis was performed on the school with its large yearly consumption of electric. The quantities of off-site pollutants of carbon dioxide emissions associated with on-site electricity use.

Introduction:

South Jefferson High School is a two story 232,705 s.f. secondary school utilized by 1200 students.

Building and Plant Systems and Equipment:

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. Calculated cooling capacities of the packaged DX roof top units were developed in the Trane TRACE software and can be seen in Figure 1.

Building Airside Systems and Plant Capacities

		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.

Figure 1 – Building Airside Systems and Plant Capacities

Hot water coils in the RTU's plus auxiliary heating coils scattered throughout South Jefferson High School are heated hydronically by two hot water boilers. These boilers are designed for heating by electric resistance. 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.

Introduction to LEED NC 2.2:

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System was established by the U.S. Green Building Council to improve the environmental and economic performance of new and existing commercial, institutional, and high-rise residential buildings.

The rating system consists of the following 6 major categories, and maximum points:

- Sustainable Sites: 14
- Water Efficiency: 05
- Energy and Atmosphere: 17
- Materials and Resources: 13
- Indoor Environmental Quality: 15
- LEED Innovation Credits: 05
- Total Maximum Possible Points: 69

Certification Levels:

- LEED Certified: 26-32 points or >37% of max.
- LEED Certified Silver: 33-38 points or >47% of max.
- LEED Certified Gold: 39-51 points or >56% of max.
- LEED Certified Platinum: 52-69 points or >75% of max.

The mechanical system of a building has and impact on the five of the major LEED categories:

1. Water Efficiency
2. Energy and Atmosphere
3. Materials and Resources
4. Indoor Environmental Quality
5. LEED Innovation Credits

There is potential for to almost be LEED certified with all of the points that can be generated by the mechanical system alone.

LEED NC 2.2 Analysis:

South Jefferson High School was not designed with the intent to improve the environmental and economic performance of the building by following the LEED rating system. For this report, a LEED checklist was formulated showing that the school had the potential to obtain LEED certification. The tally of a possible 28 points, as well as a description of how each point could be obtained is attached in Appendix D.

Introduction to ASHRAE Standard 90.1:

The purpose of this standard is to provide minimum requirements for the energy efficient design of buildings except low rise residential buildings.

ASHRAE Standard 90.1 requires energy efficiencies for building envelopes, lighting, HVAC systems, and service hot water. The provisions of this standard apply to a given building if the enclosed spaces are heated by a heating system whose output capacity is greater than or equal to 3.4 Btuh/SF. or cooled by a system whose sensible output capacity is greater than or equal to 5 Btuh/SF.

ASHRAE Standard 90.1 – Mechanical systems portion defines minimum efficiency requirements for HVAC equipment in a series of tables in Section 6.8. Tables 6.8.1A through 6.8.1G define requirements for equipment that is rated in accordance with an established test procedure.

- Table 6.8.1A: Air Conditioners and Condensing Units
- Table 6.8.1B: Heat Pumps
- Table 6.8.1C: Water Chilling Packages
- Table 6.8.1D: Packaged Terminal, Room Air Conditioners, and Heat Pumps
- Table 6.8.1E; Furnaces, Duct Furnaces, and Unit Heaters
- Table 6.8.1F: Boilers
- Table 6.8.1G: Heat Rejection Equipment

Note: Equipment not listed in the Standard 90.1 tables has no minimum performance requirements.

ASHRAE Standard 90.1 – Compliance:

In order to check for compliance of South Jefferson High under ASHRAE Standard 90.1, the Department of Energy COMcheck Software Version 3.3.1 was used. The output results of the building envelope compliance and lighting and power compliance are given below.

Building Envelope Compliance:

Section 3: Requirements Checklist

Envelope PASSES: Design 22% better than code.

Climate-Specific Requirements:

Component Name/Description	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Proposed U-Factor	Budget U-Factor
Roof 1: Insulation Entirely Above Deck	232705	---	20.0	0.048	0.063
Exterior Wall 1: Concrete Block:8", Unreinforced, Cells Empty,Normal Density , Furring: Metal	51696	5.0	10.0	0.068	0.151
Window 1: Metal Frame with Thermal Break:Double Pane, Clear, Operable, SHGC 0.79, PF 0.10	4643	---	---	0.615	0.670
Floor 1: Slab-On-Grade:Unheated	2000	---	---	---	---

(a) Budget U-factors are used for software baseline calculations ONLY, and are not code requirements.

Note: U and R-Values taken from Construction Documents and Specifications

Lighting and Power Compliance:

Interior Lighting:

❑ 1. Total actual watts must be less than or equal to total allowed watts.

