**BIOCLIMATE**

Energy gains result from solar radiation on the facade at equal area of use.

**COURTYARD**

**VOIDS**

**SHEILD**

**SOLAR**

**SAWTOOTH**

**AVERAGE HIGH AND LOW TEMPERATURE**

<table>
<thead>
<tr>
<th>Month</th>
<th>Avg. High (°F)</th>
<th>Avg. Low (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>86</td>
<td>57</td>
</tr>
<tr>
<td>July</td>
<td>88</td>
<td>59</td>
</tr>
<tr>
<td>August</td>
<td>87</td>
<td>60</td>
</tr>
<tr>
<td>September</td>
<td>79</td>
<td>51</td>
</tr>
<tr>
<td>October</td>
<td>76</td>
<td>47</td>
</tr>
</tbody>
</table>

**Glazing area (m²)**

<table>
<thead>
<tr>
<th>PV array total (MWh/y)</th>
<th>684</th>
<th>684</th>
<th>94</th>
</tr>
</thead>
</table>

**PV area (m²)**

<table>
<thead>
<tr>
<th>Daylight factor</th>
<th>8.0</th>
<th>7.8</th>
</tr>
</thead>
</table>

**PV tilt**

- Uniform height, each south face 100% PV
- Each north face is 100% glazing; PV tilt 31 degrees
- Uniform height, each south face 100% PV
- Each north face is 100% glazing; PV tilt 45 degrees
- Increasing height; front (smallest) tooth identical to any south face, subsequent teeth have equal areas of PV and glazing; PV tilt 45 degrees

**Glass**

- Transparent Conductor
- Electrochromic Electrode
- Ion Conductor
- Counter Electrode
- Transparent Conductor

**Ambient North Light**

**Direct South Light**

**MPPT**

**PV Panels**

**Ambient North Light**

**Direct South Light**

**Jan**

**Feb**

**Mar**

**Apr**

**May**

**Jun**

**Jul**

**Aug**

**Sep**

**Oct**

**Nov**

**Dec**

**VOIDS SHIELD SOLAR SAWTOOTH**

**JUNE 21**

**MARCH 21**

**DECEMBER 21**

**N W WINTER WIND**

**S E SUMMER WIND**

**NW**

**W**

**Winter Wind**

**S E**

**W**

**Summer Wind**

**Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec**

**ENERGY DESIGN**

Michael Sephons Pablo Villamil Keith McDermid Jon Jacobs
This longitudinal section illustrates the significance of the vertical shafts and displacement ventilation, which maintains human comfort levels throughout the new CSBR addition. The stack effect exhausts excess summer heat through the shafts while drawing cooler air indoors from the operable windows. When the building needs to be cooled mechanically, a displacement ventilation system pushes cool air into spaces from floor vents and eventually moves toward the ceiling as a result of heating. Hot air that reaches the ceiling is collected and either expelled through roof vents or recovered, conditioned, cooled and recycled.

The primary winter passive heating strategy is made possible by thermal mass on the floors and walls of the south-facing circulation zone. The electrochromic south glazing provides the opportunity to maximize solar heat gains in the winter while maintaining them in the summer. Fixed louvers and strategically placed panels on the south facade also provide solar control that air moves unsteadily gave one round while creating a dynamic play of shade and light. The glazing controls and the mass stores the heat for use whenever during cooler two-three hours of the day. When conventional forced heating needs to supplant passive heating loads, the displacement ventilation system pushes warm air through vents in the floor, targeting the occupable volume of air in the lower sections of the room for improved human comfort. As the air rises, it convectively moves into the plenum shaft until it cools and is collected through returns in the ceiling or wall to be recycled, reheated and recirculated.

The design intention of building up rather than to spread our parameters is this profile, which consequently in our favor made daylighting less of an issue, but there were still challenges. By removing the floors to increase south exposure and minimizing north glazing it was necessary to puncture the core of the floors in order to provide sufficient daylight to various dark spaces on the bottom level. The exploration of bouncing light through these shafts led to an opportunity to improve the poor lighting condition of the existing west courtyard of the Holl addition with heliodon mirrors.

The 5000 SF green roof on the CSBR addition saved about 40 million BTUs in building cooling loads, but only lowered our EUI by 1 kBtu/SF. A 130kW PV system offset more than our total electrical use and lowered the EUI by 11 kBtu/SF.
**GOALS**

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>SIZE</th>
<th>OCCUPANT</th>
<th>HOURS</th>
<th>IESNA DAYLIGHTING GOALS</th>
<th>THERMAL GOALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobby/Reception</td>
<td>10K</td>
<td>All</td>
<td></td>
<td>0.0 2.5 0.7 0.6</td>
<td>Dusk</td>
</tr>
<tr>
<td>Offices</td>
<td>60K</td>
<td>Faculty</td>
<td>8</td>
<td>0.0 2.5 0.7 0.6</td>
<td>Controlled</td>
</tr>
<tr>
<td>Labs</td>
<td>50K</td>
<td>Student</td>
<td>4</td>
<td>3.6 3.6 3.6 3.6</td>
<td>Controlled</td>
</tr>
<tr>
<td>Outdoor Demonstration</td>
<td>40K</td>
<td>Student</td>
<td>2</td>
<td>NA 2.5 2.5 2.5</td>
<td>Radiant</td>
</tr>
<tr>
<td>Classrooms</td>
<td>40K</td>
<td>Student</td>
<td>4</td>
<td>2.5 2.5 2.5 2.5</td>
<td>Heat</td>
</tr>
<tr>
<td>Coffee Shop</td>
<td>40K</td>
<td>All</td>
<td>2</td>
<td>0.0 0.0 0.0 0.0</td>
<td>Heat</td>
</tr>
<tr>
<td>Restrooms</td>
<td>40K</td>
<td>All</td>
<td>2</td>
<td>0.0 0.0 0.0 0.0</td>
<td>Heat</td>
</tr>
<tr>
<td>Circulation</td>
<td>40K</td>
<td>Maintenance</td>
<td>2</td>
<td>0.0 0.0 0.0 0.0</td>
<td>Heat</td>
</tr>
</tbody>
</table>

**THERMAL**

**WHOLE BUILDING**

**FINAL DESIGN PLUS RENEWABLE ≈ 14 Kbtu/sf**

**DEMONSTRATION ROOM**

This particular study of human comfort in the isolated demonstration lab space complements the discomfort of the whole building, that is being too hot during the winter months. Since the room is isolated adjacent to the south exposed corridor it is evident that even though the building's use of thermal mass is inconsiderable in micropart or heating loads in the winter, the consequence is not much heat gain in the warmer months.

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**HEATING & COOLING LOADS**

**DISCOMFORT DEGREE HOURS**

**HOURLY TEMP**

- **DECEMBER**
- **MARCH**
- **JUNE**
The worst case scenario for daylighting in December revealed that our design successfully illuminates the majority of the building.
**NORTH WALL**

1. **SECOND SKIN (VINES)**
   - Interior
   - Exterior
   - Perspective View

2. **SECOND SKIN / REFLECTORS**
   - Interior
   - Exterior
   - Top View

**SOUTH WALL**

1. **SUN SPACE**
   - December
   - March
   - June

2. **BREISOLEI**
   - December
   - March
   - June