Mechanical Project Proposal

Miller Children’s Hospital Pediatric Inpatient Addition

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Mechanical Option

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1.0 Executive Summary

The purpose of this technical report is to develop a proposed redesign for the Miller Children's Hospital Pediatric Inpatient Addition. It contains an overview of the building design, mechanical equipment summary, and design heating and cooling loads from previous technical reports 2 and 3. The annual energy consumption is also included. The proposal objective is to suggest alternative methods and solutions to the design of the Pediatric Inpatient Addition in order to reduce energy consumption, decrease operating costs, or increase efficiency of the mechanical system.

Some considered alternatives to the proposed redesign include the incorporation of a thermal ice storage system, the addition of solar panels, and addressing indoor air quality as it pertains to the growth of biological contaminants and the spread of bacteria and viruses.

The proposed redesign of the Pediatric Inpatient Addition includes replacing the existing central plant with a combined heat and power plant. The purpose of this is to sequentially produce power and useful thermal energy, ultimately reducing the amount of energy required to satisfy the building's electrical and thermal requirements by utilizing rejected heat from generation. This reduces operational costs and improves the reliability of electrical supply.

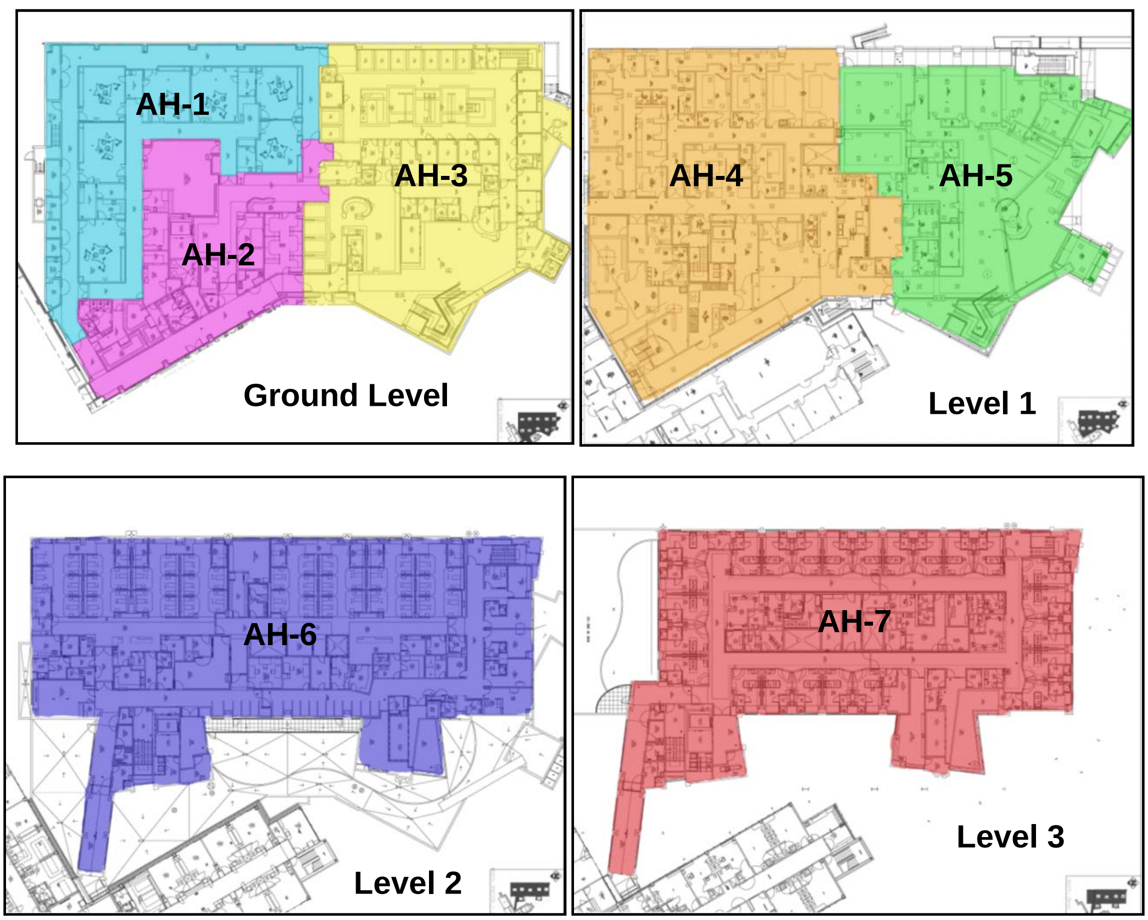
The first breadth topic addressed will be the electrical aspects of generating electricity to power the building. Mechanical equipment changes will also have an impact on the electrical system. The second breadth topic will be the structural system of the new central plant. Structural members will need to be resized with the added equipment associated with combined heat and power.

