Taming the 900-Pound Gorilla

Using Integrated Design to Create a Net-Zero Dining Hall
• 16,000 sf dining hall and commercial kitchen
• 350 seats
• Experiential Servery/Food Forest Layout

• Site Responsive Design
• Campus Social Center
• Net Zero Ready
ACHIEVING NET ZERO READY?

- Reduce envelope loads
- Reduce kitchen loads
- Efficient Mechanical Systems
- Reduce envelope loads

Floor/Slab Assembly R-value: R-27 to R-18 (6”-4” EPS)
Wall Assembly R-Value: R-38 (5.5” cellulose w/ 4” polyiso)
Roof Assembly R-Value: R-54 (13” HFO Two part PU Spray)
Windows: Triple-glazed, Argon Paradigm U-0.23, R-4.35
Envelope Infiltration Rate: 0.1 CFM50 / sq. ft.
### Efficient Mechanicals – Systems Selection Matrix

#### Proctor Dining Hall Mechanical Options

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space heat</strong></td>
<td>water-loop heat pump</td>
<td>water-loop heat pump</td>
<td>ASHP indoor unit except when too cold, then hydronic heat with cost-optimized switchover</td>
<td>ASHP for space heat, GSHP for makeup air and ventilation post ERV conditioning</td>
<td>ASHP indoor unit for space heat, multiple air-water HPs for makeup air and ventilation post, ERV conditioning</td>
</tr>
<tr>
<td><strong>Space cool</strong></td>
<td>water-loop heat pump</td>
<td>water-loop heat pump</td>
<td>ASHP indoor unit for all cooling loads</td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
<td>ASHP indoor unit for all cooling loads</td>
</tr>
<tr>
<td><strong>Kitchen Hood</strong></td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
<td>variable speed demand controlled, with heat recovery makeup air</td>
</tr>
<tr>
<td><strong>Ventilation air</strong></td>
<td>ERV for ventilation in dining areas with demand controlled (CO2) control</td>
<td>ERV for ventilation in dining areas with demand controlled (CO2) control</td>
<td>ERV for ventilation in dining areas with demand controlled (CO2) control</td>
<td>ERV for ventilation in dining areas with demand controlled (CO2) control</td>
<td>ERV for ventilation in dining areas with demand controlled (CO2) control</td>
</tr>
<tr>
<td><strong>Makeup air heat</strong></td>
<td>coils from GSHP</td>
<td>coils from GSHP or boiler</td>
<td>ASHP or boiler</td>
<td>coils from GSHP</td>
<td>ASHP multiple makeup air unit – only up to 3 or 4 tons/unit – more info needed</td>
</tr>
<tr>
<td><strong>Makeup air cool</strong></td>
<td>coils from GSHP</td>
<td>coils from GSHP</td>
<td>ASHP makeup air unit</td>
<td>coils from GSHP</td>
<td>ASHP makeup air unit</td>
</tr>
<tr>
<td><strong>Service hot water</strong></td>
<td>GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add</td>
<td>GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add</td>
<td>boiler + solar DHW possible add</td>
<td>GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add</td>
<td>Solar DHW with off-peak electric backup + chemical dishwashing</td>
</tr>
<tr>
<td><strong>Coldest weather issues?</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes [2]</td>
</tr>
<tr>
<td><strong>All renewable possible?</strong></td>
<td>Yes, all electric</td>
<td>Yes, if boiler is pellet-fired</td>
<td>Yes, if boiler is pellet-fired</td>
<td>Yes, all electric</td>
<td>Yes, all electric</td>
</tr>
<tr>
<td><strong>Energy Modeling assumptions</strong></td>
<td>All thermal energy from GSHP</td>
<td>Half of thermal energy from GSHP/half from pellet boiler, except ventilation heating makeup all pellets</td>
<td>Half of thermal energy from ASHP/half from pellet boiler</td>
<td>Half of thermal energy from ASHP/half from GSHP</td>
<td>All thermal energy from ASHP</td>
</tr>
</tbody>
</table>

---

[2] More research under way about this issue
[3] closed loop ground heat exchangers
- Efficient Mechanical Systems

Mechanical analysis

- 5 mechanical systems + 3 kitchen hood options

![Chart showing energy cost comparisons between different mechanical systems and kitchen hood options.](chart-image)
- Efficient Mechanical Systems

- HVAC OPTION 1: CODE
  - Propane Fired
  Conventional Water
  Source Heat Pump
  System
• Efficient Mechanical Systems

• HVAC OPTION 2: NET ZERO
  – Ground Source Heat Pump System
• Efficient Mechanical Systems

• HVAC OPTION 1: ALL RENEWABLE, INCLUDES COMBUSTION
  – Air Source Heat Pump System for Building Conditioning
  – Wood Pellet Boiler for Hot Water and Make-up Air
Energy Modeling and Optimizing Systems

• Question #1: What are the Loads?
Energy Modeling and Optimizing Systems

• Biggest Slice: **Hood Makeup Air**
• Client Commitments and Goals
  • Healthy Food Fresh Local Ingredients
  • Continued “From Scratch” Cooking and Baking
  • No Menu Sacrifices
  • Sustainability
• Reduce Hood Make-up Air
  • Objective #1 – Minimize hood lengths

• Client Commitments and Goals
  • Healthy Food Fresh Local Ingredients
  • Continued from Scratch Cooking and Baking
  • No Menu Sacrifices
  • Sustainability
MORE COMPACT LAYOUT =

Less SF/Less building
- 100 SF /smaller kitchen
- 17 fewer LF of hood
- Significant Building Cost Savings

Additional Cost for Equipment ($50,000)
- 1st Year Energy Savings ($40,000)
• Reduce Hood Make-up Air
  • Objective #1 – Minimize hood lengths
  • Objective #2 – Minimize number of hoods

• Client Commitments and Goals
  • “Food Forest”
  • Face to Face/Personal Staff and Student Connection
PIZZA AND ACTION STATION

COLD BAR

HOT BAR

DESSERT AND BREAD

BEVERAGE

CEREAL
Energy Modeling and Optimizing Systems

2nd Biggest Slice: Kitchen Equipment

Peak Load:
- ~100 kW (rough)

Annual Load:
~150,000 kWh/yr

Proctor Dining Commons -- Code Building Loads

- hood makeup heating
- cooking
- space heating
- hot water
- hood makeup cooling
- space cooling
- Other
Energy Modeling and Optimizing Systems

Wild Card – Gas Pizza Oven

Approaches:
• Burn wood?
• Offset with more PV?
• Make methane?
• Student boycott of gas-fired pizza?

<table>
<thead>
<tr>
<th>Gas Fired Pizza Oven</th>
<th>Hrs/day</th>
<th>Hours/year</th>
<th>Avg% full load</th>
<th>MMBtu/yr</th>
<th>Total Btu/hr</th>
<th>gal/yr. propane</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>1,038</td>
<td>0.25</td>
<td>91</td>
<td>350,000</td>
<td>993</td>
</tr>
</tbody>
</table>
3rd Biggest Slice: Space Heat

NZR building energy
- 36 MMBtu/yr
  (14 MWh/yr)

Approaches:
**Super-insulate**
- 0.1 cfm50/sq.ft. shell
- R-5 windows
- R-20 slab
- R-40 walls
- R-60 roof

- **GSHP with heat recovering water source heat pump loop**