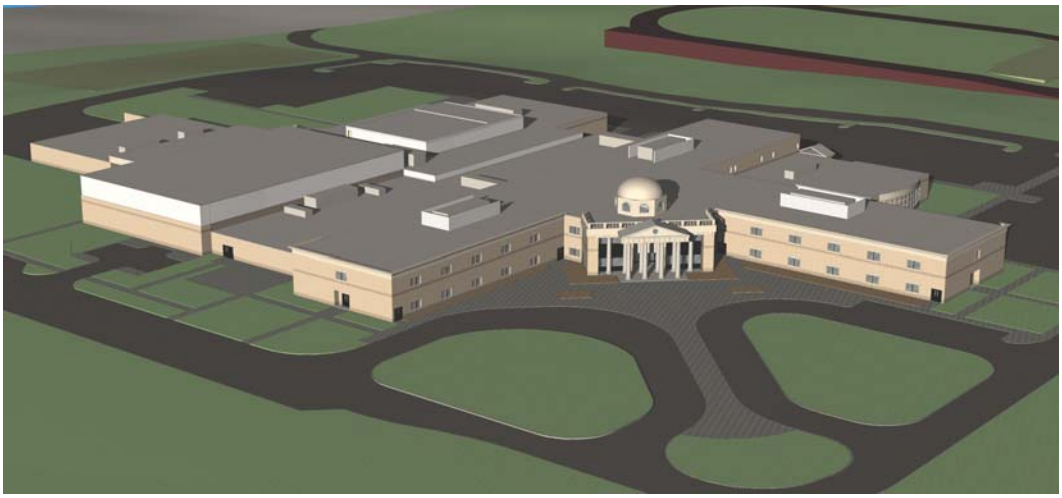
Thesis Proposal

Mechanical System Redesign Report



South Jefferson High School

Huyett Road
Charles Town, WV 25414

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Mechanical Option

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1.0 Table of Contents

2.0 Executive Summary:

This report develops the proposed ideas for re-design and modification of South Jefferson High School. 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. The analysis of the existing mechanical systems shows specific areas in which the building can be improved with possible re-design or modification. After several alternatives are discussed, the proposed redesign is described.

The proposed re-design includes replacing existing direct expansion equipment with a more energy efficient VAV system utilizing a chilled water system. A ground source heat pump system will be researched and compared to the existing VAV system. Energy recovery will be tested as a viable option for both systems and humidity controls will be incorporated into the system to improve indoor air quality.

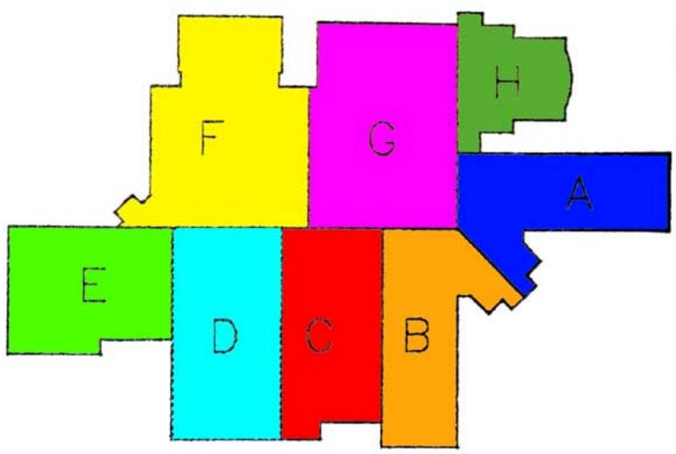
In addition to the main depth area of the thesis proposal, two breadth areas will also be developed. The first deals with the replacement of existing lighting fixtures with more energy efficient models while maintaining the original light output. The second revolves around the added cost and scheduling concerns derived from installing chillers and a ground source heat pump well field and loop.

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 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 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.

4.1 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 1.

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 1 - 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.

4.2 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 2.