2.0 Building Design Background

The Pediatric Inpatient Addition to Miller Children's Hospital is a 4-story, 127,000 sq. ft. facility. Operating rooms are located on the ground floor, which is actually below grade. The first floor consists of the main lobby with gift shop and sanctuary, conference and office spaces, and physicians' rooms. The second floor houses the neonatal intensive care unit. Finally, the patient rooms are located on the third floor with mechanical penthouse on the roof above.

The building utilizes a constant air volume with reheat system. Seven AHUs located on the roof of the tower supply air to the 4 levels of the building through two centrally-located mechanical shafts. Figure 1 below shows the areas for each AHU.

Figure 1: AHU Areas



The central plant for the Pediatric Inpatient Addition is located on the site but was part of a separate drawing package. It has been highlighted and shown in Figure 2 below. The central plant houses the chillers, cooling towers, and pumps as well as other electrical equipment. Two 500-ton centrifugal water chillers supply chilled water to the AHUs and fan coil units for the building. Two induced draft cooling towers, located on the roof of the central plant, cool condenser water from 95˚F to 85˚F. Hot water is supplied to the reheat coils throughout the building with two gas-fired boilers housed in the rooftop mechanical room of the tower.

Figure 2: Central Plant

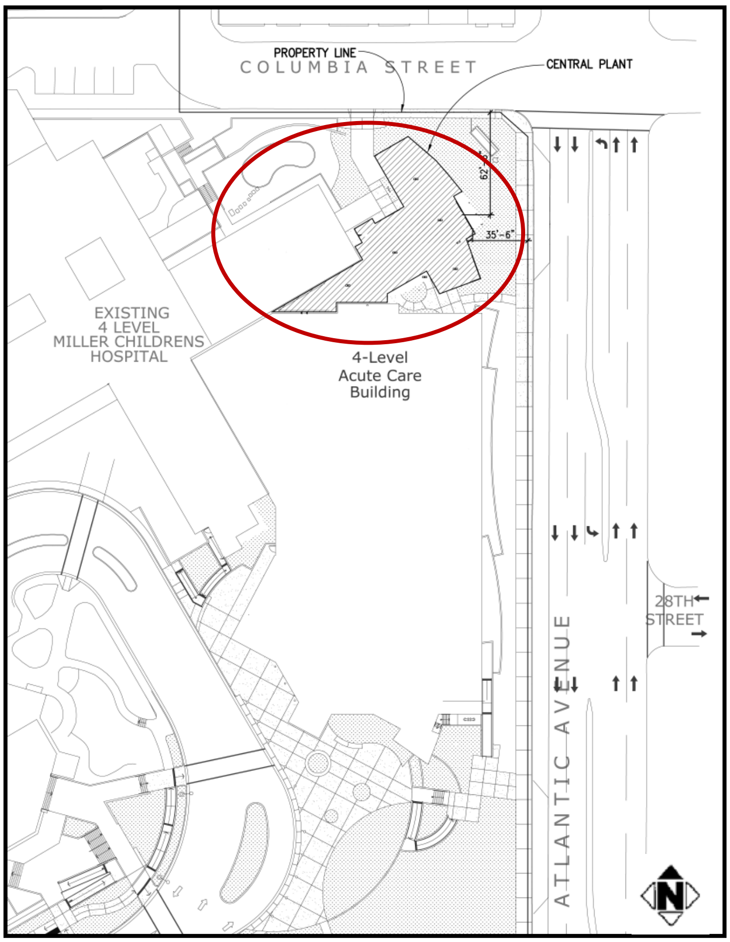


Figure 2 shows the central plant (circled in red) of the Pediatric Inpatient Addition. The tower is just adjacent to the central plant with the existing Miller Children's Hospital as shown.

3.0 Mechanical Equipment Summary

As stated earlier, the mechanical equipment for the Pediatric Inpatient Addition is primarily located in two areas: the central plant and the tower roof. The central plant houses the chillers, cooling towers, and chilled water pumps. The air handling units, boilers, and hot water pumps are located on the tower roof. This section summarizes the major equipment that comprises the mechanical system for the building.

3.1 Chilled Water System

The chilled water system for the Pediatric Inpatient Addition is located in the central plant. Two centrifugal water cooled chillers supply chilled water to the rooftop AHUs as well as various fan coil units located throughout the building. The chiller data can be found in Table 1 below. The induced draft cooling towers are located on the roof of the central plant and are fitted with variable frequency drives. The cooling tower data can be found below in Table 2.

