Technical Report 3

Mechanical System Existing Conditons Evaluation

EMD Serono Research Center - existing | Billerica, MA

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1 Executive Summary

The purpose of this report is to provide a clear, concise summary of the EMD Serono Research Center – existing building's mechanical system. Design requirements, external influences on design, major equipment, system configuration, control logic and operating characteristics of this building are evaluated in this report.

One of the main objectives of the mechanical system design is to provide safe and healthy indoor air quality to its occupants. AHU-1 serves the research and development laboratories, AHU-2 serves vivarium rooms, and AHU-3 serves administrative offices. Since laboratories and vivarium rooms are critical spaces that generate potential hazardous contaminants, both AHU-1 and AHU-2 provide 100% outdoor air to these spaces. Those critical spaces also use high efficiency filters (MERV15) and have 100% exhaust air rate. As a result, the HVAC system ensures that contaminated air does not recirculate and transfer inside the building.

The mechanical system of the EMD Serono Research Center – existing lab building has a chilled water cooling plant and a gas fired central heating plant. The cooling plant consists of a water cooled centrifugal chiller, a cooling tower, and an air cooled chiller. The heating plant consists of two low pressure steam boilers and two heat exchangers. Air is distributed throughout the building by variable and constant volume terminal boxes in each space. There are three air handling units in this building. Inside each air handling units, there is low pressure steam pre-heat coils to precondition the outside air in the winter time, cooling coil are located downstream of the preheat coil to cool the air in the summer time. Conditioned air is then distributed into the spaces. In the summer, conditioned cold air is then reheated by the hot water heating coils in the terminal boxes for temperature control. In the winter season, pre-conditioned air from AHUs is conditioned again by the heating coils in the terminal boxes prior to entering the space. Hot water inside the heating coils is coming from the heat exchangers.

The overall construction cost of this building is approximately 15 million. The cost of the HVAC system and control system is about 3.2 million. When accounting the plumbing and fire protection systems, the total mechanical cost is about 4.6 million which is 29% of the total construction cost.

A LEED analysis for the mechanical system was also performed in this report. LEED 2009 for New Construction and Major Renovations rating system was used. According to the analysis, 2 credit points were earned from the Energy and Atmosphere section and 3 credit points were earned from the Indoor Environmental Quality section. The United States Green Building Council (USGBC) began LEED certification in 1998. Since this project was started in 1999, LEED certification was a fairly new concept at

the time of design so that it was not considered in the design process. Undoubtedly many more credits would have been achieved if LEED accreditation standard was utilized during the design process.

Overall, the mechanical system designed for this building responds well to the objectives and challenges presented in this project. Great efforts were made to minimize contaminated air's recirculation and transfer inside the building in order to provide safe and healthy indoor air quality to its occupants. The reports to follow will attempt to continue investigating the mechanical system, and improving system design to reduce energy consumption of this building.

2 Building Summary

EMD Serono Research Center – existing lab building was constructed as the research and development building. This building has 2 stories, a basement, and a penthouse, with gross area of 56,700 square foot. The building program contains management office, research and development laboratories, and vivarium rooms. Mechanical rooms are located on the basement floor and in the penthouse. Vivarium facilities, research lab rooms, support rooms are located on both the 1st and 2nd floor.

3 Design Objectives and Requirements

EMD Serono intended for this research and development facility to contain the highest quality materials and systems practical for its designed uses. Getting the best value for dollars spent was essential, but cost must not take precedence over quality. The guiding principal governing selection of systems and design was to maximize comfort in a practical way for the scientists and staff to do their work. The main mechanical design objectives for the EMD Serono Research Center - existing lab building were environmental comfort, energy responsiveness, flexibility for future changes, durability, ease of maintenance, reliability, and modular approach.

Due to the dynamic, rapidly evolving developments in the chemical and biological sciences researched at EMD Serono, designs must accommodates two characteristics of EMD Serono itself – endurance and change. Designs should be flexible in character and sufficiently adaptable to allow for future changes and modifications as the needs arise.

Internal spaces should be planned on an optimum module for offices and laboratories, within the constraints of the building geometry that will allow convenient space changes over time. Ducts and shafts should be so arranges as to provide easy conversion of space usage when requiring more or different services. While accommodating the specific needs of the program, the design mechanical layout should be generic in approach rather than specialized. System design, layout and equipment locations should encourage routine preventive maintenance by providing easy access for maintenance personnel.

All systems and equipment should be designed in accordance with the Massachusetts State Building Code, recommendations of ASHRAE, Massachusetts Energy Code, and recommendations of AAALAC for animal areas.

4 Site

The site for the EMD Serono Research Center – existing lab building is located in Billerica, Massachusetts. This is a multi-phased pharmaceutical research and development project, anticipated to total approximately 318,000 sf. Phase 1 consisted of the 56,000 sf EMD Serono Research Center – existing building and a 17,000 sf pilot plant. Subsequent phases will include three additional research and development building and an 80,000 sf processing facility. As of 2010, the new EMD Serono building addition is under construction adjacent to the existing building.

Figure-1 Existing EMD Serono Research Center and Pilot Plant

Figure-2 New EMD Serono Research Center Addition Adjacent to Existing Building

5 Outdoor and Indoor Design Conditions

Outdoor weather design conditions were taken from the ASHRAE Handbook of Fundamentals 2009, and they represented the 0.4% summer cooling design and 99.6% winter heating design. Outdoor conditions for Boston, MA were selected.

Indoor design conditions were taken from the design documents. There were different design conditions for different type of spaces.

Weather Data		
	Dry Bulb (F)	**Wet Bulb (F)**
Summer Design Cooling	**90.8**	**73.1**
Winter Design Heating	**7.7**	**N/A**

Table-1 Weather Data

Indoor Design Conditions			
	Summer (F)	Winter (F)	Relative Humidity (%)
General Space	$75^o \pm 2^o$	$72^o \pm 2^o$	55 % Max
Animal Holding Room (Rodent, Nude Mice)	$64 - 79^o \pm 2^o$	$64 - 79^o \pm 2^o$	Summer: 35-58% ± 5% Winter: 40-70% ± 5%
Animal Holding Room (Rabbit)	$64 - 79^o \pm 2^o$	$61 - 70^o \pm 2^o$	Summer: 58-35% ± 5% Winter: 70-40% ± 5%
Animal Support Spaces	$70 - 75^o \pm 2^o$	$70 - 75^o \pm 2^o$	55 % Max
Mech./Elec. Spaces	10^o Above Ambient	65^o Min.	N/A
Transfer Room	10^o Above Ambient	65^o Min.	N/A

Table-2 Indoor Design Conditions

6 Existing Mechanical System Descriptions and Schematics

6.1 Air Side System

There are a total for 3 air handling units in this building. AHU-1 that serves all the research and development labs and AHU-2 that serves all the administrative offices are located in the penthouse. AHU-3 that serves the vivarium rooms and the mechanical room in the basement is located in the basement. Since both AHU-1 and AHU-3 serves laboratories and animal spaces, both AHU-1 and AHU-3 provides 100% outside air to the space.

Since modern chemical and engineering sciences require daily use of toxic chemical and other potentially dangerous device, both laboratories and vivarium spaces are potentially dangerous places. AHU-1 and AHU-3 that serve those spaces provide 100% outside air into the spaces to ensure contaminated air does not recirculate and transfer inside the building. AHU-2 that serves office space does have return air to recirculate back into the space to reduce energy consumption.

Automatic temperature control system is used to accomplish all sensing and control via electronics with pneumatic activation for large valves/dampers and electronic actuation for small terminal unit valves/dampers. All VAV/VAV devices have individual DDC (direct digital control) controllers.

