March 03, 2006

BIOME DESIGN TECHNICAL DATA

1) Dimensions:

Each biome has the following clear interior dimensions: length 6,096 m, width: 3,404 m

Interior clearance throughout: 4,268 m (floor to underside of trusses)

Maximum interior height at center of biome: 6,000 m (at peak, interior dimension)

Floor area is nominally 20,8 square meters (clear).
Roof area is nominally 24,8 square meters.
Interior volume is nominally 98,1 cubic meters.

2) General considerations/Glazing

Biomes are entirely independent individual units. They are identical in form and function but can be operated in widely different climate conditions. There is no operable vent in the biomes. Biomes are sealed from the outside. Glazing for the roof and exterior walls (south) are insulated glass units allowing approximately 73% of visible light through, and with a solar heat gain coefficient of 62%. Glazing for the partition walls between biomes is made of tempered standard float glass with visible light transmission of 90%.

3) Temperature range

Each biome has 24,7 kW of available heating power.
Each biome has 33,9 kW of available cooling power, rated as 18,9 kW of sensible capacity and 14,9 kW of latent capacity.

The heating power is sufficient to maintain 30 C inside temperature at night when outside temperature is -20 C, with no sun, allowing in 10% of outside air (146 liters per second) at -20 C and recirculating 90% of the biome air. Air infiltration from outside is assumed to be 0.40 natural air exchange per hour (40 cu.m per hour), a number that will likely be lower by careful construction and attention to details. During the day, the heating system will have the ability to reach even higher temperature as the solar gain will help to reduce the heat load and therefore allow increased interior temperatures. Interior temperatures can also be raised higher during both day and night by decreasing the volume of outside air allowed in from 10% down to zero. It is not however a good practice to run without outside air for extended periods of time as phytotoxic gases such as ethylene can accumulate.

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It is more difficult to define the limits of the cooling system as they vary considerably with interior and exterior conditions. If the biome is empty of plants, the total available cooling power of 33,9 kW will mostly be sensible cooling (that part affecting directly the air temperature). If the biome is jammed packed with tall and heavy foliage plants then a large part of the cooling power will be used as latent power to condensate humidity on the cooling coil. Basically, assumptions have to be made in order to calculate the required cooling power of the biome. An interior temperature of 17 C with coincident RH of 70% should be maintained during a bright cloudless sunny day with exterior temperature of 30 C and RH of 55%, with 5% outside air being allowed in. Solar gain is then 12,2 kW, conduction gain is 9,4 kW for a total of 21,6 kW of required sensible power. This leaves about 12,9 kW for latent power. Assuming a biome filled with small plants, say 300 mm high, with little foliage, then the interior temperature will probably go down to 15 C but this will largely depend on desired interior RH to be maintained. I don't believe the temperature will go much below that as the chilled water is only 4.4 C and the interior humidity conditions will eat up the power.

As a streamlined guide, the following can be used:

Winter: interior temperatures of 10 C to 30 C (day and night)
Summer: interior temperatures of 17 C to 30 C (day and night)

In addition to the above information on heating, a general "snow melting" heating system is planned for the entire facility. This system consists of finned tubing installed close to the roof glazing. The system will be triggered by the detection of falling snow by the computer control and will generate heat radiation close to glass in order to melt the snow falling on the roof surface. This system will ensure that no loss of light caused by snow accumulation will occur for extended periods of time. The system is also a redundant level of safety for emergency heating.

All biome HVAC equipment in under emergency power.

4) Humidity Range

There is no dehumidification equipment for the biomes. Therefore, there is no minimum RH that can be guaranteed. There will be some dehumidification at the cooling coil and by the admission of larger volumes of outside air in the system. The fog system in the biome will allow increasing the RH up to 100% and maintain it there. The range that should be shown is : ambiant to 100%.

5) Light Intensity Range

Each biome has the capacity to accept 8 fixtures (600 W high pressure sodium) on two different switchable circuits. The design is based on providing 200 micromoles per second per square meter (or 40 watts/square meter (PAR) or 16638 lux) with a uniformity of 91% (minimum over average intensity) when installed 2,28 meters (bulb) above plant lighting level.