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 2 – 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 3 – Pump Data

4.3 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

5.0 Indoor Humidity Conditions:

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 and/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 recent studies that improving these two areas can increase performance of students and lower absenteeism. Table 4 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 G119	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 4 – System Humidity Profile

6.0 Proposal Objective:

The results of this thesis will suggest alternative solutions to the design of the South Jefferson High School. All modifications are for academic purposes and do not imply flaws in the original design. All modifications are simply alternative solutions which will include one extensive modification to the mechanical system and resulting changes to the other building systems.

7.0 Considered Alternatives:

These design alternatives were considered but not selected in the redesign of South Jefferson High School.

- Combustion Air Preheating

Combustion air preheating is for fuel-fired heating equipment, one of the most potent ways to improve efficiency and productivity is to preheat the combustion air going to the burners. The source of this heat energy is the exhaust gas stream, which leaves the process at elevated temperatures. A heat exchanger, placed in the exhaust stack or ductwork, can extract a large portion of the thermal energy in the flue gases and transfer it to the incoming combustion air. This strategy would require boilers with a fuel source other than the current electrical fuel source. Although obtaining an alternate fuel source may be possible, material and maintenance costs for this method are too expensive for a school budget. Also, combustion air preheating is typically used for larger scale projects.

- Displacement Ventilation

In displacement ventilation the range of supply air temperatures and discharge velocities is limited to avoid discomfort to occupants, displacement ventilation has a limited ability to handle high heating or cooling loads if the space served is occupied. The system would require extensive alteration to the architectural design of the building. It is also costly and is not common in schools.

- Night Precooling

There are two variations on night precooling. One, termed night ventilation precooling, involves the circulation of outdoor air into the space during the naturally cooler nighttime hours. This can be considered a passive technique except for any fan power requirement needed to circulate the outdoor air through the space. The night ventilation precooling system benefits the building indoor air quality through the cleansing effect of introducing more ventilation air. With the other variation, mechanical precooling, the building mechanical cooling system is operated during the nighttime hours to precool the building space to a setpoint usually lower than that of normal daytime hours.

The location and mass of building are not ideal for this strategy. Thermal comfort is also a concern requiring building occupants to be more tolerant of the potential for slightly cooler temperatures during the morning hours.

8.0 Proposed Redesign:

The approach taken in the proposed redesign of South Jefferson High School is that of the green design initiative. A motivator for green design is lowering the total cost of ownership in lure of resource management and energy efficiency. Sustainable green design is useful in a school project because of tight budgets, close observation within the community, and typical long time periods between renovation or new construction of a school. A secondary benefit associated with green design is the increased productivity from a building that is comfortable and provides healthy conditions. Comfortable occupants are less distracted, able to focus better on their tasks/activities, and they appreciate the physiological and physical benefits good green design provides.

-VAV System with Chilled Water Plant

Calculated cooling capacities of the packaged DX roof top units were developed in the Trane TRACE 700 software and can be seen in Table 5. This data shows that the total peak load cooling tonnage is 590.4 tons. This load is handled completely by the roof top units condensing units. Installing a central chilled water plant in which the condensing units could be replaced by two 300 ton water cooled chillers, would result in a significant annual energy savings,

		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

This system design alternative will require the least amount of redesign because of its similarity to the existing system. Still, adding a chilled water plant requires many alterations and additions to the current building design. Finding viable space for two 300 ton water cooled chillers will affect usable space either inside or outside the school. If an exterior site is chosen for the central plant, construction scheduling will be generated (See 9.0 Breadth Areas). Extensive chilled water piping will be required throughout the building inevitably adding to the initial cost. A cooling tower or some other equivalent form of heat rejection equipment will also need to be designed and positioned. The VAV system with chilled water plant design will most likely generate energy savings over the multiple packaged units, but life cycle cost and payback will present the final decision towards the feasibility of this system.