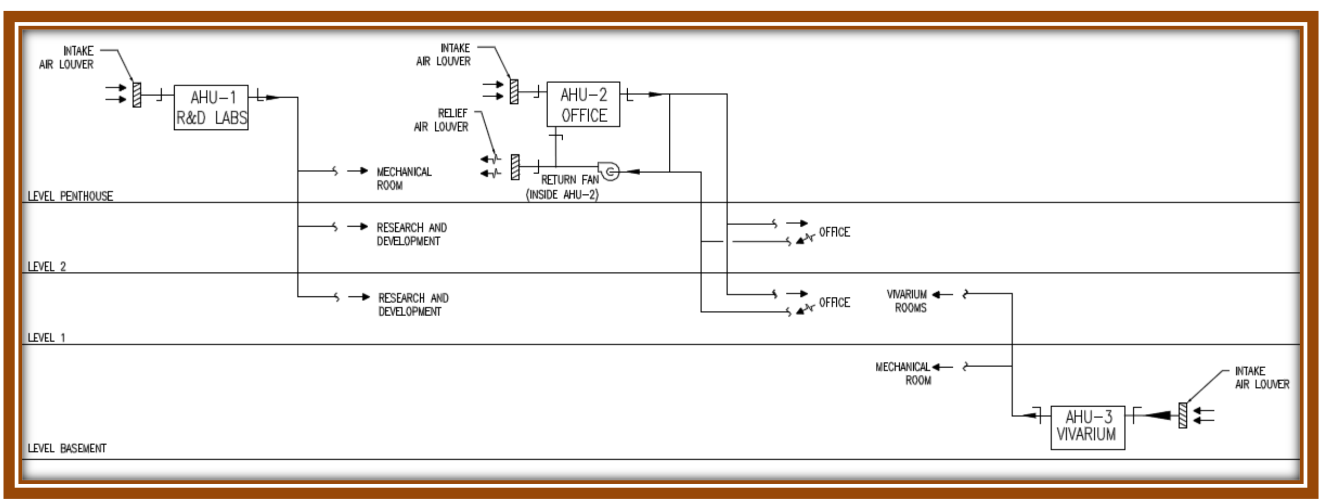


Figure-3 Air Side Riser Diagram

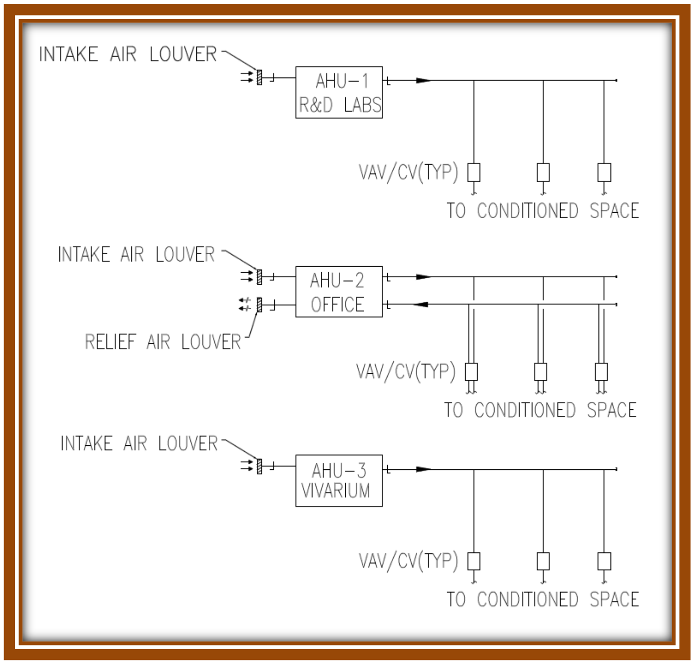


Figure-4 Air Side Schematic

6.2 Water Side Cooling System

The EMD Serono Research Center – existing lab building uses a chilled water system utilizing a water cooled centrifugal chiller and an air cooled chiller. Direct Digital Control (DDC) with pneumatic actuators is used in this building. The chilled water system uses a primary centralized flow system.

At the design condition, AHU-1 requires 675 gpm of chilled water, AHU-2 requires 70 gpm, and AHU-3 requires 155 gpm. There is a water cooled chiller that provides 840 gpm of chilled water (350 tons) and an air cooled chiller work in parallel with it to provide an additional 135 gpm of chilled water (60tons). There are 2 equal capacity chilled water pumps on the return side of the air cooled chiller water loop; one of the two is for redundancy.

There is 1050 gpm of condenser water cycles between the cooling tower and the water cooled chiller condenser to reject system heat. On the water cooled chiller side, an 840 gpm chilled water pump is connected to the evaporator and a 1050 gpm condenser water pump is connected to the condenser. There is a standby pump sized for redundancy of the condenser water loop system. This standby pump is also in parallel with the chilled water loop system. It is piped and valved such that in the case of an emergency, it can be used for back up for either system.

The DDC control system sequences the chiller to maintain a supply water temperature of 45F. Whenever the leaving chilled water temperature is 5F below the desired chilled water set point, the compressor would automatically cycle off to minimize energy usage. During that period, chilled water pump would remain on. When the leaving chilled water temperature rises above the set point by a user-configured amount, the compressor will automatically be recycled back on.