Allowed Watts	Actual Watts	Complies
279246	213431	YES

Note: Calculations for Lighting and Power Compliance were computed using the building-area-method. Calculations are located in Appendix B of this report.

Mechanical Compliance:

All mechanical equipment was specified in by design engineer in the construction documents to meet minimum efficiency requirements of Standard 90.1.

Equipment minimum efficiency: Rooftop Package Unit:

Unit	Min. Efficiency
RTU-1, RTU-2, & RTU-4	9.2 EER, 9.4 IPLV
RTU-3 & RTU-7	9.5 EER, 9.7 IPLV
RTU-5	9.2 EER, 9.4 IPLV
RTU-6	9.5 EER, 9.7 IPLV
RTU-8	9.5 EER, 9.7 IPLV
RTU-9, RTU-10, RTU-13, & RTU-14	9.5 EER, 9.7 IPLV
RTU-11 & RTU-12	9.5 EER, 9.7 IPLV

Equipment minimum efficiency: Air Cooled Condensing Unit:

Unit	Min. Efficiency
Air Cooled Condensing Unit	10.1 EER, 11.2 IPLV

All other equipment is not specified in ASHRAE Standard 90.1 and do not have a minimum efficiency requirement.

Mechanical System Lost Rentable Space:

Most of the space take by mechanical equipment is roof space because of the 14 RTU's. Less than 7% of the total rentable space is taken up by the boilers and mechanical shafts.

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.

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

Figure 2 – HVAC System First Cost

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.

Annual Energy Consumption:

Since South Jefferson High School is currently under construction there are no utility values from the site. All 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.

	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	

Figure 3 –HVAC Annual Energy Cost Estimation (Btu)

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

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. Values were approximated for conservative means.

DESIGN ENERGY PERFORMANCE RESULTS

	DESIGN	ENERGY STAR
Energy		
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

Figure 4 – Source energy usage various Energy Star targets

Conclusion:

The annual energy usage and cost values output by the Trane TRACE 700 software appear to be accurate. They closely resemble the values located in the construction documents. South Jefferson High School's mechanical systems were designed with the end-user in mind. The systems were designed to be maintained easily, not to reduce energy losses and emissions. The system is still relatively efficient because the designers followed ASHRAE Standard 90.1 – 2004 closely.

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.

Design Airflow Quantities:

Symbol	Variable or Constant Volume	Supply Air (CFM)	Design Outdoor Air (CFM)	Model OA (CFM)	Cooling Airflow (CFM)	Heating Airflow (CFM)	Return Airflow (CFM)	Heating Airflow (CFM)
RTU-8	CV	4,500	1,200	900	3,337	3,337	3,337	900
RTU-2	VV	25,500	10,600	11,034	20,877	22,605	22,605	11,034
RTU-3	VV	13,000	3,600	3,560	10,231	3,069	10,231	3,560
RTU-4	VV	24,000	10,500	7,425	18,776	18,840	18,840	7,425
RTU-5	CV	14,000	14,000	4,369	11,273	11,276	11,276	4,369
RTU-6	VV	12,000	2,700	1,874	6,993	7,156	7,156	1,874
RTU-7	VV	15,000	6,400	5,807	12,521	12,979	12,979	5,807
RTU-1	VV	22,000	9,600	9,826	1,951	19,741	19,741	9,826
RTU-9	CV	9,000	8,000	7,950	7,950	7,950	7,950	7,950
RTU-10	CV	13,000	7,500	7,200	9,963	9,963	9,963	7,200
RTU-11	CV	6,000	4,670	661	3,581	3,581	3,581	661
RTU-12	CV	12,000	12,000	4,757	7,448	7,448	7,448	4,757
RTU-13	CV	9,500	5,500	9,375	9,375	9,375	9,375	9,375
RTU-14	CV	9,500	5,500	9,375	9,662	9,662	9,662	9,375
Totals:		**184,500**	**100,570**	**83,213**	**130,601**	**143,645**	**150,807**	**83,213**

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

APPENDIX A: Energy Model Data

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 Compliance - Building-Area-Method