Table 1: Chiller Data

Centrifugal Water Cooled Chiller												
Quantity	Nominal Size (tons)	Evaporator				Condenser			Full Load Capacity (kW/ton)	NPLV (kW/ton)	Refrigerant Type	VFD
		GPM	EWT	LWT	Max ΔP (ft)	GPM	EWT	Max ΔP (ft)				
2	500	1000	56	44	12	1500	85	16	0.566	0.501	HFC-134A	No

Table 2: Cooling Tower Data

Induced Draft Cooling Tower								
Quantity	GPM	EWT ˚F	LWT ˚F	EAT ˚F WB	Fan Motor			
					HP	Volts	Phase	VFD
2	1500	95	85	78	25	460	3	Yes

3.2 Hot Water System

The hot water system for the Pediatric Inpatient Addition is located in the mechanical room on the tower roof. Two copper finned tube gas-fired hot water boilers supply hot water to 145 reheat coils located throughout the building. The boilers also supply hot water to the heating coil for AH-3. Boiler data can be found in Table 3 below.

Table 3: Hot Water Boiler Data

Copper Finned Tube Hot Water Boiler			
Quantity	Input (MBH)	Heat Output (MBH)	Thermal Efficiency
2	2000	1740	0.87

3.3 Air Handling Units

As previously stated, the air handling units for the Pediatric Inpatient Addition are located on the roof of the tower and serve the four levels of the building. The units supply a constant air volume with zone reheat to maintain pressure differences between spaces. AH-3 supplies 100% OA and the others supply mixed air. Data for each of the 7 AHUs can be found in Tables 4 through 6. Fan data for the supply and return fans are located in Table 4, cooling coil data is located in Table 5, and heating coil data is located in Table 6. Note that only one air handling unit has a heating coil, AH-3.

Table 4: AHU Fan Data

Air Handling Unit Fans										
AHU	Supply Fan				Return/Exhaust Fan				Min OA CFM	Volts/ Phase
	CFM	Total Static Pressure (in. WC)	Fan RPM	Motor HP	CFM	Total Static Pressure (in. WC)	Fan RPM	Motor HP		
1	20,000	6.0	1476	40	19,000	1.5	829	10	6,000	460/3
2	7,000	5.0	1852	10	6,000	1.5	1238	5	1,500	460/3
3	15,000	5.0	1258	25	-	-	-	-	15,000	460/3
4	20,000	5.0	1397	30	16,000	1.5	756	7.5	5,000	460/3
5	18,000	5.0	1340	25	16,700	1.5	965	10	4,000	460/3
6	20,000	5.0	1397	30	17,000	1.5	773	10	6,000	460/3
7	18,000	5.0	1340	25	15,000	1.5	900	10	5,000	460/3