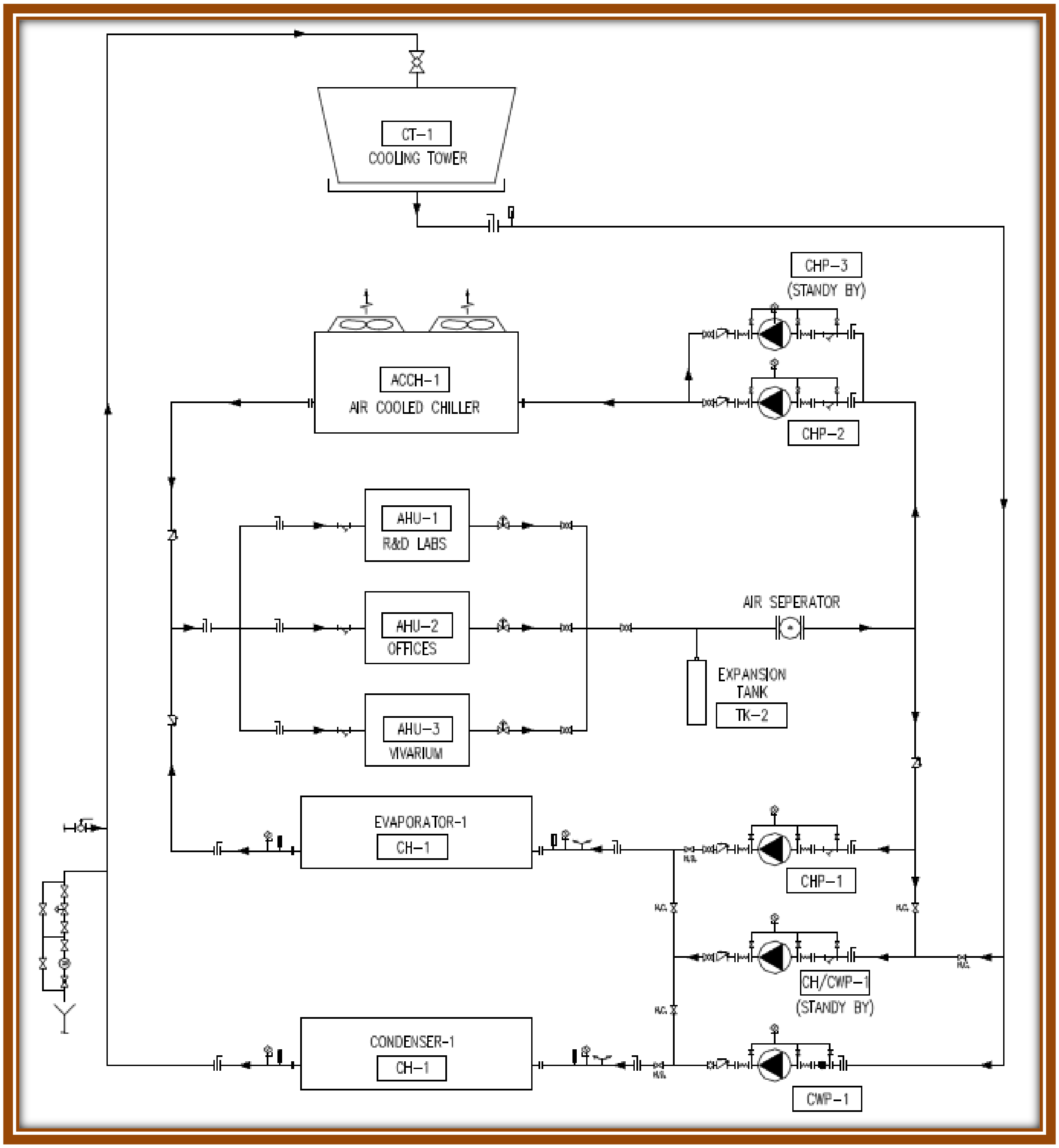


Figure-5 Water Side Cooling Schematic

6.3 Water Side Heating System

The gas fired central heating plant operates year-round. Low pressure steam boilers were designed for 15 psig steam to provide winter heating, humidification, and summer reheat for temperature control. Only one boiler operates at any one time. The 175 hp boiler operates during the winter for heating and humidification purposes while the 50 hp boiler operates during the summer for reheat.

Water is treated by softener and brine before it goes to the boiler feed system. The boiler feed system has dual feed pumps to pump 10 gpm to feed water to the 50 hp boiler and pump 28 gpm of feed water for the 175 hp boiler at a 30 psig discharge pressure. A packaged chemical feed system provides an additional 100 gallons of chemically feed water to the boilers.

Low pressure steam generated by the boiler is distributed to the preheat coils and humidifiers inside the air handling units as well as to the two hot water heat exchangers. All the air handling units and heat exchangers work in parallel with each other. Two condensate pumps also works parallel, one pumps low pressure return from all the air handling units back to the boiler feed while the other pumps low pressure return from the two heat exchangers back to the boiler feed.

Inside the air handling units, the DDC control system modulate the 2-way preheat coil control valve to maintain a 55F leaving air temperature. If the discharge air temperature from the air handling units falls below 38F, the freeze protection thermostats locate downstream of the preheat coil would stop the supply fan.

Steam-to-hot water shell-and-tube heat exchangers supply hot water to the heating coils inside the terminal boxes throughout the building to provide winter heating. Hot water supply temperature is measured by a remote bulb transmitter with its sensing element downstream in the hot water supply. The remote bulb transmitter send signal to the DDC panel. The DDC panel will then modulate the hot water control valves to maintain a water discharge temperature set point. Air preheated by the air handling units is then passed through the heating coil at the terminal box into the space.

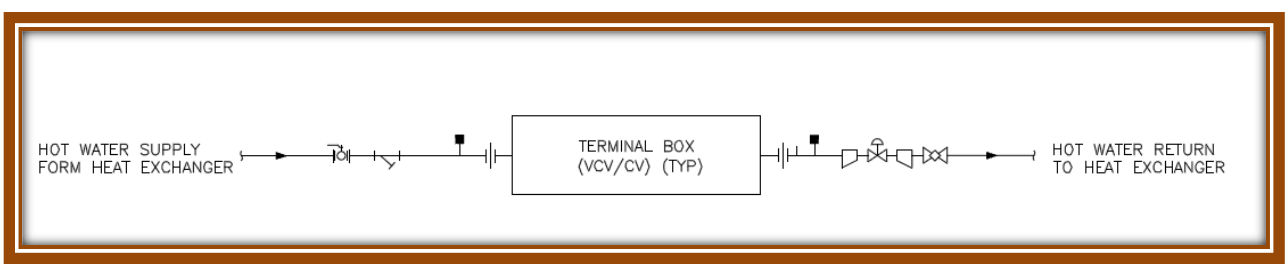


Figure-6 Water Side Hot Water Schematic

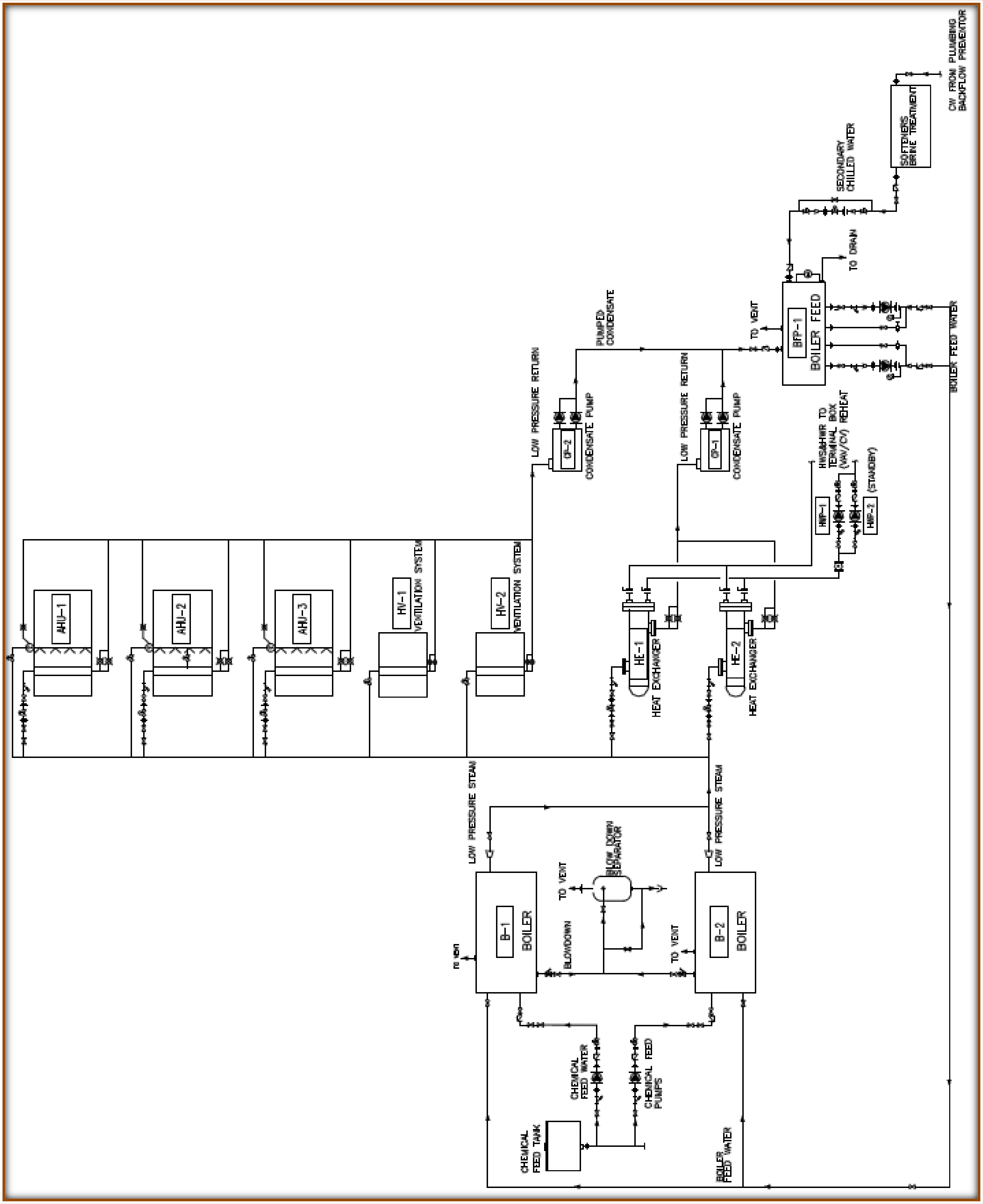


Figure-7 Water Side Heating Schematic

7 Technical Report 2 Energy Analysis Results

In Technical Report 1, a ventilation requirement analysis was done by following ventilation rate procedure from ASHRAE Standard 62.1-2007.

