majority of the air handlers. There are louvers along the north side of the building that allow for outdoor air to come in and feed the air handlers.

On levels 4-8 the research laboratories are variable volume, as are the office spaces on the opposite side of the floors. However not all spaces on levels 4-8 are variable volume there are a some laboratory support spaces that are constant volume, typically the presence of a fume hood will indicate constant volume. The air within the laboratory and laboratory support spaces is exhausted through exhaust fans located on the roof via exhaust risers or through fume hoods that also exhaust through the roof. The laboratory and office spaces on levels 4-8 are separated by a pressurized corridor/interaction space. Air in the office side and separating corridor/interaction space is returned.

Existing Mechanical System Operation

This section of the report will describe the operation of the four main systems throughout the building. These systems are the steam, chilled water, heating hot water and air systems within the building. Each section will describe the system and reference and accompanying schematic of the system.

Building Steam System

The Margaret M. Alkek Building for Biomedical Research has an extensive steam system. Baylor College of Medicine’s campus is located at the Texas Medical Center which produces its own steam via the Texas Medical Center Central Heating and Cooling Services Cooperative Association (TECO). The research tower utilizes this campus steam loop for many different uses.

The campus steam loop conditions are 398°F and 225 psig. The building draws in 26,000 lb/hr of steam at peak load. The amount of demand depends on the following; humidification in the air handlers, the amount of process of steam required, domestic hot water and heating hot water needs. The high pressure steam is brought into the building and then goes through a series of pressure reducing valves which creates medium pressure steam (80 psig) and low pressure steam (15 psig) loops.

The low pressure steam loop feeds two shell & tube heat exchangers (HE-1 & HE-2 on Figure 5 below) which create the heating hot water for the building. HE-2 unit is used as standby. The low pressure steam is then returned to a condensate pump (CP-1 on Figure 5 below) and then is fed back into the TECO condensate system. The high pressure return and low pressure return from the pressure reducing valves feed into a flash tank which vents off any existing steam and then connects to the same condensate pump as the low pressure steam system which again connects into the TECO condensate system.

The medium pressure steam loop goes to feed 3 clean steam generators and the domestic hot water heaters. As shown on figure 5, CSG-1 creates clean low pressure steam (CLPS) which feeds the air handling units for humidification needs. This CLPS then returns to a condensate cooler which connects to the existing water recovery system on campus. CSG-2 & CSG-3 create clean medium pressure steam which feeds all the process steam requirements throughout the building for sterilization of lab equipment and other needs. The process steam is then returned to a flash tank which then feeds clean low pressure return steam into the same condensate cooler as mentioned above which then connects to the existing water recovery system. The domestic hot water heaters connect right off of the medium pressure steam loop. All of the medium pressure return from the CSG's and domestic water heaters connects to a flash tank which connects back to CP-1 (same condensate pump as the other HPR and MPR connect into) and then into the TECO condensate system.

The amount of steam drawn off the high pressure steam loop depends entirely on the heating and steam generation needs of the building at any point in time. See the below schematic (Figure 5) for a complete view of steam usage in the building.

BUILDING STEAM SYSTEM

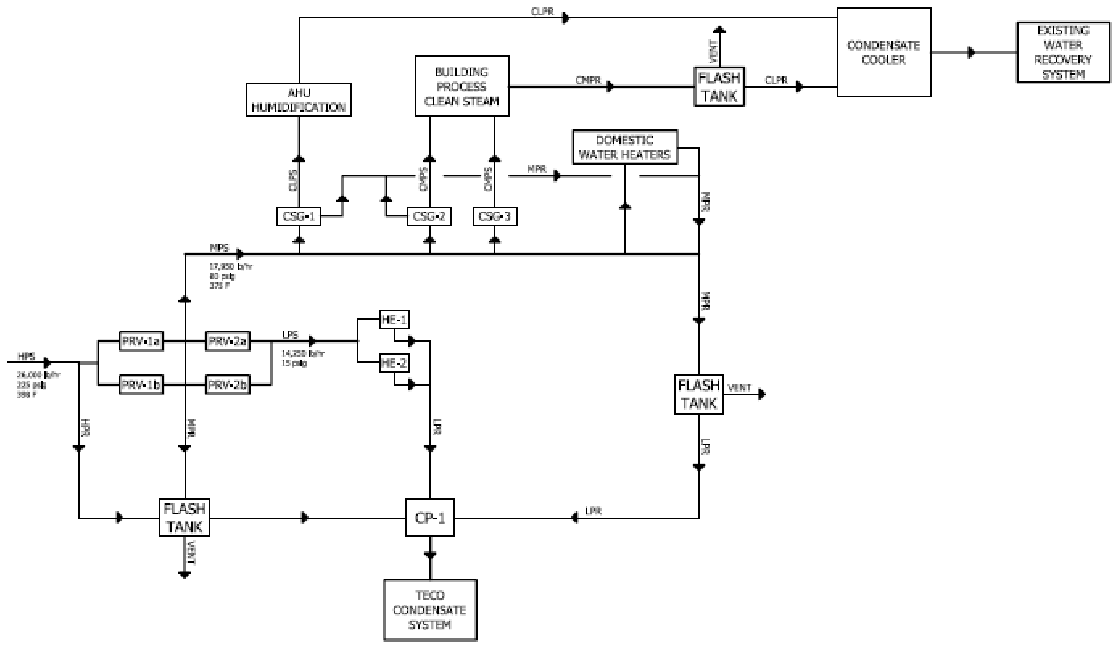

Figure 5

Building Chilled Water System

The Margaret M. Alkek Building for Biomedical Research utilizes the existing campus chilled water loop for all its chilled water needs. The chilled water is produced in the north campus chiller plant. With the addition of the new research tower, a chiller had to be replaced. An existing 800 ton centrifugal chiller was replaced with a new 1300 ton centrifugal chiller to assist in the handling of the new load on campus and for future expansion. The campus loop circulates chilled water at 45°F.

Chilled water is drawn into the building and separated into two loops. The first loop takes 45°F water through two pumps in parallel (CHP-1 & CHP-2). This chilled water is pumped to the cooling coils on the air handling units that serve levels 4-8's office and lab space (AHU-L.1a, AHU-L.1b, AHU-L.2a and AHU-L.2b) as well as the cooling coils on the stairwell pressurization air handlers. The sensors on the coils in the air handling units connect back to the two pumps (CHP-1 & CHP-2) which are connected to variable frequency drives for control of how much chilled water is brought into the building via this loop. At peak load this loop will draw in 2750 GPM. The chilled water used by these air handlers is then returned at 60°F to the campus chilled water return loop.

The second chilled water loop created within the building feeds the air handlers for the animal research facility floors (AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A.1d), fan coil units and process cooling throughout the building. Two parallel pumps (CHP-3 & CHP-4) draw in 1720 GPM (peak design load) of chilled water, of which, 1360 goes directly to the air handlers for the animal research facility floors. A sensor on the cooling coils connects back to the variable frequency drives attached to CHP-3 and CHP-4. The chilled water is returned from these air handlers at 60°F to the campus chilled water return loop. A 360 GPM branch breaks off to feed a plate and frame heat exchanger (PFX-1). Chilled water enters the PFX-1 at 45°F and leaves at 60°F, this water then is returned to the campus chilled water return loop. The plate and frame heat exchanger creates 50°F chilled water which then feeds fan coil units and any process cooling needs throughout the rest of the building. The water is then returned to the PFX-1 at 65°F. The schematic of this system can be seen below.

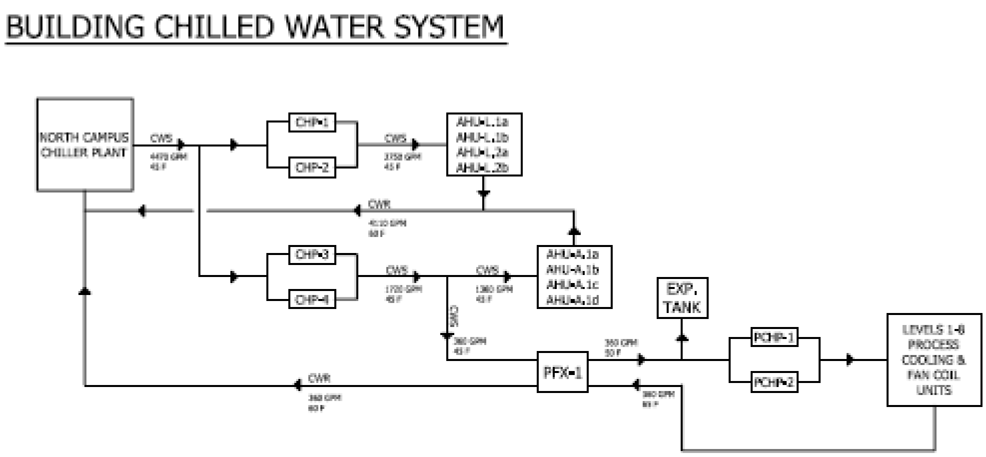

Figure 6

Building Heating Hot Water System

The research tower's heating hot water system is fairly simple. As stated above in the steam section two shell & tube heat exchangers (HE-1 & HE-2) are used for heating hot water creation for the building. HE-2 is a standby unit. At peak design HE-1 creates 950 GPM (peak design load) of heating hot water for distribution throughout the building. The two heat exchangers are connected to two parallel pumps (HWP-1 & HWP-2) which distribute the heating hot water. There are 3 loads that the heating hot water feeds; the reheat coils in the VAV/CV boxes on levels 1 and 2, the reheat coils in the VAV/CV boxes on levels 4-8 and level 3 which houses the air handling units for laboratory, office and animal research facilities. The heating hot water is distributed at 190°F and returned at 160°F.

The controls on the heating hot water are slightly more complex than the other systems. Each space (or zone) within the building has its own CV or VAV box. Each box (with the exception of cold rooms, electrical and mechanical rooms) has a reheat coil in the box. The thermostats in each room then connect to the diffusers and reheat coils. If the thermostat is set to where reheat is needed at the box, the reheat coil is turned on. The reheat coils in the boxes and heating coils in the boxes connect to the variable frequency drives connected to the pumps for control of how much heating hot water is distributed. The complete diagram can be seen below.

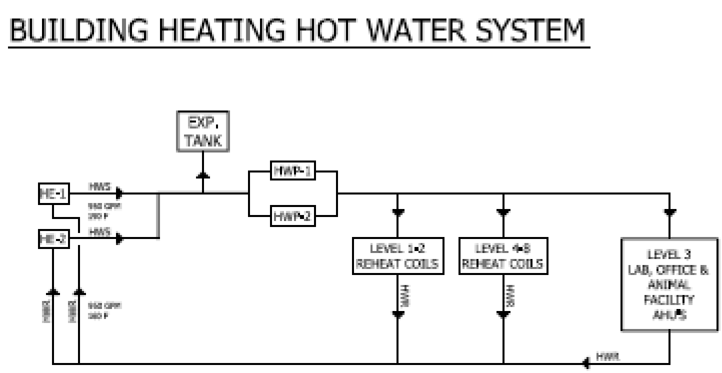

Figure 7

Building Air Side Systems

The research tower's air system is relatively simple as well. The building has three separate air systems with multiple air handling units serving each of these three systems. System 1 serves animal research facility on levels 1 and 2. System 2 serves the laboratory spaces on levels 4-8, while System 3 serves the office spaces on levels 4-8 as well as the remaining laboratory spaces not covered by System 2.

System 1: AHU-A.1a, AHU-A.1b, AHU-A.1c & AHU-A.1d

System 1 serves the animal facilities on levels 1 & 2. This system consists of four 25,000 CFM air handlers; AHU-A.1a, AHU-A.1b, AHU-A.1c and AHU-A1.d. The animal facilities on the first floor are made up of animal housing rooms in which animals to conduct experiments on are held. Connected to the animal housing rooms are procedure rooms where the experiments or preparation for experiments can be carried out. A majority of the space on level 1 is taken up by a cage wash facility for cleansing of all the cages in which animals are stored. Level 2 consists almost exclusively of the aforementioned animal housing rooms and adjacent procedure rooms.

System 1's four air handlers are stacked in a 2x2 configuration and "dump" all their supply air into a supply plenum where air from all 4 air handlers is mixed. Air is then supplied from there to the appropriate spaces on levels 1 & 2. The system is 100% outdoor air, this is due to needing the air as clean as possible so as to not influence experiments or spread contaminants/sickness. The air is exhausted from these spaces through four separate means; biological safety cabinets (similar to fume hoods), an exhaust riser dedicated to animal spaces, toilet exhaust and an exhaust for the cagewash exhaust which is a "wet" exhaust because of the steam used to sterilize during cleaning.

The thermostats determine how much air is required for these spaces which connect back to the variable frequency drives connected to the fans of the air handling unit as well as the VAV/CV boxes. The exhaust tracks the supply so that pressurization required in certain rooms are maintained. Many of the spaces within this system are constant volume to maintain pressurization due to the fume hoods and biological safety cabinets which draw a constant amount of air from the room. The diagram of this system can be seen below in Figure 8.

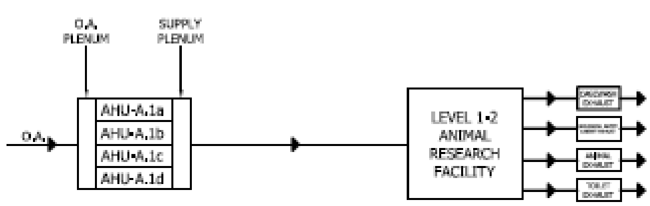

Figure 8

System 2: AHU-L.2a & AHU-L.2b

System 2 serves the laboratory spaces on levels 4-8. This system consists of air handlers; AHU-L.2a and AHU-L.2b. The laboratory spaces on these levels are for research purposes at the college. The adjacent spaces are laboratory support and are made up of spaces such as fume hood rooms, equipment rooms, microscopy and general lab support rooms. The air handlers are stacked on top of each other and supply into a supply plenum similar to system 1. This system is also 100% outdoor air for the same reasons as system 1.

System 2 is controlled the same as System 1. The difference being that much fewer spaces are constant volume due to only a few fume hoods being present (and in specific rooms). The spaces are exhausted via exhaust risers that connect to four exhaust fans connected in parallel. The diagram of this system can be seen below.

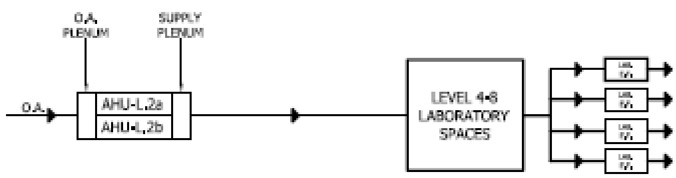

Figure 9

System 3: AHU-L.1a & AHU-L.1b

System 3 is the only system in the research tower that uses recirculated air. This system serves the rest of the laboratory spaces on levels 4-8 not covered by system 2, the office spaces on levels 4-8 and the main lobby and attached corridor on level 1. This system is made up of air handling units AHU-L.1a and AHU-L.1b. These units are also stacked one on top of the other and use the supply plenum like the other 2 systems. Air in the laboratory spaces on these floors is exhausted through the roof of the building. The office side of levels 4-8 and few level 1 spaces are the spaces that are returned. The system is approximately 50% outdoor air.

The controls on System 3 are similar to the other 2 systems. In this case return tracks the supply in the office spaces that return air. There are no constant volume spaces (outside of the restrooms) in this system because the few laboratory spaces that are covered by this system do not require it. The laboratory spaces are exhausted by exhaust fans located on the roof via duct risers. The diagram of this system can be seen below in Figure 10.

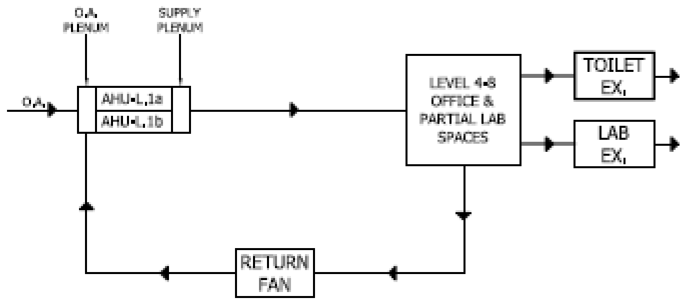

Figure 10

Proposed Redesign

Scope

The proposed redesign intends to address the energy consumption and indoor air quality issues of the building. Currently the solution to controlling the indoor air quality is to use 100% outdoor air systems which contribute to the energy consumption of the building. Using 100% outdoor air means there is no return air which means there is no energy savings through mixing of air. The basic premise of the redesign will be using air quality sensors placed before and after filters in what is currently the exhaust stream to track the air quality and then when it is acceptable either return the air or use an energy recovery device such as an enthalpy, sensible or desiccant wheel in an attempt to cut down on the energy consumption of the building.

The first issue to deal with will be implementation of filters and the indoor air quality controls. The system will need to be able to monitor what will become an exhaust/return stream and determine when the air is acceptable to use or when it needs to be exhausted. It appears as though this sort of system is somewhat rare.

A fair amount of information will need to be gathered to set up controls like this. The first bit of information will be what sort of particles do mice release since the main animal being used for experimentation is mice. Also information on what sort of toxins and particles are typically released during the types of experiments that are