Table 5: AHU Cooling Coil Data

Air Handling Unit Cooling Coil										
AHU	Air Side					Water Side				Face Velocity (fpm)
	Entering Temp. (˚F)		Leaving Temp. (˚F)		Max. ΔP (in. WC)	GPM	Entering Temp. (˚F)	Leaving Temp. (˚F)	Max. ΔP (ft. WC)	
	D.B.	W.B.	D.B.	W.B.						
1	79.5	65.5	52.4	52.1	1.0	121.6	45	58	10	430
2	81.4	66.3	52.8	52.5	1.0	44.4	45	58	10	453
3	90	71	53.6	53.4	1.0	130	45	58	10	437
4	78.8	64.8	52.3	52.1	1.0	114.5	45	58	10	424
5	78.3	64.7	52.4	52.2	1.0	101.5	45	58	10	443
6	79.5	65.5	52.5	52.3	1.0	120.4	45	58	10	424
7	79.1	65.1	52.5	52.2	1.0	105	45	58	10	443

Table 6: AHU Heating Coil Data

Air Handling Unit Heating Coil								
AHU	Air Side			Water Side				Face Velocity (fpm)
	Entering Temp. D.B. (˚F)	Leaving Temp. D.B. (˚F)	Max. ΔP (in. WC)	GPM	Entering Temp. (˚F)	Leaving Temp. (˚F)	Max. ΔP (ft. WC)	
3	38	83.5	0.3	61.4	180	156	5	436

3.4 Water Pumps

Water pumps for the chilled water loop and condenser water loop are located in the pump room in the central plant for the Pediatric Inpatient Addition. The condenser water loop has two centrifugal pumps, with one as a standby. The chilled water loop uses two primary pumps and two secondary pumps, with one secondary as a standby. The hot water loop has two primary and two secondary pumps as well. All ten centrifugal pumps are suction frame mounted. The water pump data for these pumps is listed in Table 7 on the following page.

Table 7: Water Pump Data

Centrifugal Water Pump								
Pump	Quantity	GPM	Total Head (ft.)	Motor				VFD
				HP	Volts/ Phase	RPM	Min. Efficiency	
Condenser Water	2	1500	60	40	460/3	1750	0.8	No
Primary Chilled Water	2	1000	50	20	460/3	1750	0.81	Yes
Secondary Chilled Water	2	750	70	20	460/3	1750	0.78	Yes
Primary Hot Water	2	90	20	1	460/3	1750	0.67	No
Secondary Hot Water	2	240	60	7	460/3	1750	0.76	Yes

4.0 Design Heating and Cooling Loads

The design heating and cooling loads for the Pediatric Inpatient Addition were calculated in Technical Report 2 and are summarized in Table 3 on the following page. Trane's Trace 700 software program was used to estimate the design loads for the HVAC system in the Pediatric Inpatient Addition. No such program was used in the initial design of the building, and instead hand calculations were done to size the HVAC system. The system was designed by JBA Consulting Engineers. The engineer's values for lights and equipment loads, design occupancy, and the design indoor and outdoor air conditions for heating and cooling were inputted into Trace for each space. The schedules for lights, people, and equipment loads were all created according to the use of a typical hospital facility. The HVAC system was then created according to the design documents.

The designed supply air values for the Pediatric Inpatient Addition are slightly higher than the Trace calculated values, which is typically the case when comparing Trace output to hand calculations in that the hand calculations tend to be slightly more conservative. The Trace calculations are a closer approximation to the actual building loads than the hand calculations. This trend continues with the heating loads and all but two of the cooling loads.