In Technical Report 2, a block load analysis was performed for the EMD Serono Research Center – existing lab building using Trane TRACE 700. The block load analysis was used to predict the building's heating and cooling load, energy consumption, and energy cost.

In order for the model to have comparable result when compared to the actual design, modeling data was taken from the actual design documents, such as design criteria, equipment load, and lighting loads. This building was divided into 5 types of spaces: lunch area, office area, mechanical room area, vivarium area, and research & development area. Each type of space has its unique design criteria. There are total of 9 blocks for this building. Blocks were assigned to 3 air handling units (AHU) according to the actual design.

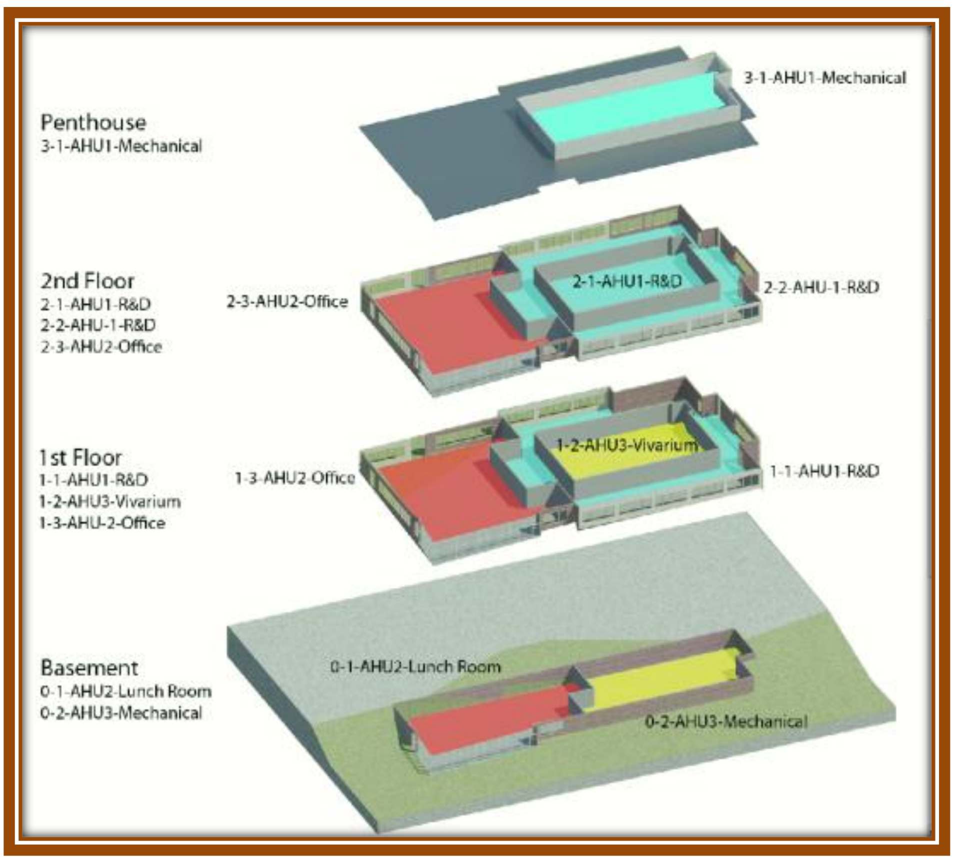


Figure-8 Building Block Division

7.1 Design Ventilation Requirements

The table listed below shows the ventilation rate used in this energy analysis that was taken from the design document. Those rates were input into the Trane TRACE model to calculate building ventilation rates.

Outside Air Ventilation Rate	
	Outside Air Ventilation Rate (%)
Office	20 cfm/occupant minimum
Lunch	20 cfm/occupant minimum
Mechanical	100
R&D	100
Vivarium	100

Table-1 Outside Air Ventilation Rate

Both AHU-1 and AHU-3 provides 100% outside air to their conditioned spaces. AHU-3 utilizes return air to the system. Two ventilation rate comparisons were done: outside air ventilation rate and total supply air rate comparisons. There was a slight variation on modeled outside air ventilation rates and the actual design rates.

Total Ventilation (Cooling)							
	Type	Design OA	Design TA	Model OA	Model TA	Difference OA	Difference TA
		cfm	cfm	cfm	cfm	%	%
AHU-1	100%OA	45000	45000	39198	39198	-13%	-13%
AHU-2	With RA	6300	19000	7194	45976	14%	141%
AHU-3	100%OA	5000	5000	7829	7829	57%	57%
Overall		56300	69000	54221	92790	-4%	34%

Table-2 Ventilation Rate Comparison

7.2 Design Load Estimates

Design and modeled heating loads and cooling loads were compared in Table-3 and Table – 4. Results were within a reasonable range when compared to design values. One of the reasons that modeled values were different from design values is the use of simplified block load calculation method.

The modeled block heating load resulted in values that were greater than the actual design values. AHU-3 had the largest variation among the 3 air handling units. AHU-3 solely serves the vivarium block on the first floor during winter heating mode and serves both the mechanical block in the basement and the vivarium block during the summer cooling mode. The vivarium block comprised of animal holding room, cold room, instrument room, preparation rooms and corridor. Animal holding rooms have the highest heating demand among the other rooms. Calculation were done based on the animal holding room design criteria, which led to an over-estimated value of heating load on the vivarium block for AHU-3.

Heating Load						
	System Load			System Load/Area		
	Design	Model	Difference	Design	Model	Difference
	Mbh	Mbh	%	Mbh/sf	Mbh/sf	%
AHU-1	2126	2295	8%	0.08	0.09	8%
AHU-2	920	1004	9%	0.05	0.05	9%
AHU-3	320	526	64%	0.03	0.06	64%
Overall	3366	3825	14%	0.06	0.07	14%

Table-3 Heating Load Comparison

When comparing the design and modeled cooling loads, there was an average of 29% deviation. The main differences for this deviation are due to the different outside air conditions and the cooling coil selections. The actual design cooling load was not given from the design document. Calculations were done to find the sensible and latent loads of the air handling units from the given entering and leaving air temperature of the cooling coil. There were different entering and leaving air temperatures for design and modeled cooling coils in air handling units. 99.6% summer outdoor air conditions from the ASHRAE Handbook of Fundamentals 2009 was used to model the building. The design calculation used different outdoor air conditions, therefore different entering air temperature for the cooling coil. The modeled air handling units have higher humidity ratio difference than the design air handling units which causes higher latent loads.

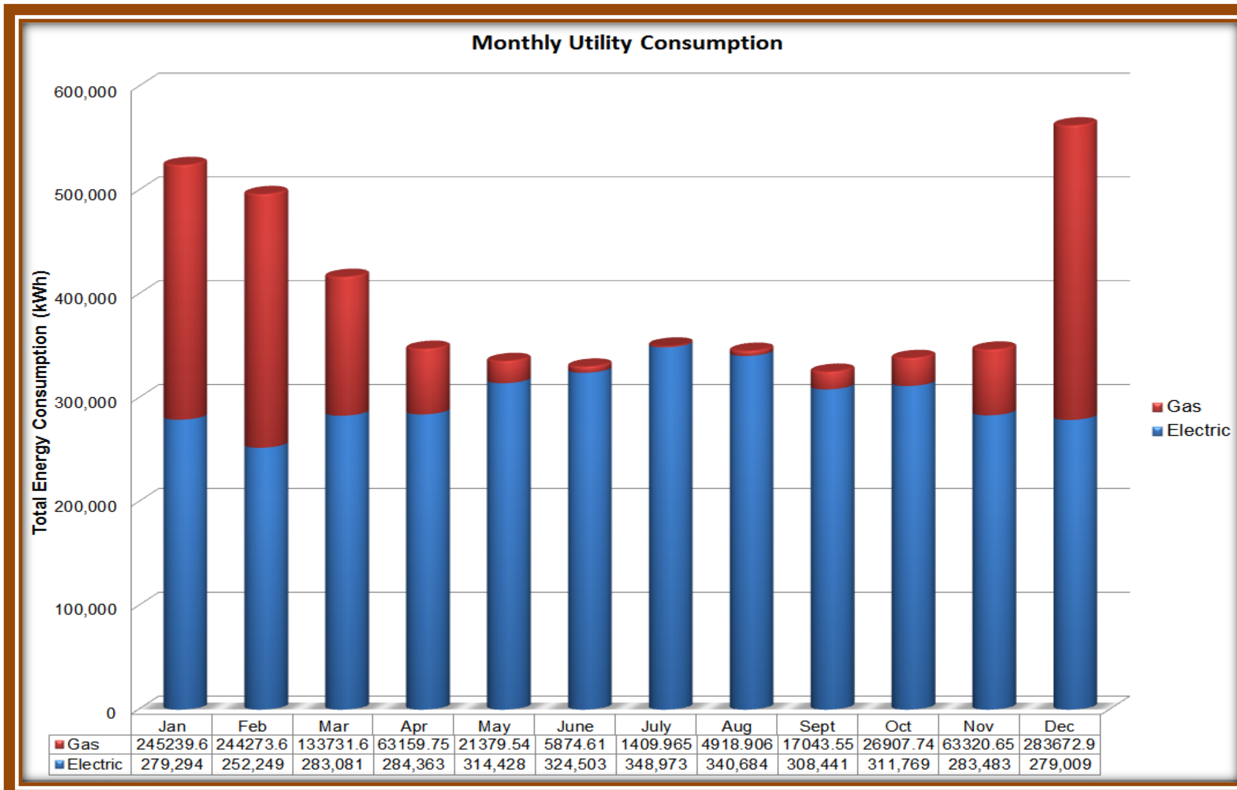
Cooling Load						
	System Load			Area/System Load		
	Design	Model	Difference	Design	Model	Difference
	Mbh	Mbh	%	SF/Ton	SF/Ton	%
AHU-1	3245	4125	27%	0.1	0.08	-21%
AHU-2	1039	1345	29%	0.23	0.18	-23%
AHU-3	307	465	51%	0.37	0.24	-34%
Overall	4592	5935	29%	0.15	0.11	-23%

Table-4 Cooling Load Comparison

7.3 Annual Energy Use

The annual energy simulation analysis was performed for EMD Serono Research Center –existing lab building using the same Trace700 model. Cooling equipment uses electricity to operate. Water consumption is mainly come from the cooling tower operation. The gas fired central heating plant operates year-round. Low pressure steam boilers provide winter heating, humidification, and summer reheat for temperature control.

The total annual energy consumption for the EMD Serono Research Center-existing lab building is 4,721,208 kWh, with 3,610,276 kWh coming from electricity, 1,110,932 kWh (37907 therms) coming from natural gas. The annual water consumption for mechanical equipment of this building is 1,875,000 gallon. This building has a large equipment and lighting load, due to the fact that pharmaceutical research and development building has high electric demand of lab instruments and light.



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Gas	245239.6	244273.6	133731.6	63159.75	21379.54	5874.61	1409.965	4918.906	17043.55	26907.74	63320.65	283672.9
Electric	279,294	252,249	283,081	284,363	314,428	324,503	348,973	340,684	308,441	311,769	283,483	279,009

Figure-9 Annual Energy Consumption

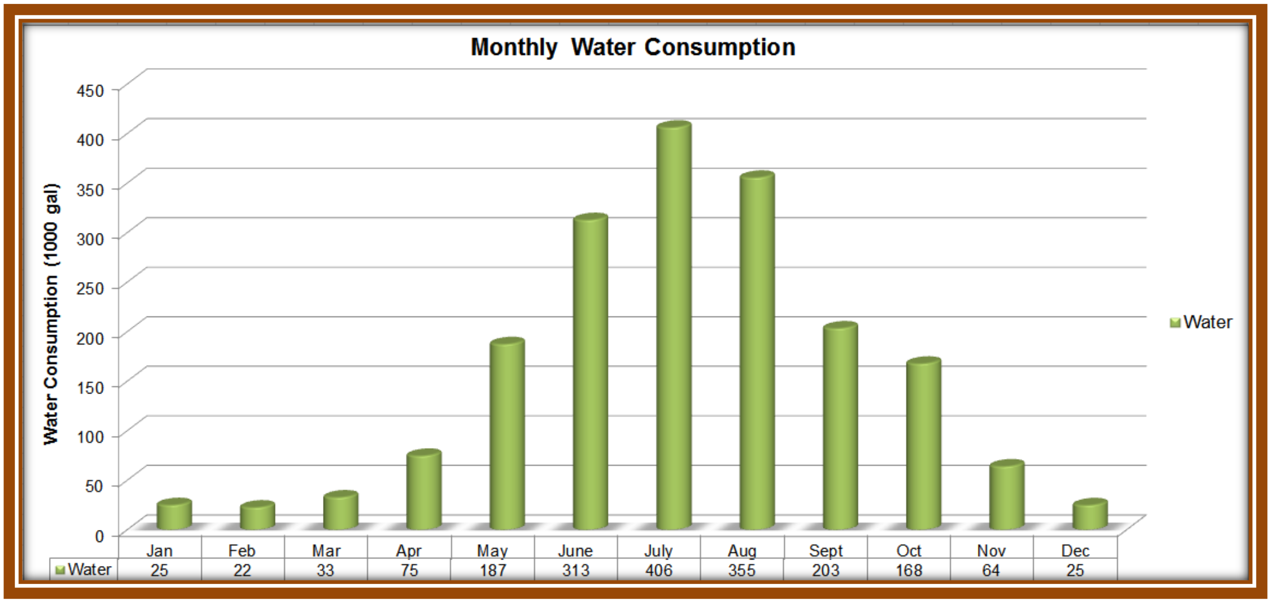


Figure-10 Annual Water Consumption

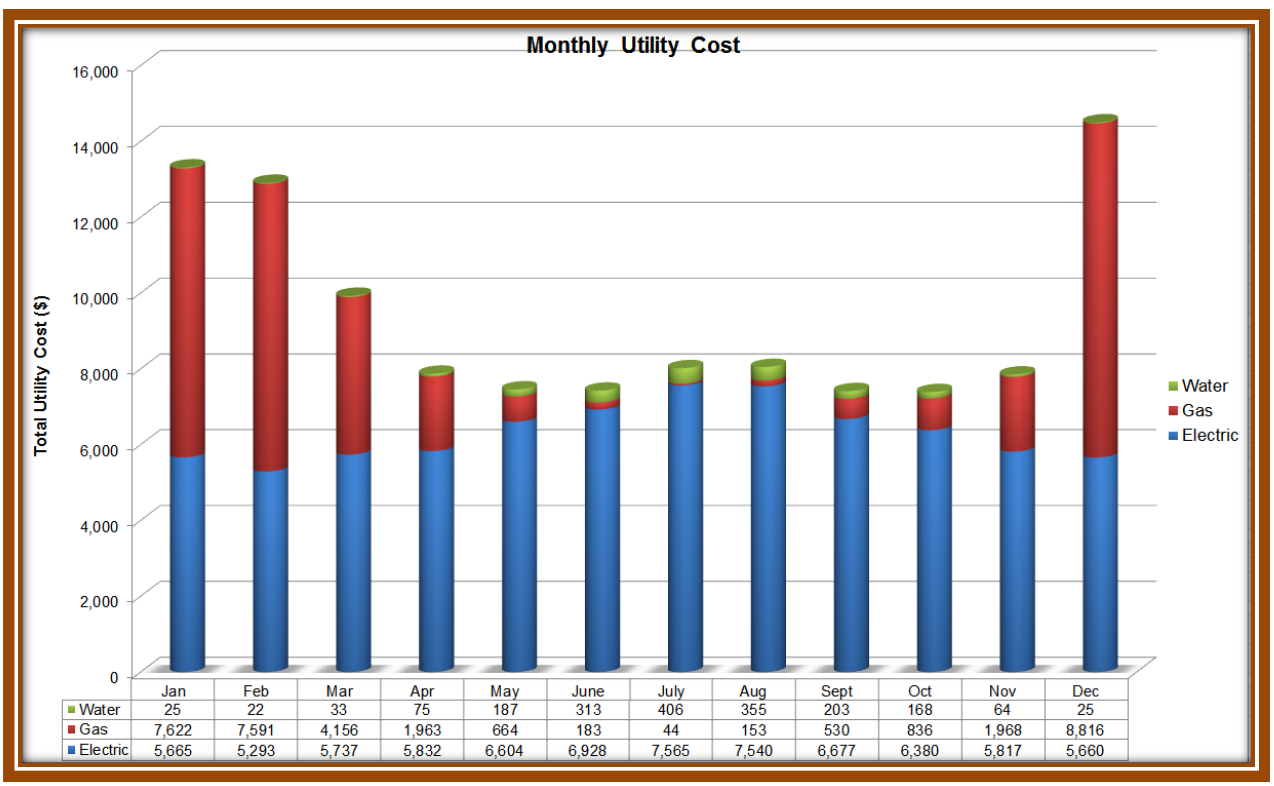


Figure-11 Annual Utility Cost

7.4 Energy Sources and Rates

The primary electrical service to the building is provided by the Massachusetts Electric Company. Since the building has an electrical demand of 1158kW, greater than 200kW, it is qualify for the Time-of-Use(G-3) electric rate.

$0.9108/therm was used as the natural gas rate. This gas rate was taken from the National Grid for Boston area with G-42-Low Load Factor General Service Rate-Medium building type.

Electricity Rate	
Customer Charge	$200.00/month
Distribution Demand Charge	$3.92/kW
Distribution Charge	
Peak Hours	1.374¢/kWh
Off-Peak Hours	0.621¢/kWh
Transmission Charge	1.328¢/kWh
Transition Energy Charge	0.030¢/kWh
Energy Efficiency Charge	0.433¢/kWh
Renewables Charge	0.050¢/kWh

Table- 5 Electric Rate for Time-of-Use (G-3) Building

8 Major Equipment Summary

The chiller plant of the EMD Serono Research Center – existing lab building consists of 2 chillers, a cooling tower, chilled water pumps, and condenser water pumps. The gas fire central heating plant consists of 2 boilers, steam-to-hot water shell-and-tube heat exchangers, boiler feed water pumps, and condensate pumps. The majority of the building's winter heating load is provided by the heating coils in the terminal boxes. There are a total of 207 terminal boxes throughout the building.

Air Handling Units								
	CFM	O.A.	Preheat Coil Steam	Cooling Coil		Humidifier	Filter	
				EDB	LDT		Pre-Filter	Final Filter
AHU-1	45,000	100%	10 psig	92	53	Yes	30%	65%
AHU-2	19,000	33%	10 psig	82	53	No	30%	65%
AHU-3	5,000	100%	10 psig	92	53	Yes	30%	65%

Table- 6 Air Handling Unit Schedule

Heat Exchangers					
	Water Side (Tube)				Steam Side (Shell)
	EWT (F)	LWT (F)	GPM	MBH	
HE-1	170	190	225	2299	10 psig
HE-2	170	190	225	2299	10 psig

Table- 7 Heat Exchanger Schedule

Water Pumps				
	GPM	Total Head (ft of H_2O)	Motor Data	
			MHP	RPM
CHP-1	840	60	20	1750
CHP-2	135	50	3	1750
CHP-3	135	50	3	1750
CWP-1	1050	50	15	1750
CH/CWP-1	1050	50	15	1750
HWP-1	225	50	5	1750
HWP-2	225	50	5	1750

Table- 8 Water Pump Schedule

Condensate Pumps				
	GPM	Suction Temperature (F)	# of Pumps	MHP each
CP-1	4	220	2	1/3
CP-2	8	200	2	3/4

Table- 9 Condensate Pump Schedule

Steam Boilers				
	Operating Pressure	HP	Lb/hr	Efficiency
B-1	15	175	6590	81%
B-2	15	50	2070	81%

Table- 10 Steam Boiler Schedule

Boiler Feed Water Pump					
	Service	GPM	Total Head (ft of H_2O)	Motor	
				HP	RPM
BFP-1	B-1,B-2	28/10	70	1 each	1750

Table – 11 Boiler Feed Water Pump Schedule

Chillers									
	Type	Tons	Evaporator			Condenser			Compressor
			EWT	LWT	GPM	EWT	LWT	GPM	LW/TON
CH-1	Centrifugal	350	55	45	840	95	85	1050	0.56
ACCH-1	Air Cooled	60	55	45	150	NA			1.24

Table – 12 Chiller Schedule

Cooling Tower					
	Tons	EWT	LWT	GPM	BHP
CT-1	350	95	85	1050	50

Table – 13 Cooling Tower Schedule

Fans						
	CFM	S.P. **(ft of H_2O)**	Fan RPM	Wheel Diameter (in)	MBHP	MHP
EX-1	20,000	2.5	1136	33	40	16.1
EX-2	20,000	2.5	1136	33	40	16.1
EX-3	7,000	3.0	1800	21	10	6.3
EX-3A	7,000	3.0	1800	21	10	6.3
EX-4	1,200	3.0	NA	NA	2	NA
EX-5	850	2.0	NA	NA	2	
EX-6	800	1.5	1750	12	½	0.33
EX-7	800	1.5	1750	12	½	0.33
EX-8	2,500	1.5	1725	NA	1 ½	NA