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

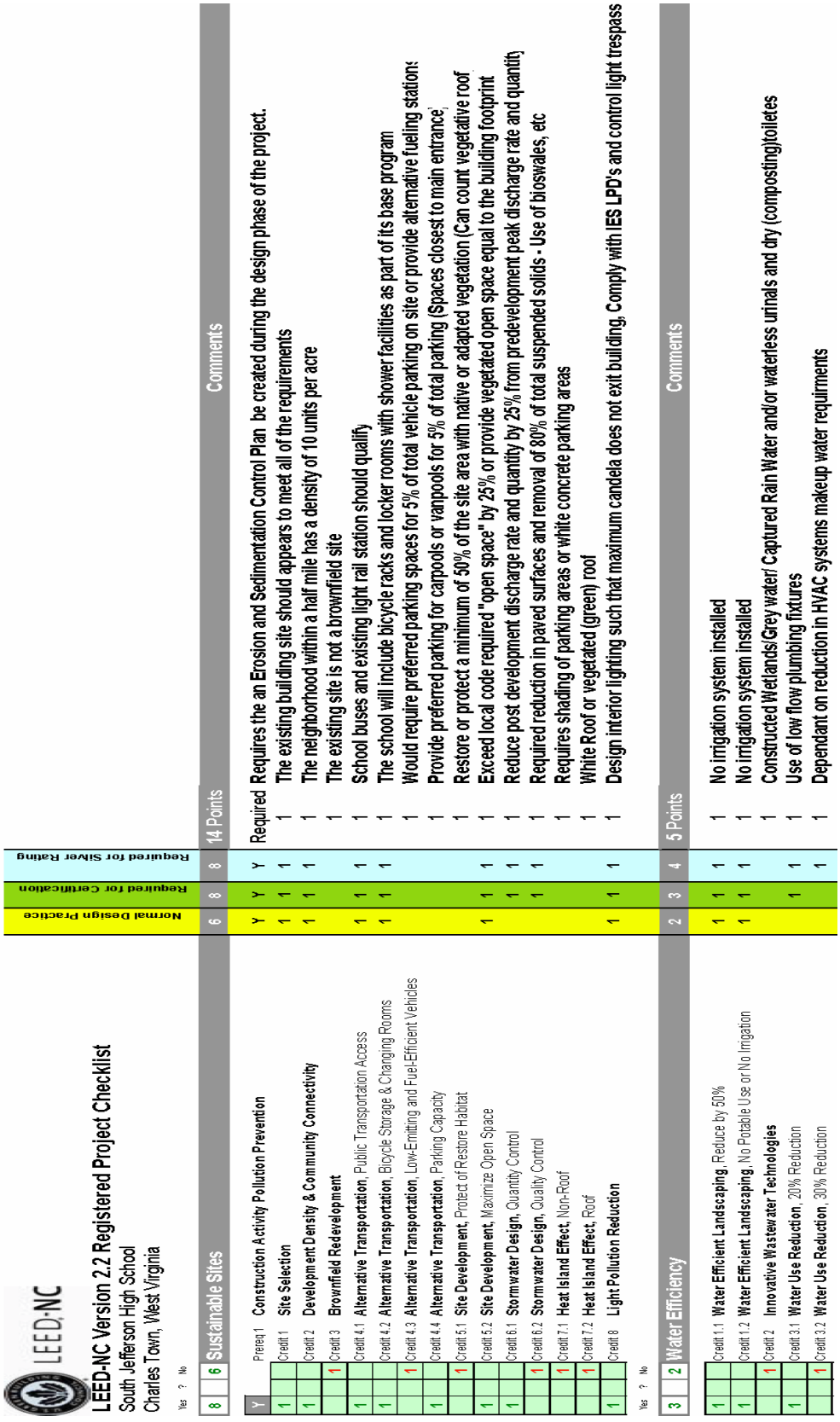
APPENDIX C: Breakdown – Mechanical First Cost (Cont'd)

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 of HVAC 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: LEED NC 2.2 Checklist



LEED-NC

LEED-NC Version 2.2 Registered Project Checklist
South Jefferson High School
Charles Town, West Virginia

