Identified areas of opportunity include capitalizing on natural ventilation, something that currently is not a part of Rapson Hall, as well as mitigating glare and direct sunlight that penetrates the courtyard. This condition continuously creates an undesirable environment in a space that is often used for reviewing student work.

**WIND STUDIES**

**AUTUMN WIND**
Autumn winds come primarily from the south/southwest at 20 km/h. Strongest winds from northwest and northeast at 55 km/h.

**WINTER WIND**
Winter winds come primarily from the north/northeast at 25 km/h. Strongest winds from northwest at 55 km/h.

**SPRING WIND**
Spring winds come primarily from the east at 25 km/h. Strongest winds from the northeast, southwest, and northwest at 55 km/h.

**SUMMER WIND**
Summer winds come primarily from the south/southwest at 20 km/h. Strongest winds from the south/northwest at 55 km/h.

**SOLAR STUDIES**

**DECEMBER 21ST 12:00PM**

**SEPT/MARCH 21ST 12:00PM**

**JUNE 21ST 12:00PM**
From the beginning, we wanted to create a circulation program that was both experiential as well as a tool for passive design strategies. Seen here is an early exploration testing out potential ways to achieve both of these conditions.

One of our major design drivers was to redefine spaces used for reviewing work. Currently, pinup space in Rapson Hall is also circulation space. At times this is not an ideal condition due to interruption of reviews. Seen here is an exploration of separating these two programs in the GLED addition.

CIRCLE AND THE SQUARE

CIRCLE AND SQUARE CONCEPT

CIRCLE
relating self with nature

SQUARE
embodied matter, 4 seasons, 4 directions

CSBR
building relationships with nature through architecture

RAPSON HALL EVOLUTION DIAGRAM

Original Cerel Building
Original Hall Proposal
Built Hall Addition
New Addition Proposal
**CONDITIONS OF LIGHT**

**AMBIENT**
- Direct and indirect light used to create a consistent light throughout the space.
- **CLASSROOMS**: 30-75 FC
- **PINUP SPACE**: 30-70 FC
- **MATERIALS LAB**: 30-60 FC
- **INDOOR DEMO**: 30-70 FC

**DYNAMIC**
- Direct light casting beams onto interior surfaces in particular shapes that change throughout the day and year. For spaces used for short amounts of time.
- **CIRCULATION**: 5-150 FC
- **LOUNGES**: 15-100 FC
- **LOBBY**: 15-100 FC

**REFLECTED**
- Light diffused along walls and ceilings to highlight specific areas.
- **OFFICES**: 30-60 FC
- **DAYLIGHT LAB**: 30-60 FC
- **SITE & WATER CONFERENCES**: 20-65 FC
- **RESEARCHERS ENERGY & IAQ**: 30-60 FC

**ATMOSPHERIC**
- Allows users to get controllable direct and diffused light for working on tasks while also having connection to nature.

**ROOM & ENVELOPE STUDIES**

**CEILING STUDY**
- A study aimed at achieving an ambient light condition within a space. This is done by reflecting light upwards onto the ceiling. This condition also taps into the perception that a room is adequately well lit when the ceiling is getting plenty of light.

**LIGHT SHELF STUDY**
- Several different light shelves were tested to see what shape and material reflectance were optimal. A highly reflective material, like metal, reflected the most light into the room. A curved light shelf allowed light to get the furthest into the room.

**WALL THICKNESS STUDY**
- This study explored merging the idea of the light shelf into a thick wall to create a geometric wall that is pushed in or pulled out to project more light into the room. With further study, we would like to explore thinner walls with a greater amount of area on the angled wall to project more light into the room rather than having extremely bright light projections only near the windows.

**LIVING WALL STUDY**
- Louvers allow for low winter solar exposure to penetrate the interior and shelter the extreme solar hours in the summer, decreasing large temperature fluctuations. The Living Wall with a deciduous vine adds even more protection from rain and temperature fluctuations by screening with foliage in the summer and allowing solar penetration in the winter when the foliage has fallen.
MAIN CONCEPTS

1. Green roofs adjacent to courtyard on north and south allow for daylighting to occur in courtyard

2. Living walls provide summer shading on walls exposed to the summer sun

3. View to Pillsbury Hall

4. View to the Armory Building

5. View to Downtown Minneapolis

6. Metal skin system disguises apertures while acting as a breathable and evolving skin

7. Louver system on south facade filters the amount of light seasonally

8. Photovoltaic panels on the courtyard roof as well as the Holl addition generate and store power for the mnZED Lab

9. Moments of connection create visual spatial context between the old and the new, and continuously provide a sense of place
The DAYSIM analysis reveals several important things. The continuous daylight autonomy study showed that the majority of circulation, classrooms, research room, site, and water lab, pin-up space, indoor demonstration received adequate daylighting 70-84% of the time. The mechanical room and daylight lab intentionally have low light levels based on their primary usage. The useful daylight index reveals that most spaces get footcandle levels between 10-200. Only a small amount of square footage ever get above 200 ft².

**Carbon Calculator**

- **Building Energy Use**
  - **Code Baseline**
  - **Optimize Design**
  - **Full Design**

- **Energy Consumption**
  - **Electricity**
    - **Code Baseline**: 120,000 kWh
    - **Optimize Design**: 90,000 kWh
    - **Full Design**: 70,000 kWh

- **Site Energy Use**
  - **Code Baseline**: 20,000 kWh
  - **Optimize Design**: 15,000 kWh
  - **Full Design**: 10,000 kWh

- **Transportation Energy Use**
  - **Code Baseline**: 20,000 kWh
  - **Optimize Design**: 15,000 kWh
  - **Full Design**: 10,000 kWh

- **Water Use**
  - **Code Baseline**: 20,000 kWh
  - **Optimize Design**: 15,000 kWh
  - **Full Design**: 10,000 kWh

**WEST SECTION**

**EAST ELEVATION**
ECOTECT COMPARATIVE ANALYSIS

ENERGY USE INTENSITY

MONTHLY HEATING/COOLING LOADS

<table>
<thead>
<tr>
<th>MONTH</th>
<th>HEATING (Btu)</th>
<th>COOLING (Btu)</th>
<th>TOTAL (Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
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<td>35,751,534</td>
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<td>Jul</td>
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<td>Oct</td>
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<td>Dec</td>
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<td>Floor Area</td>
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PEAK: 917,584 543,979 93 Kbtu/SF

Total Annual Lighting Load 71,109 kWh
Total Annual Equipment Load 82,627 kWh
Total Energy Use 2,341,314 kWh
TOTAL ENERGY USE INTENSITY (EUI) 115 Kbtu/SF

Total Annual Carbon Emissions 412 Tons

MONTHLY HEATING/COOLING LOADS

<table>
<thead>
<tr>
<th>MONTH</th>
<th>HEATING (Btu)</th>
<th>COOLING (Btu)</th>
<th>TOTAL (Btu)</th>
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<tbody>
<tr>
<td>Jan</td>
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<td>TOTAL</td>
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<td>PER M²</td>
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<td>Floor Area</td>
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PEAK: 310,034 303,780 23 Kbtu/SF

Total Annual Lighting Load 31,235 kWh
Total Annual Equipment Load 63,808 kWh
Total Energy Use 76,084 Kbtu
TOTAL ENERGY USE INTENSITY (EUI) 38 Kbtu/SF
PV Production (15,610 kWh) 22,741 kWh
Total Renewable Energy Production 77,992 Kbtu
Total Annual Carbon Emissions 0 (88) Tons

FINAL DESIGN WITH ORISITE RENEWABLE ENERGY 0 Kbtu