The uniformity and intensity varies with the distance between the bulbs and the plant lighting level. The highest installation level is 3,0 meters above bench. The lowest installation is 600 mm above bench. Obviously, intensity will increase when you lower the distance between plant and bulb but the uniformity will decrease.

6) CO2 range

The CO2 range in the biome will vary depending on the amount of outside air allowed in the HVAC system. With 10% outside air allowed in, the range can be maintained from ambient to 3000 ppm. It is not recommend to increase the volume of outside air above 10% if CO2 injection is programmed to occur as it will result in large consumption of the gas.

7) Other features

Each biome is equipped with a **horizontal shading system** providing 50% solar shade, to be deployed whenever light level in the biome gets too high or too low, to cut on the solar gain, to save energy at night or in other circumstances as decided by the users.

Each biome is equipped with a **vertical shading system** installed on the south wall and providing 70% shading when deployed. Mostly used to cut high lighting levels when desired or to cut on solar gain if temperature control is deemed more important than light level by users.

Computer controlled outlets: there are 4 independent and computer controlled 120 VAC outlets in each biome. These outlets can be put permanently at on to be used as regular power outlets, can be tied in to any other parameter(s) of the control system to turn on whenever a special condition is reached or can be turned on a time basis, etc...

Two **unassigned sensor input jacks** are provided in each biome. These inputs allow users to connect any sensing device with analog outputs. The outputs are read by the control system and can be simply logged or otherwise used to control any of the system's output. For example, a leaf sensor can be used to trigger a localized heater plugged in a computer controlled outlet.

A **fog generating system** is provided in each biome. This system is mostly used to maintain humidity. It can also be programmed to simulate real fog conditions as seen in the natural environment.

A **rain simulation system** is provided in each biome. This system is controlled separately and can be activated at any time for any duration. The system creates a maximum of 38 mm of rain per hour uniformly over the whole biome area. By adjusting the pressure delivrered to the nozzles, this precipitation rate can be altered to lower desired intensities. This system is fed with water at a constant 25 C temperature.

A **wind generator** is provided in each biome. This device has a variable field drive that can be programmed to generate winds of various velocities from gentle breeze to gale force.

Two independent **irrigation solenoid valves** are provided for each biome. These valves will control misting equipment, drip irrigation equipment or sprinklers as desired by the users. This system is fed with water at a constant 25 C temperature.

8) Airlocks

Each biome has its own small preparation room serving also as an airlock between the central corridor and the biome itself. The airlock has a stainless steel counter with a deep sink and sand trap. Under the counter are drawers and cabinet. Shelves are provided above the counter. A coat rack will keep containment gowning ready for people needing to go in the biome. The airlock also has the solenoid valves and other serviceable mechanical equipment serving the biomes to minimize the service needed within the biome room itself.

9) Containment features

Each biome/airlock are designed to operate at a containment level of BSL-2+. The biome is constantly kept at a negative pressure of 25 Pa as compared to exterior atmospheric pressure. The airlock is constantly kept at a negative pressure of 13 Pa as compared to exterior atmospheric pressure. The central corridor air will flow toward the airlock when opening the airlock-corridor door. The airlock air will flow toward the biome when opening the airlock-biome door. Both doors are interlocked so that one door has to be closed before the other will open (barring emergency egress when emergency door opening is available at all times).

The biome glass is sealed using gasketed high-quality aluminum extrusions. Each biome degree of airtightness is tested and must be measured below 0.40 natural air exchange with concurrent and sustained wind velocity of 8 kmh or greater or 0.30 natural air exchange with concurrent and sustained wind velocity of 7.9 kmh or lower at time of testing. It is anticipated that the actual measured airtightness of the biomes will be even better than the above criteria.

Alarms will sound and be relayed to the maintenance headquarters of the campus anytime the respective negative pressures will not be measured by the control system for a programmable period of time to avoid alarms when doors are opened.

All outside air admitted in the biome systems and all air exhausted from the biome systems are filtered to high efficiency air filters. The air goes first through a MERV 7 disposable filter and then through a MERV 14 ASHRAE 52.2 with average dust spot efficienncy of 90-95% per ASHRAE 52.1. In addition, all recirculated air within each biome is filtered in the AHUs.