Yes	?	No		Normal Design Practice	Required for Certification	Required for Silver Rating		
8		6	**Sustainable Sites**	6	8	8	14 Points	Comments
Y			Prereq 1 **Construction Activity Pollution Prevention**	Y	Y	Y	Required	Requires the an Erosion and Sedimentation Control Plan be created during the design phase of the project.
1			Credit 1 **Site Selection**	1	1	1	1	The existing building site should appears to meet all of the requirements
1			Credit 2 **Development Density & Community Connectivity**	1	1	1	1	The neighborhood within a half mile has a density of 10 units per acre
		1	Credit 3 **Brownfield Redevelopment**				1	The existing site is not a brownfield site
1			Credit 4.1 **Alternative Transportation**, Public Transportation Access	1	1	1	1	School buses and existing light rail station should qualify
1			Credit 4.2 **Alternative Transportation**, Bicycle Storage & Changing Rooms	1	1	1	1	The school will include bicycle racks and locker rooms with shower facilities as part of its base program
		1	Credit 4.3 **Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles				1	Would require preferred parking spaces for 5% of total vehicle parking on site or provide alternative fueling station
1			Credit 4.4 **Alternative Transportation**, Parking Capacity				1	Provide preferred parking for carpools or vanpools for 5% of total parking (Spaces closest to main entrance)
		1	Credit 5.1 **Site Development**, Protect of Restore Habitat				1	Restore or protect a minimum of 50% of the site area with native or adapted vegetation (Can count vegetative roof
1			Credit 5.2 **Site Development**, Maximize Open Space	1	1	1	1	Exceed local code required "open space" by 25% or provide vegetated open space equal to the building footprint
1			Credit 6.1 **Stormwater Design**, Quantity Control	1	1	1	1	Reduce post development discharge rate and quantity by 25% from predevelopment peak discharge rate and quantity
		1	Credit 6.2 **Stormwater Design**, Quality Control		1	1	1	Required reduction in paved surfaces and removal of 80% of total suspended solids - Use of bioswales, etc
		1	Credit 7.1 **Heat Island Effect**, Non-Roof				1	Requires shading of parking areas or white concrete parking areas
		1	Credit 7.2 **Heat Island Effect**, Roof				1	White Roof or vegetated (green) roof
1			Credit 8 **Light Pollution Reduction**	1	1	1	1	Design interior lighting such that maximum candela does not exit building, Comply with IES LPD's and control light trespass

Yes	?	No						
3		2	**Water Efficiency**	2	3	4	5 Points	Comments
1			Credit 1.1 **Water Efficient Landscaping**, Reduce by 50%	1	1	1	1	No irrigation system installed
1			Credit 1.2 **Water Efficient Landscaping**, No Potable Use or No Irrigation	1	1	1	1	No irrigation system installed
		1	Credit 2 **Innovative Wastewater Technologies**				1	Constructed Wetlands/Grey water/ Captured Rain Water and/or waterless urinals and dry (composting)toiletes
1			Credit 3.1 **Water Use Reduction**, 20% Reduction		1	1	1	Use of low flow plumbing fixtures
		1	Credit 3.2 **Water Use Reduction**, 30% Reduction			1	1	Dependant on reduction in HVAC systems makeup water requirments

APPENDIX D: LEED NC 2.2 Checklist

Yes	?	No									
3		5	**Energy & Atmosphere**	3	7		8	17 Points			**Comments**
Y			Prereq 1 **Fundamental Commissioning of the Building Energy Systems**		Y	Y	Y	Required	Can use "disinterested" employees of the design team - Requires functional testing of energy related systems		
Y			Prereq 2 **Minimum Energy Performance**	Y	Y	Y	Y	Required	This is required by the Commonwealth of Pennsylvania's Energy Code - The IECC		
Y			Prereq 3 **Fundamental Refrigerant Management**	Y	Y	Y	Y	Required	All existing systems will be replaced. Equipment that uses CFC's are no longer manufactured.		
	2		Credit 1 **Optimize Energy Performance**	2	4	5		1 to 10	Requires energy modeling to document		
		3	Credit 2.1 **On-Site Renewable Energy**					1 to 3	Requires on site PhotoVoltaics or wind turbines		
		1	Credit 3 **Enhanced Commissioning**		1	1		1	Requires Independent 3rd Party for design review, and post occupancy activities		
	1		Credit 4 **Enhanced Refrigerant Management**	1	1	1		1	Balance refrigerant ODP, GWP and Minimize Refrigerant Leakage		
		1	Credit 5 **Measurement & Verification**		1			1	Compare "Whole Building Calibrated Simulation" vs actual building energy usage		
		1	Credit 6 **Green Power**					1	Requires School District to contract with renewable energy supplier for at least 35% of building's electrical use		