Table 8: Heating and Cooling Loads

	Tech 2 Estimated Values		JBA Design Values	
	Cooling Load (tons)	Heating Load (MBH)	Cooling Load (tons)	Heating Load (MBH)
AH-1	44	275	66	535
AH-2	12	68	25	187
AH-3	34	164	80	386
AH-4	50	302	58	434
AH-5	63	312	59	480
AH-6	70	407	66	566
AH-7	50	307	57	501

Table 8 summarizes the findings from Tech 2 for the heating and cooling loads. The designed values tend to be slightly more conservative than the calculated TRACE values for both heating and cooling loads.

5.0 Annual Energy Consumption

The annual energy consumption for the Pediatric Inpatient Addition was also calculated as part of the Technical Report 2 using Trace 700. An energy analysis was not performed by the engineer on the project. The reason for this is because the energy consumption of the building was not the primary element driving the design. The importance of patient health and safety exceeds the need to reduce energy consumption. The building was designed in accordance with OSHPD standards, which exempt medical facilities from meeting many energy consumption requirements. The annual electric energy consumption for the Pediatric Inpatient Addition is approximately 4,410,000 kWh, and the gas consumption is 42,000 therms. The percent breakdown can be seen in Figure 3 on the following page.

Figure 3: Annual Energy Consumption

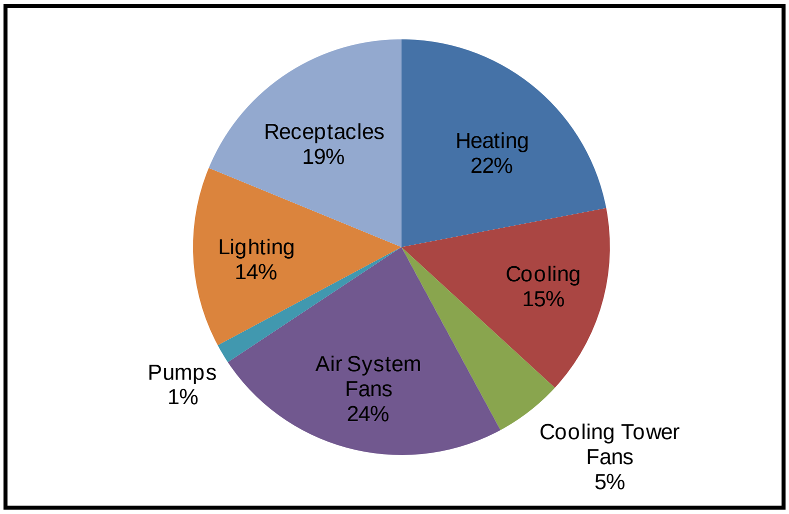


Figure 3 shows the percent breakdown of the annual total energy consumption for the Pediatric Inpatient Addition. The mechanical systems comprise 67% of the entire building energy consumption.

6.0 Proposal Objective

The purpose of this thesis proposal is to suggest alternative methods and solutions to the design of the Pediatric Inpatient Addition. These in no way suggest that the original design is flawed, but rather introduce design alternatives that may or may not have been considered by the designer in order to reduce energy consumption, decrease operating costs, or increase efficiency of the mechanical system.

7.0 Considered Alternatives

This section addresses alternative design solutions that were considered for the thesis proposal. These alternative design solutions may in some cases affect one or more building components such as electrical or structural systems, and would have to be addressed accordingly. The three alternatives considered are listed in the following sections.

7.1 Thermal Ice Storage

The basic concept of thermal ice storage is to reduce mechanical operational costs by creating a supply of ice when the energy rates are low, and later use the supply for cooling loads. This could reduce a significant portion of the cooling costs of the Pediatric Inpatient Addition. One problem with this alternative is the large space requirements for thermal ice storage. Because the building is an addition, the amount of available space is limited by the existing Miller Children's Hospital to the west, Atlantic Avenue to the east, and East Columbia Street to the north (See Figure 2). It would be very difficult to place a thermal storage central plant on the site.