Table – 14 Fan Schedule

Variable & Constant Volume Terminal Boxes								
	Design Range	Hot Water Coil					Air Side	
	CFM	MBH	EWT	LWT	GPM	MAX. ΔP **(in H_2O)**	EAT	LAT
VAV-5	65-250	12.2	180	140	0.6	0.5	55	100
VAV-6	75-400	19.4	180	140	1.0	0.5	55	100
VAV-8	150-700	34.0	180	140	1.7	0.5	55	100
VAV-10	250-1000	48.6	180	140	2.4	0.5	55	100
VAV-12	350-1500	72.9	180	140	3.7	0.5	55	100
VAV-14	475-1950	94.8	180	140	4.7	0.5	55	100
CV-5	65-250	12.2	180	140	0.6	0.5	55	100
CV-6	75-400	19.4	180	140	1.0	0.5	55	100
CV-8	150-700	34.0	180	140	1.7	0.5	55	100
CV-10	250-1000	48.6	180	140	2.4	0.5	55	100
CV-12	350-1500	72.9	180	140	3.7	0.5	55	100
CV-14	475-1950	94.8	180	140	4.7	0.5	55	100

Table – 15 Variable & Constant Volume Terminal Box Schedule

9 Lost Usable Space

The total space that was allocated for mechanical system components such as mechanical equipment floor space and vertical mechanical shaft area is outlined in Table - 16 below. Majority of the mechanical equipment are located within the dedicated mechanical rooms in the basement and the penthouse. A cooling tower and an air cooled chiller are located on the roof, which is not considered as usable space. A total of $10429 sf of usable space is lost due to the mechanical system.

Mechanical Space			
Floor	Lost Space (sf)		
	Mechanical Rooms	Vertical Shafts	Total
Basement	4750	21	4771
1st Floor	NA	103	103
2nd Floor	NA	189	189
Penthouse	5366	NA	5366
Total	10116	NA	**10429**

Table – 16 Lose Space due to Mechanical System

10 Mechanical System First Cost

The approximate first cost of the mechanical, plumbing, and fire protection systems of the project is listed in Table - 17. The HVAC and controls systems total to $3,186,441, which equates to $54.4/sf and accounts for 20% of the total construction cost. Including plumbing and fire protection systems, the cost raises to $4,601,037, which equates to $78.58/sf and accounts for 29% of the total construction cost. The mechanical system cost is the most significant amount compared to other systems in the building.

Mechanical System Initial Cost			
	Total GMP ($)	$/sf	Percentage of Total Cost
Plumbing and Drainage	1,242,260	21.21	8%
Fire Protection	172,336	2.94	1%
HVAC	2,731,241	46.63	17%
Controls	455,200	7.77	3%
Total Mechanical Cost	4,601, 037	78.58	**29%**
Total Construction Cost	15,885,210	217.23	100%

Table- 17 Mechanical System Initial Cost

11 LEED Analysis

The Leadership in Energy and Environmental Design (LEED)2009 for New Construction and Major Renovations rating system was used to perform the assessment for the EMD Serono Research Center – existing building' mechanical systems. The two main categories for mechanical system assessment are Energy and Atmosphere, and Indoor Air Quality. In the Indoor Air Quality category, only IEQ C1, IEQ C2, IEQ C5, IEQ C6.2, IEQ C7.1, and IEQ C7.2 are associated with mechanical system; other credits are associated with construction practice, electrical, and day lighting. Only credits that are associated with mechanical systems were analyzed in this report.

11.1 Energy and Atmosphere

Prerequisite 1 Fundamental Commissioning of Building Energy Systems - Yes

Intent: To verify that the project's energy-related systems are installed, and calibrated to perform as specified by the design engineer.

EMD Serono: This intent was achieved throught the HVAC contracter, who provided the commissioning services on this project.

Prerequisite 2 Minimum Energy Performance - Yes

Intent: To establish the minimum level of energy efficiency for the buidling systems to reduce enviromental and economic impacts associated with excessive energy use.

EMD Serono: To satisfy this intent, the buidling's system is in compliance with all mandatory provisions as well as the prescriptive requirements of ASHRAE Standard 90.1-2007.

Prerequisite 3 Fundamental Refrigerant Management – Yes

Intent: Zero use of chlorofluorocarbon(CFC)-based refrigerants to reduce stratospheric ozone depletion.

EMD Serono: All of the refrigeration equipments uses HFC-134a or HCFC-123.

Credit 1 Optimize Energy Performance – No

Intent: To achieve higher levels of energy performance beyond the prerequiste.

EMD Serono: An energy model was done by Trane TRACE 700 to compare the energy consumption of the ASHRAE Standard 90.1-2007 baseline buidling system and the designed building system. According to the model, the baseline building consumes 14,423 MMBtu/year while the designed system consumes 16,108 MMBtu/year. The baseline system has a lower energy consumption than the designed system. Therefore, no credit will be earned in this section.

Credit 2 On-site renewable Energy - No

Intent: To encourage the use of on-site renewable energy to self-supply energy to the building.

EMD Serono: The design of this building does not incorporate the use of any renewable energy sources. Therefore, no credit will be earned in this section.

Credit 3 Enhanced Commissioning - No

Intent: To begin the commissioning process early in the design process and execute additional activity after systems performance verification is completed.

EMD Serono: Only basic commissioning was done on this project. Therefore, no credit will be earned in this section.

Credit 4 Enhanced Refrigerant Management - Yes

Intent: To reduce atmospheric ozone depletion and support of the Montreal Protocol.

EMD Serono: Since HFC-134a or HCFC-123 refrigerants are used in the systems, the following formula must be followed to earn credit points:

$$\mathrm{LCGWP} + (\mathrm{LCODP} \times 105) \leq 100$$

$$\mathrm{LCODP} = \frac{[\mathrm{ODPr} \times (\mathrm{Lr} \times \mathrm{Life} + \mathrm{Mr}) \times \mathrm{Rc}]}{\mathrm{Life}}$$

$$\mathrm{LCGWP} = \frac{[\mathrm{GWPr} \times (\mathrm{Lr} \times \mathrm{Life} + \mathrm{Mr}) \times \mathrm{Rc}]}{\mathrm{Life}}$$

LCODP: Lifecycle Ozone Depletion Potential

LCGWP: Lifecycle Direct Global Warming Potential

GWPr: Global Warming Potential of Refrigerant

ODPr: Ozone Depletion Potential of Refrigerant

Lr: Refrigerant Leakage Rate (2%)

Mr: End of Life Refrigerant Loss (10%)

Rc: Refrigerant Charge (lb/ton)

Life: Equipment Life (20 years)

Refrigerant Management										
	ODPr	GWPr	Lr	Life	Mr	Rc	LCODP	LCGWP0	Total	Credit
HFC134a	0.02	96	0.02	20	0.1	1.5	0.00075	3.6	78.6	**Yes**
HCFC123	0	1300	0.02	20	0.1	1.5	0	48.75	48.75	**Yes**

Table- 18 Refrigerant Management

When HFC134a is used, a total of 78.6 is obtained. When HCFC123 is used, a total of 48.75 is obtained. In either case, the numbers are less than 100, therefore, the buidling will receive 2 credit points.

Credit 5 Measurement and Verification - No

Intent: To provide for the ongoing accountability of building energy consumption over time.

EMD Serono: Since this building does not monitor their energy use for an entire year after post construction occupancy, no credit will be given in this section.

Credit 6 Green Power - No

Intent: To encourage the use of grid-source, renewable energy technology.

EMD Serono: This building does not purchase any of its power that are generated using green power througt the grid. Therefore, no credit will be given in this section.

11.2 Indoor Environmental Quality

Prerequisite 1 Minimum Indoor Air Quality Performance - Yes

Intent: To establish indoor air quality performance to enhance indoor air quality in building.

EMD Serono: Mechanical ventilation is used through out the building and has been designed using the ventilation rate procedure outlined in ASHRAE Standard 62.1 – 2007.

Prerequisite 2 Enviromental Tobacco Smoke (ETS) Control - Yes

Intent: To minimize building occupants, indoor surfaces, and ventilation air distribution systems to enviromental tabacco smoke(ETS).

EMD Serono: Smoking is prohibited for this building.

Credit 1 Outdoor Air Delivery Monitoring - No

Intent: To provide ventilation system monitoring to promote occupant comfort.

EMD Serono: Since the majority of space in the building are conditioned with 100% constant volume outdoor air, CO_2 monitor sensor is not utilized in this building. Therefore, no credit will be given in this section.

Credit 2 Increased Ventilation - Yes

Intent: To provide additional outdoor air ventilation to improve indoor air quality.

EMD Serono: There are 3 air handling units in this building. AHU-1 and AHU-3 provides 100% outdoor air to their conditioned spaces, therefore, exceed at least 30% minimum ventilation required by ASHRAE Standard 62.1-2007. AHU-2 has return air recirculates back to the buidling and the ventilation rate it supplies to each occupied zone exceed the 30% increase over ASHRAE Standard 62.1-2007. Therefore, 1 point will be earned for this section.

Credit 5 Indoor Chemical and Pollutant Source Control - Yes

Intent: To minimize building occupant exposure to potentially hazardous particulates and chemical pollutants.

EMD Serono: All potentially hazardous spaces such as R&D labs and vivarium rooms are 100% exhausted. Laboratories have pressure equal to adjacent laboratories and negative in relation to corridors and office spaces. Tissue culture rooms, vivarium rooms, and other potentially hazarous spaces have pressure negative in relation to adjacent spaces. A 30% pre-filter and a 65% post-filter is installed in each air handling unit which gives an overall filter efficiency of 75%. For potentailly hazardous spaces, 99.97% HEPA final filters are used, which is equivalent to MERV15 filters. Intent was achieved and the building will receive 1 credit point.

Credit 6.2 Controllability of Systems – Thermal Comfort - No

Intent: To promote thermal comfort control for individual occupants.

EMD Serono: This credit is not achieved because rooms with similar occupancies are zoned together and serves by a single terminal box with one corresponding thermostat.

Credit 7.1 Thermal Comfort - Design - Yes

Intent: To providea comfortable thermal enviroment that promote occupant productivity and well-being.

EMD Serono: All of the heating, ventilating and air conditioning (HVAC) systems designed meet the criteria stated by ASHRAE Standard 55-2004. Therefore, 1 point will be given.

Credit 7.2 Thermal Comfort - Verification - No

Intent: To provide assessment of building occupant thermal comfort over time.

EMD Serono: A thermal comfort survey of building occupants within 6 to 18 months after occupancy was not done.

11.3 Conclusion

LEED mechanical system assessment was performed. Only categories that are assoicated with mechanical system in the Energy and Atmoshere section and Indoor Enviromental Quality section were analysised. Result of the assessemnt is shown in Table – 19 and Table - 20. The mechancial system meets the prerequisites of both sections as well as qulifies to earn 2 credit points from the Energy and Atmosphere section and 3 credit points from the Indoor Enviromental Quality section.

Energy and Atmosphere		
	Yes	No
Prerequisite 1	1	
Prerequisite 2	1	
Prerequisite 3	1	
EA Credit 1		1
EA Credit 2		1
EA Credit 3		1
EA Credit 4	2	
EA Credit 5		1
EA Credit 6		1

Table- 19 Energy and Atmosphere

Indoor Environmental Quality		
	Yes	No
Prerequisite 1	1	
Prerequisite 2	1	
IEQ Credit 1		1
IEQ Credit 2	1	
IEQ Credit 5	1	
IEQ Credit 6.2		1
IEQ Credit 7.1	1	
IEQ Credit 7.2		1

Table- 20 Indoor Environmental Quality

12 Overall Evaluation

The mechanical system of the EMD Serono Research Center – existing lab building was well designed. Significant efforts were made to provide safe indoor air quality to promote occupants' comforts, well-beings, and productivities. There is 100% outdoor air and 100% exhaust provided to critical spaces; such as laboratories and vivarium room. Pre-filters and post-filters are installed in every air handling unit with an overall filter efficiency of 75%. Critical spaces used 99.97 HEPA final filters, which is equivalent to MERV 15 filters. With different systems for critical spaces, excessive outdoor air, and high efficiency filters, the mechanical system design was designed to ensure that contaminated air does not recirculate and transfer inside the building. However, majority of the terminal boxes in the laboratory areas and office areas are variable volume terminal boxes, it is difficult to maintain negative pressurization in critical spaces relative to adjacent spaces in reality.

The Chilled water cooling plant consists of a water cooled centrifugal chiller, a cooling tower, and an air cooled chiller. Air is distributed throughout the building by variable and constant volume terminal boxes in the spaces. The cooling system is designed as a parallel chiller – primary constant flow system. Utilizing secondary/primary system or variable primary flow system might help reduce pumping energy consumption. The Gas fired central heating plant consists of two low pressure steam boilers and two heat exchangers. Air is preheated in the air handling units by low pressure steam pre-heat coils and heated again at the terminal boxes by hot water heating coils. Hot water comes from the heat exchangers. Automatic temperature control system and direct digital control systems are utilized in this building. The existing system was found to have slightly higher energy consumption than the baseline system provided by ASHRAE Standard 90.1-2007. Optimizing a new control system may be done in order to reduce energy consumption.

The first cost for the mechanical system is $3,186,441 or $54.4/sf. The mechanical system represents approximately 20% of the building's total construction cost. Including plumbing and fire protection systems, the total mechanical cost is $4,601,037 or $78.58/sf, which is 29% of the total construction cost. Since typical mechanical system cost represents 15-20% of the total building construction cost, this mechanical system's first cost is relatively high. The annual energy consumption is 4,721,208 kWh with 3,610,276 kWh coming from electricity and 1,110,932 kWh (37907 therms) coming from natural gas. The annual operating cost for the mechanical system is approximately $112,097 or $1.99/sf.

The mechanical system mainly occupies dedicated mechanical rooms in both the basement and the penthouse. A cooling tower and air cooled chiller are located on the roof level. There are also some vertical shafts located throughout the building for mechanical ducts. The lost space due to mechanical system is approximately 10429 sf, which is approximately 18% of the total gross area of the building.

One of the main objectives of the mechanical design is to encourage routine preventive maintenance by providing ease access for maintenance personnel. Equipment was laid out and located to provide enough clearances. Manual isolation valves were provided to enable servicing and expansion of any part of the existing building without unscheduled interruption of services in adjacent areas.

A LEED mechanical system assessment was performed. This building was able to received 2 credit points from the Energy and Atmosphere section and 3 credit points from the Indoor Environmental Quality section. Since this building was designed in 1999, LEED accreditation was a fairly new concept at the time of design so that it was not considered in the design process. Utilizing LEED accreditation standard in the design process would improve the sustainability of this building.

Reference

ASHRAE Standard 62.1 – 2007

ASHRAE Standard 90.1 -2007

ASHRAE Handbook of Fundamentals

LEED 2009 for New Construction and Major Renovations

EMD Serono, Inc. http://www.emdserono.com/en/index.htm

Bard, Rao+Athanas Consulting Engineers, LLC http://brplusa.com/

Appendix A

List of Tables

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