Yes	?	No									
3			**Materials & Resources**	1	4	5		13 Points			**Comments**
Y			Prereq 1 **Storage & Collection of Recyclables**		Y	Y		Required	Provide a minimum of 275 sf for collection and storage of non-hazardous recyclables		
	1		Credit 1.1 **Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1	1	1		1	Not achievable in new school		
	1		Credit 1.2 **Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof					1	Not achievable in new school		
	1		Credit 1.3 **Building Reuse**, Maintain 50% of Interior Non-Structural Elements					1	Not achievable in new school		
	1		Credit 2.1 **Construction Waste Management**, Divert 50% from Disposal		1	1		1	Dependant on availability of construction haulers and recyclers within the Region		
	1		Credit 2.2 **Construction Waste Management**, Divert 75% from Disposal			1		1	Dependant on availability of construction haulers and recyclers within the Region		
	1		Credit 3.1 **Materials Reuse**, 5%					1	Not achievable in new school		
	1		Credit 3.2 **Materials Reuse**, 10%					1	Not achievable in new school		
1			Credit 4.1 **Recycled Content**, 10% (post-consumer + ½ pre-consumer)		1	1		1	Specify products manufactured with recycled materials		
	1		Credit 4.2 **Recycled Content**, 20% (post-consumer + ½ pre-consumer)					1	Specify products manufactured with recycled materials		
1			Credit 5.1 **Regional Materials**, 10% Extracted, Processed & Manufactured Regionally		1	1		1	Dependant on bidding - May require proprietary specification		
	1		Credit 5.2 **Regional Materials**, 20% Extracted, Processed & Manufactured Regionally					1	Dependant on bidding - May require proprietary specification		
	1		Credit 6 **Rapidly Renewable Materials**					1	Bamboo flooring, Linoleum Flooring, Wheatboard Cabinetry, Wool Carpeting, Cork Flooring		
	1		Credit 7 **Certified Wood**					1	50% of Wood must be certified in accordance with FSC principals and criteria - Dependant on suppliers		

APPENDIX D: LEED NC 2.2 Checklist (Cont'd)

10	5	**Indoor Environmental Quality**	6	7	11	15 Points			Comments
Y		Prereq 1 **Minimum IAQ Performance**	Y	Y	Y	Required	**State Building Code - IMC exceeds requirments of ASHRAE 62.1-2004**		
Y		Prereq 2 **Environmental Tobacco Smoke** (ETS) **Control**	Y	Y	Y	Required	**No Smoking Building - Smoking area at least 25 feet away from entries, outdoor air intakes and operable windows**		
1		Credit 1 **Outdoor Air Delivery Monitoring**			1	1	**Provide CO_2 Sensors in heavily occupied spaces such as cafeteria, gymnasium and auditorium**		
1		Credit 2 **Increased Ventilation**	1	1	1	1	**State Building Code - IMC exceeds requirments of ASHRAE 62.1-2004**		
1		Credit 3.1 **Construction IAQ Management Plan**, During Construction		1	1	1	**Achieving this point is fully dependant on the general contractor**		
1		Credit 3.2 **Construction IAQ Management Plan**, Before Occupancy			1	1	**Requires building flushout or baseline IAQ testing**		
1		Credit 4.1 **Low-Emitting Materials**, Adhesives & Sealants	1	1	1	1	**Specify and use low VOC adhesives and sealants**		
1		Credit 4.2 **Low-Emitting Materials**, Paints & Coatings	1	1	1	1	**Specify and use low VOC paints and coatings**		
1		Credit 4.3 **Low-Emitting Materials**, Carpet Systems	1	1	1	1	**Specify and install Carpet and Rug Institute Green Lable compliant with low VOC carpet adhesive**		
1		Credit 4.4 **Low-Emitting Materials**, Composite Wood & Agrifiber Products			1	1	**Use materials with no added urea-formaldehyde resins**		
1		Credit 5 **Indoor Chemical & Pollutant Source Control**	1	1	1	1	**Permanent entry systems to capture dirt, copier, printers in separate rooms with exhaust, MERV 13 filters**		
	1	Credit 6.1 **Controllability of Systems**, Lighting				1	**Not feasible in a classroom building**		
	1	Credit 6.2 **Controllability of Systems**, Thermal Comfort				1	**Not feasible in a classroom building**		
	1	Credit 7.1 **Thermal Comfort**, Design				1	**May require space humidification systems to maintain stay within ASHRAE 55 Comfort Range**		
	1	Credit 7.2 **Thermal Comfort**, Verification				1	**Would require a survey of occupants - not feasible with middle school age students**		
1		Credit 8.1 **Daylight & Views**, Daylight 75% of Spaces	1	1	1	1	**"Normal" design will easily provide 25 fc to at least 75% of all spaces.**		
1		Credit 8.2 **Daylight & Views**, Views for 90% of Spaces			1	1	**Requires line of site to outdoors via vision glazing between 30" and 90" AFF**		
Yes	?	No							
1	4	**Innovation & Design Process**	1	1	1	5 Points			Comments
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	1	1	1	**HFL had a LEED Accredited Professional directly involved with this project**		
Yes	?	No							
28	22	**Project Totals** (pre-certification estimates)	19	30	37	69 Points			

Certified 26-32 points Silver 33-38 points Gold 39-51 points Platinum 52-69 points