7.2 Solar Panels

In order to reduce operating costs for the Pediatric Inpatient Addition, solar panels could be used to produce electricity and reduce the amount purchased by the utility company. Solar panels are still quite expensive and the initial cost to purchase them would far outweigh the energy savings. However, the state California Public Utilities Commission has been taking steps to fund solar electricity systems for businesses with the goal to create new solar-produced electricity and drive down the costs of solar panels. This could significantly reduce the initial cost to purchase the panels and prove to be cost-effective to implement. The problem with this alternative is that it requires a large roof area to locate the solar panels. The amount of roof area available is significantly reduced by the seven air handling units located there. It may be cost-effective to purchase and place the solar panels, but the need to relocate the AHUs creates many other problems that would outweigh the benefits of solar energy.

7.3 Indoor Air Quality

The issue of indoor air quality is crucial in hospital-type settings such as the Pediatric Inpatient Addition. The designer ensured that the filters used were installed per ASHRAE Standard 52.1-92 for pre-filters and Standard 52.76 for final filters. Also, third stage HEPA filtration was installed with 99.97% efficiency on AH-1 serving the operating rooms on the ground level. Also, pressure differences between spaces are maintained to prevent the spread of contaminants from one space to another. Another method to address indoor air quality would be to introduce UV-filtration to the air system. UV-filtration can prevent the growth of biological contaminants and reduce the spread of bacteria and viruses, ideal for hospital and laboratory environments. It may be possible to show that the addition of UV-filtration reduces these contaminants and provides for a cleaner

The problem with addressing indoor air quality is that it is hard to define indoor air quality. This is evident in the numerous addendums and changes to ASHRAE Standard 62.1 since it was first published in 1973. It is also difficult to show the quantitative benefits of addressing indoor air quality. The advantages calculated must be significantly greater than the increase in energy costs in order to justify their use. This is not easy to do since it is hard to prove that better indoor air quality equates to cost savings in terms of hospital worker productivity and patient health costs. Finally, it is would be very difficult to incorporate breadths into this option.

8.0 Proposed Redesign

The proposed redesign of the Pediatric Inpatient Addition is to replace the central plant with a combined heat and power (CHP) plant. The purpose of CHP is to sequentially produce power and useful thermal energy. CHP ultimately reduces the amount of energy required to satisfy a building's electrical and thermal requirements because the rejected heat from the generation process is recovered and used to heat the building. There are two main advantages to this approach. First, the operational costs of the building are reduced due to heat recovery which intern reduces emissions produced by generation. Second, the overall reliability of electric supply improves by eliminating external problems with generation, transmission, and distribution.

The type of CHP plant proposed is a topping cycle plant, which produces electricity first and then the exhausted steam is used for heating. The main components of the CHP system are the gas-fired boilers, steam turbines and generators, and the heat recovery system. The existing boilers are located in the rooftop mechanical room and will need to be relocated to the CHP plant. A larger area will be required for the new CHP plant for the added equipment. Because of the limited space on the site, there are two possible solutions to obtain the needed space. The first is to add an additional level to the existing central plan. The second is to relocate the new CHP plant across Atlantic Avenue on property that Miller Children's Hospital owns just adjacent to the site. Supply and return lines would then need to be run under Atlantic Avenue to the Pediatric Inpatient Addition. This approach was already considered by the designer, JBA Consulting Engineers. See figure 4 below for the relocation plan.

Figure 4: Central Plant Relocation

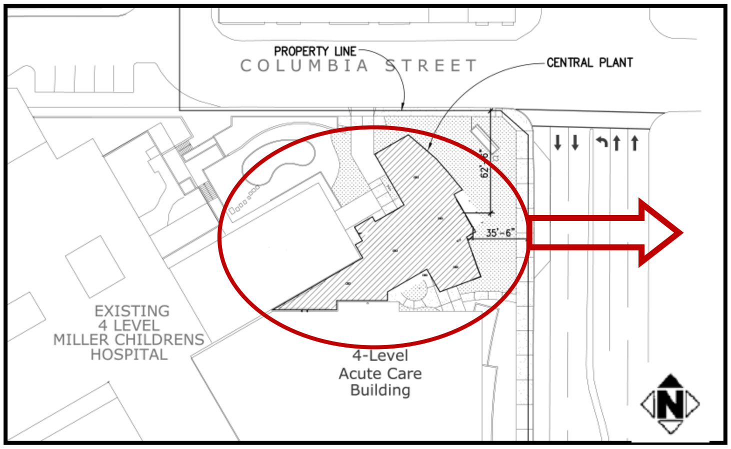


Figure 4 shows the existing central plant and the relocation area across Atlantic Ave. This is one of two options to gain the needed space for the CHP plant.

All other building systems will remain the same, including all air-side systems. The main difficulty of the proposed redesign is the relocation of the CHP plant to the other side of Atlantic Ave. This brings up many challenges including site development and construction of the CHP plant as well as the difficulty of running lines below Atlantic Ave. Therefore, this option will be used only if the additional level to the existing central plant proves to be too costly. Trane's Trace 700 will be used to model the mechanical aspects of the new CHP plant.

9.0 Breadth Topics

Electrical - The first breadth topic that will be addressed is the electrical aspects associated with the new CHP plant. Because the supply will be switched from the utility company to the CHP plant, the generators will need to be sized according to the demand of the building, thus requiring electrical calculations to be done. Also, some of the feeders may need to be resized due to the voltage drop associated with relocating the CHP plant.

Structural - The second breadth topic will be the structural aspects of the new CHP plant. Adding equipment will require that structural members be increased in some areas. Also, adding a second floor to the central plant will require a reevaluation of the structural system that supports it. If the CHP plant is relocated to across Atlantic Ave., the structural aspects of tunneling below the street will need to be addressed to ensure that the supply and return lines can reach the Pediatric Inpatient Addition.

10.0 References

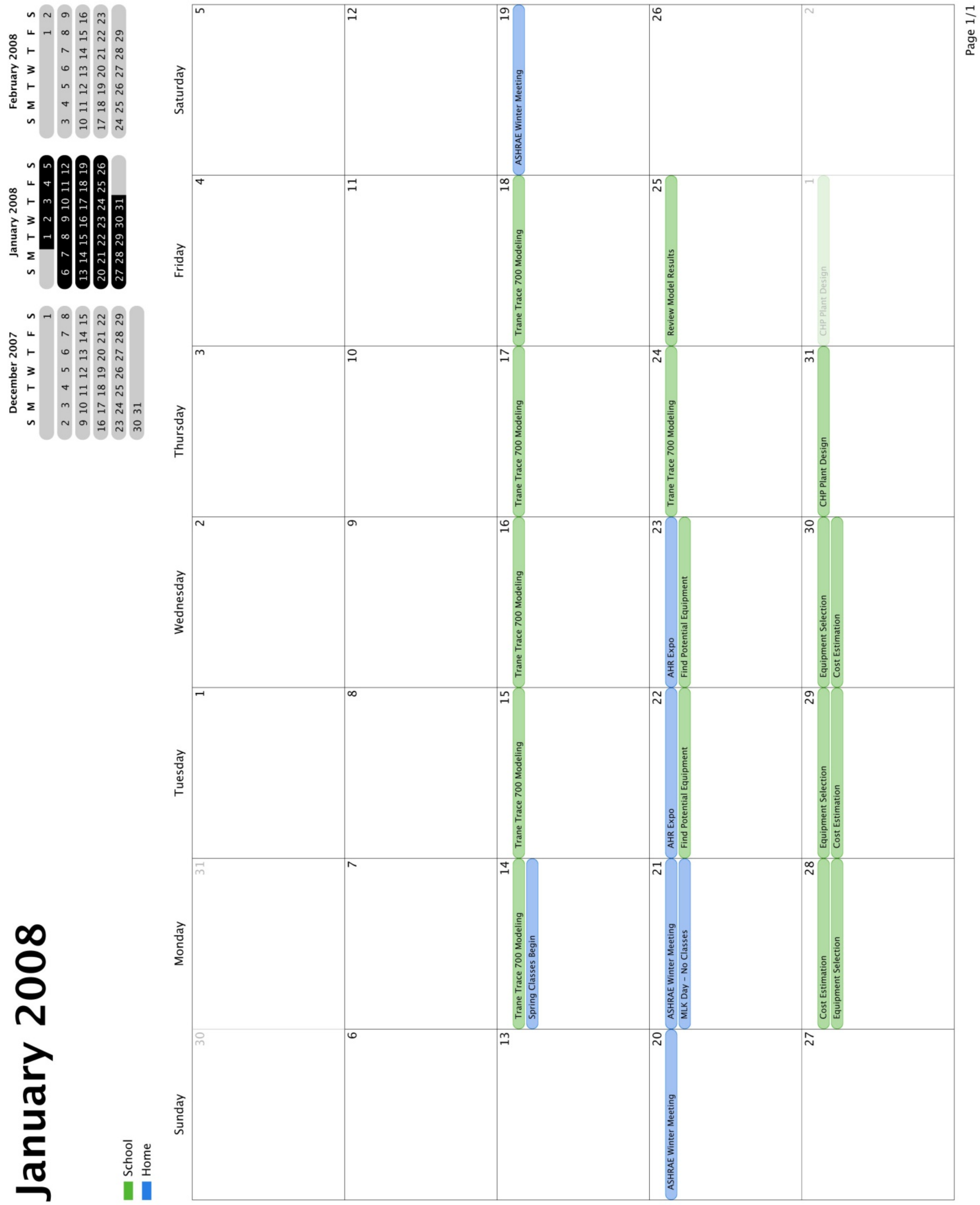
California Public Utilities Commission. "The California Solar Initiative." Effective 2007. Visited 15 Dec. 2007. http://www.cpuc.ca.gov/PUC/energy/solar/.