-Ground Source Heat Pump

Once the results of adding the chilled water system are analyzed a ground source heat pump system will replace the existing fan powered boxes. Ground source heat pump systems take advantage of the earth's relatively constant temperatures just below its surface (a range of 45° to 65°F). In the heating season, a fluid in the loop collects heat from the earth and transfers that heat to the building. The system then uses electrically driven compressors and heat exchangers to concentrate the heat and release it at a higher temperature into the building. One of the drawbacks to using ground source heat pumps in lieu of the other systems is that humidity control is not as good with heat pumps. Additional, humidity control equipment is will need to be designed to aid with this problem. Hybrid or independent, two-pipe and one-pipe ground source heat pump systems will all be considered in the redesign of South Jefferson High School. All of these options require a well field to be sized and incorporated into the construction schedule. In hybrid ground source heat pump systems the ground heat exchanger size is reduced and an auxiliary heat rejecter (e.g., a cooling tower or some other option) is used to handle the excess heat rejection loads during building cooling operation. If practical, all heat rejection should be done by the ground without the aid of any other form of heat exchanger. Space for a large enough well field to cover all heat rejection should not be a concern because of the vast amount of available land surrounding the school. The data collected from simulation of this system shall be compared to both the original mechanical system and the VAV system with chilled water plant.

-Air-to-Air Heat Recovery

Next, air-to-air heat recovery utilizing heat exchange enthalpy wheels will be integrated into the air-handling equipment or added through the use of energy recovery ventilators. Energy recovery will be incorporated as alternatives for both the VAV system with chilled water plant and ground source heat pump designs. The total HVAC system installed cost may lower because central heating and cooling equipment may be reduced in sized. If this is the case, air-to-air heat recovery should aid either system in comparison to the existing system.

-Humidity Control

Humidity control will be incorporated along with the use of enthalpy wheels and/or desiccant wheels in order to maintain humidity levels below 60%, ideally between 30% and 50%. The density of school population results in large amounts of outdoor air must move through the building to assure proper ventilation. If the air is not properly conditioned, small amounts of moisture in the outdoor air can lead to too much moisture indoors and moisture-related problems during the varying seasons.

-Building Orientation

Once all energy models are generated, building orientation will be optimized. Oreintation can simply be adjusted in most energy simulation software packages. This will distinguish how much of a savings another building orientation would provide over the original orientation.

-Software

Trane Trace 700 software package was used to perform the initial building load energy analysis and life cycle cost estimation. All data will be transferred to the DOE EnergyPlus v 1.4.0 software package, because of additional features incorporated in the software. These features aid the design process by providing the ability to fine-tune data and generate more graphical output.

9.0 Breadth Areas:

The two main breadth analysis areas proposed of South Jefferson High School were chosen because of the effect the analyses have on one another. The results of improving some of the lighting systems will directly affect the mechanical systems by decreasing cooling loads. Also, the redesign of the mechanical systems at South Jefferson High School will have effects on some of the building's cost and scheduling concerns.

-Lighting

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 from reducing cooling loads would considerably help annual energy costs. A summary of the total lighting fixture wattage calculation is provided in Appendix B. The lower watt per square foot lighting values will be incorporated into the EnergyPlus inputs, therefore, becoming included in life cycle cost analyses. A daylight analysis will also be performed to see if some additional daylighting and/or lighting controls will reduce energy consumption.

-Construction Management

Adding a chiller water system or ground source heat pump system will directly affect the cost and scheduling for the projects construction manager. Construction costs for installing chillers and ground source heat pumps will be generated using the RSMeans Costworks software, while scheduling will be generated by the Primavera software package.

10.0 Project Method:

Various methods could be used to analyze the proposed redesign of South Jefferson High School. Most of the data for the redesign will be generated through the use of software. The major software packages that will be used are either accessible from Penn State or H.F. Lenz Company's available software collection.

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APPENDIX A: 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

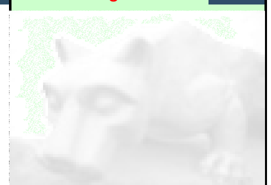
Section 2: Actual Lighting Power Calculation

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.