10) Sensors

Each biome has several sensors that can be grouped in two different categories: climate control oriented and research oriented. Each sensor is monitored and logged. The information can be retrieved at exported in excel format at user's will. Although categorized here, each and any sensor can be used to program certain climate functions as desired by users.

The **climate control** oriented sensors/inputs consist in the following, for **each** biome except for the weather station:

-Biome dry bulb air temperature
-Air temperature monitoring directly to BAS (independent from Biome control system)
-Biome solid state relative humidity sensor
-Heating coil water temperature
-Cooling coil water temperature

-CO2 solid state sensor
-Outside air flow measuring station
-Exhaust air flow measuring station
-Air handling unit running signal
-Air handling unit malfunction signal
-Differential pressure alarm in biome
-Biome Room pressure transmitter
-Biome Room pressure indicator (local, at door)
-Smoke Detector in ducting
-Frost Protection (freezestats) in ducting
-Snow-melt heating water temperature
-Air handling unit supply fan running
-Air handling unit return fan running
-Air handling unit chilled water pump running
-Air handling unit heating water pump running
-Outside air pressure readout
-Weather station air temperature dry bulb
-Weather station relative humidity
-Weather station outside light level
-Weather station wind velocity
-Weather station wind direction
-Weather station precipitation sensor
-General emergency power on signal
-Biome non-critical alarm to BAS
-Biome critical alarm to BAS
-Alarm to auto-dialer
-Temperature alarm in biome

The **research** oriented sensors/inputs consist in the following for each biome:

-Soil temperature sensor #1
-Soil temperature sensor #2
-Dedicated light sensor (PAR)
-Unassigned sensor port #1 (can be used to plug in any possible sensor with 4-20 mA or 0-10 VAC signal)
-Unassigned sensor port #2 (can be used to plug in any possible sensor with 4-20 mA or 0-10 VAC signal)

All sensors from the climate control oriented list above can also be used as parameters for research oriented functions.

11) Controls

The control strategy for the biomes is designed to give control of the climate to the users and control of the machines to the building automation system (BAS). This method allows the users to program any and all of the biome functions (temperature, humidity, CO2, lighting, irrigation, shading, etc...) directly using a user friendly specialized greenhouse computer control system. Down at the penthouse level where the air handling units are located, the controls of the equipment (AHUs, pumps, control valves, etc.) is done by the BAS directly. This way, the equipment serving the biomes is monitored, serviced and maintained by the usual university staff the just like any other piece of equipment serving campus' buildings.

The BAS will operate the air handlers of the biomes based on signals calculated by the Biome control system and relayed to the BAS controlled DDC units. The demand signals are: heating demand, cooling demand, outside air demand. Each demand signal is a 4-20 mA signal derived by the Biome system from the programming input by the users for each biome. The BAS will therefore satisfy the demand signals by increasing or decreasing the actual heating, cooling and outside air available to the air stream of the biome many times per minute. BACnet communication technology has been used extensively on this project.

Once the biomes are started up and commissioned, there will be very little interaction between the users of the biomes (researchers) and the maintenance staff of UWO. Communication between users and maintenance staff will be required in instances when, for example, maintenance wants to shut off an air handler for belt replacement, change filters or perform some other maintenance work.

The combined control points for both systems add up to 439 I/O points for the whole biome level rooms (including preparation room, plant conditioning and nursery seedling) but excluding airlocks, central corridor and the east part of the level where the elevator and stairs are located.

The Biome Control System (used by researchers) has 5 different Operator Remote Cabinets (ORCs). The ORC are located close to the room they control and include ON-OFF-AUTO button for each individual load (valve, shade motors, vents, etc...). All ORCs are tied to a master controller installed in the control room (Room 302X) along with the main computer from where all programming occurs for the biomes and other rooms. The computer is tied to the general ethernet link of the campus and fitted with an individual telephone line for remote help by the control manufacturer.

There is redundancy in the control functions in that if the main computer crashes, the rooms will continue to operate based on the latest programming. If the ORC crashes, the AHU DDC controllers at penthouse levels will continue to operate based on the latest received signal values.

This pretty much sums up the technical information about the biomes.

Sincerely,

Richard Denis, P.E.
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