Haines, Stephen. Technical Assignment #2: Building and Plant Energy Analysis. October 29, 2007.

Haines, Stephen. Technical Assignment #3: Mechanical Systems Existing Conditions Evaluation. December 2, 2007.

JBA Consulting Engineers. 2006, Mechanical Construction Documents. JBA Consulting Engineers, Costa Mesa, CA. 2006.

Appendix – Spring Semester Work Plan



February 2008

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School
Home

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
27	28 Cost Estimation Equipment Selection	29 Equipment Selection Cost Estimation	30 Equipment Selection Cost Estimation	31 CHP Plant Design	1 CHP Plant Design	2
3	4 CHP Plant Design	5 CHP Plant Design	6 CHP Plant Design	7 CHP Plant Design	8 CHP Plant Design	9
10	11 Connecting CHP Plant to Building	12 Connecting CHP Plant to Building	13 Connecting CHP Plant to Building	14 Mechanical Systems Energy Analysis	15 Mechanical Systems Energy Analysis	16
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School
Home

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
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2	3 Organize Electrical Systems	4 Structural Load Calcs	5 Structural Load Calcs	6 Structural Load Calcs	7 Structural Systems Design	8 Spring Break
9 Spring Break	10 Spring Break – No Class To be used if behind	11 To be used if behind Spring Break – No Class	12 Spring Break – No Class To be used if behind	13 Spring Break – No Class To be used if behind	14 To be used if behind Spring Break – No Class	15 Spring Break
16 Spring Break	17 Structural Systems Design	18 Organize Structural Systems	19 E/S Cost Estimations	20 E/S Cost Estimations	21 E/S Cost Estimations	22
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April 2008

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School
Home

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6	7 Final Report Work Presentation	8 Presentation Final Report Work	9 Final Revisions	10 Practice Presentation	11 Practice Presentation	12
13	14 Final Presentations	15 Final Presentations	16 Final Presentations	17 Final Presentations	18 Final Presentations	19
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