January 2007

AE 482 | 2/8/2007 | **Jonathon A. Gridley**

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 New Year's Day Penn State Bowl Game Outback Bowl	2	3	4	5 Meeting w/ Dr. Bahnfleth	6
7	8	9	10 Meeting w/ Dr. Bahnfleth	11	12	13
14	15 ML King Day	16 Classes Begin 	17	18	19	20
21	22	23	24	25	26	27 Attending ASHRAE Winter Meeting Dallas, Texas
28 Attending ASHRAE Winter Meeting Dallas, Texas	29 Attending ASHRAE Winter Meeting and AHR Expo Dallas, Texas Finding Potention Equip.	30 Attending ASHRAE Winter Meeting and AHR Expo Dallas, Texas Finding Potention Equip.	31 Equiptment Research			

December 2006

S	M	T	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February 2007

S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

Notes:

Appendix B: Schedule Calendar

February 2007

AE 482 **2/8/2007** **Jonathon A. Gridley**

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 Equiptment Research	Groundhog Day 2 Equiptment Research Meeting w/ Dr. Bahnfleth	3
4	5 EnergyPlus Modeling and Simulation	6 Revise Proposal EnergyPlus Modeling and Simulation	7 Revise Proposal Meeting w/ Dr. Bahnfleth CPEP Website Maintenance	8 EnergyPlus Modeling and Simulation	9 EnergyPlus Modeling and Simulation	10 EnergyPlus Modeling and Simulation
11 EnergyPlus Modeling and Simulation	Lincoln's B-Day 12 EnergyPlus Energy Analysis Life Cycle Cost Analysis	ASHRAE Meeting 13 EnergyPlus Energy Analysis Life Cycle Cost Analysis	Valentines Day 14 EnergyPlus Energy Analysis Life Cycle Cost Analysis	15 EnergyPlus Energy Analysis Life Cycle Cost Analysis	16 Equiptment Selection 1st and Maintenance Cost	17
18 Electrical Load Calculation	President's Day 19 Electrical Load Calculation	20 Electrical Load Calculation	21 Electrical Load Calculation	22 Electrical Load Calculation	23 Electrical Load Calculation	24
25 Field Construction Scheduling	26 Field Construction Scheduling	27 Field Construction Scheduling	28 Field Construction Scheduling			

January 2007

S	M	T	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

March 2007

S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Notes:

March 2007

AE 482 | 2/8/2007 | Jonathon A. Gridley

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1 Field Construction Scheduling	2 Field Construction Meeting w/ Dr. Bahnfleth	3
4 Electrical and Construction Cost Estimation	5 Electrical and Construction Cost Estimation	6 Electrical and Construction	7 Meeting w/ Dr. Bahnfleth Construction Cost Estimation	8 Formulate Comparisons from Data Results	9 Formulate Comparisons from Data Results	10 Spring Break Formulate Comparisons from Data Results
11 Spring Break Daylight Savings To be used if behind	12 Spring Break To be used if behind	13 Spring Break To be used if behind	14 Spring Break To be used if behind	15 Spring Break To be used if behind	16 Spring Break To be used if behind	17 St. Patrick's Day Spring Break
18 Spring Break	19 Final Report Work Organization and Graphics	20 Final Report Work Organization and Graphics	21 Final Report Work Organization and Graphics	22 Final Report Work Writing	23 Final Report Work Writing	24
25 Final Report Work Writing	26 Final Report Work Writing	27 ASHRAE Meeting Final Report Work Writing	28 Final Report Work Writing	29 Final Report Work Writing	30 Final Report Work Writing	31

February 2007

S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

April 2007

S	M	T	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Notes:

April 2007

AE 482 | 2/8/2007 | Jonathon A. Gridley

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 April Fool's Day Presentation Work	2 Presentation Work	3 Presentation Work	4 Presentation Work	5 Presentation Work	6 Good Friday Presentation Work Meeting w/ Dr. Bahnfleth	7 Final Revisions
8 Easter Final Revisions	9 Final Revisions Poster for Student Night	10 Practice Presentation Final Revisions Poster for Student Night	11 Practice Presentation Meeting w/ Dr. Bahnfleth Present Poster Version of Project at Meeting	12 Final Report Due Final Revisions	13	14
15 Practice Presentation	16 Taxes Due Presentations Day 1	17 Presentations Day 2	18 Presentations Day 3	19 Presentations Day 4	20 Presentations Day 5	21
22 Earth Day	23	24	25	26	27	28
29	30					

March 2007

S	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

May 2007

S	M	T	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Notes: