Hello, everyone! We are the LightHAUS Team from the University of Missouri Columbia and Missouri S&T. We are proud to have come this far with LightHAUS and are very excited to present our project at NREL!
Convert a currently vacant, former brownfield into mixed use affordable housing and market for international students, a learning center for early care educators, and their families.

Key Details:

- Central location
- Community Resources
- Walkable
- Currently underutilized site
- Net positive building
- Health positive
DESIGN GOALS

Goal 1: Environmental
Create sustainable, resilient, and livable spaces that benefit both people and the planet.

Goal 2: Social
Make decisions that incorporate and facilitate mental health whilst being accessible to all people.

Goal 3: Economic
Balance financial objectives with project requirements, sustainability goals, and user needs.
WHO ARE THEY?

INTERNATIONAL STUDENTS & EARLY-CARE EDUCATORS

• Population: 126,853 people

• 37,800 are students from three major collegiate institutions: 1,800 of this population are international students.

• Columbia's international students and early care educators are experiencing resource deserts; struggling to obtain affordable resources.

• International students are also not eligible to majority of scholarships & ineligible for instate tuition.

• Affordable housing options international students tend to settle for are approx. 40-50 minutes walking distance from campuses.

• Creates isolation from resources due to the lack of transportation.

• Most apartments provide shuttle systems, but they operate within a certain time frame, restricting student activities on campus.

<table>
<thead>
<tr>
<th></th>
<th>University of Missouri</th>
<th>Stephen's College</th>
<th>Columbia College</th>
<th>International student fee's</th>
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</thead>
<tbody>
<tr>
<td>Tuition (yearly)</td>
<td>$14,122 - $34,322</td>
<td>$25,586</td>
<td>$24,806</td>
<td>$34,640 - $38,240</td>
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<tr>
<td>Housing</td>
<td>$13,550</td>
<td>$11,000</td>
<td>$8,500</td>
<td>$11,050</td>
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<tr>
<td>Total cost of living</td>
<td>$18,142</td>
<td>$18,000</td>
<td>$13,524</td>
<td>$18,196</td>
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<tr>
<td>Total Estimated cost</td>
<td>$32,264 - $52,464</td>
<td>$43,586</td>
<td>$38,330</td>
<td>$55,336 - $58,936</td>
</tr>
</tbody>
</table>

Total estimated yearly costs for Columbia students
“IT IS THE SITE THAT TURNED ON THE FIRST LIGHTS IN COLUMBIA.”

COMO Manufactured gas plant – 1875-1932

The Orr Street site was once the biggest energy source in Columbia – the beginning point of electric lighting.

Brownfield Site

- Site was polluted for years by raw tar (byproduct of gasification)
- Leaks into ground water + into buildings (coal tar is heavier than water)
- **1994 Soil Remediation began**
  - 31,612 tons of soil were cleaned up
  - Is now clean to occupy
LightHAUS is located within the Climate and Environmental Justice Screening Tool and is recognized as a Disadvantaged community.
CLIMATE

Location: 208 Orr St, Columbia, MO  
Lot Size: 2.1 acres  
Neighborhood: North Village Arts District

Climate Zone: **4A & 3A**
- Columbia falls under the 4A (Mixed-humid) climate zone.
- Columbia is centrally located in the Midwest of the United States, it experiences extreme changes in temperature.
- Summers are hot and humid, while the winters are frigid, snowy, and windy.
- Over the year, the temperatures vary from 21°F to 89°F.

Humidity
The practice for managing humidity levels in a 4A climate zone is to pull air through the spaces with fans (mechanical assisted ventilation).
• We used the climate positive app to calculate the impact of our landscape design.
• 8500 sf of loose aggregate paving is pedestrian walkways.
• 3400 sf of stabilized crushed stone is vehicular paving.
• The total impact of site materials will add to approximately 26,000 kg CO2.
• We are balancing this impact through a series of carbon sink strategies.

• The two on-site greywater retention ponds will serve as wetlands.
• Excess space on site will be mostly covered in no-mow lawn.
• This will sequester 217 tons more carbon than it emits in its estimated lifespan.
• Therefore, the site is expected to reach climate-positive within 5 years of its construction.
1. Begin With Two Volumes
   - Larger Volume for Residential towers (Red)
   - Smaller Volume for Commercial spaces (Blue)

2. Shear Volumes in Opposite Directions
   - Commercial volume closer to street for pedestrian interaction
   - Residential volume is setback from street
   - Public and Private Spaces

3. Shear Commercial into Three Volumes
   - Extenuates Main Entrance and Cultural Market
   - Creates partially hidden space
   - Stretch & Pinch Residential into Three Volumes
     - Creates street setback
     - Increases privacy and reduces proximity to noise

4. Carve & Add Small Portions to Each Section
   - Increases light permeation and curtain wall ventilation

5. Carve Two Volumes From Center of Residential
   - Creates semi-conditioned atriums
   - Increases light permeation
   - Carve Detailed Footprint of Residential
     - Creates space for private balconies
     - Ensure natural lighting in each bedroom and living room
• The building is 179,483 SF in total
• 7 Floors of Residential Units
• 2 Floors Commercial and Community Spaces
• Includes a mixture of conditioned and semi-conditioned spaces.
COMMERCIAL

MARKET

Ground Floor
• Semi-conditioned space
• Local foods and vegetables
• Produce from the agrivoltaic gardens
• Overhead doors on south walls
• Operable windows throughout

Mezzanine
• Rentable space for gatherings and events

ECOGYM

• 17 cardio machines
• 3000 watts of energy per hour
• Powers lights in gym

Person exercising → Micro-inverter → 120 V outlet ≈ 3000 Watts/hour

RESILIENT CORE

Details:
• 545 sqft per floor
• Min. 5 sqft per occupant

1. G660 TREADMILL
2. G876 ELLIPTICAL
3. G516 INDOOR CYCLE

Resilient Core 3275 sq ft (545 sq. ft./floor)
A total of 5-unit types
30 one-bedroom units, 31 two-bedroom units, 27 three-bedroom units and 14 studio units.
For every bedroom and living room, one ceiling fan and one sprinkler head is included.
The project's structural system contains steel columns and beams with bar joists. W sections were used for all columns and 98% of beams on the structure's interior. The spans were kept to a minimum to maintain a shallow plenum space for electrical, lighting, and HVAC.
**PVs & AGRIVOLTAICS**

- **Rooftop array**
  - Silfab Elite panels
  - 1087 panels, 486.51 kWp

- **Battery storage shed**

- **Agrivoltaic garden walls**
  - QCELL Q.PEAK DUO panels
  - 204 panels, 108.33 kWp array

- **E. Ash St.**
- **Orr St.**

- **Maintenance aisle**
  - Follows ISEP guidelines

- **Sunny Tripower inverter**

- **AV Lot spans approximately 17,037 sqft**
- **Set on an east-west tracker, 4 meters above ground**
- **We worked with Dogwood Solar a local consultant to select panels, converters, and onsite battery storage for both rooftop array and the agrivoltaics.**
• 8 Trane Mitsubishi Air-Source hybrid VRF systems.
• 8 Trane Horizon Dedicated Outdoor Air Systems (DOAS) with Energy Recovery Ventilators (ERV).
• Heat and cool 8 or 16 zones with high efficiency.
• Using a VRF conduit instead of ductwork reduces energy loss and material cost for excess MEP space.
• The hybrid branch controller (HBC) lowers the use of refrigerant and keeps the piping in the indoor space refrigerant-free.
• The HBC exchanges heat between refrigerant and water via 8/16 ports connecting to indoor units.
• Introducing interior water lines, HVRF reduces the amount of refrigerant in the overall system by up to 30% compared to conventional VRF.
The southernmost portion of the commercial space is a semi-conditioned market with overhead doors on the north and south walls that would remain open during business hours.

The emphasis on managing humidity levels in a 4A and 3A climate zone is to pull air through the spaces with fans (mechanical assisted ventilation). Creating flexibility to adapt to our climatic temperature extremes in winter and summer.

**SEMI-CONDITIONED SPACES:**
- Cross-Ventilation
- Mechanically Assisted Air Movement
- Shading Devices on South & West Facades
- Operable Windows in Curtain Systems
- Heaters for Thermal Comfort
**Exterior Lighting:**

- With Interact Retail Lighting management software, automated schedules ensure light levels match opening hours or can be adjusted to harvest available daylight.
- Areas of the store that are used very little, can remain unlit when not in use, resulting in energy savings and cost reduction.

**RCP & HVAC:**
SYSTEMS - RESIDENTIAL

HVRF

DOAS

Fire sprinklers

Supply/return ducts

Outdoor exhaust vent

Level 2 (10'-0”)

Building envelope

Ground Floor (0'-0”)

Pre-fabricated aluminum deck

38 gal. electric water heater

Fire Rated wall assembly

Water line supply

Water line return

Plumbing wall

Fire Rated ceiling assembly

Homasote board

Sheathing

Cold Form steel joists (20 ga.)

Column wrap

Indoor condensing unit

Fire Rated floor assembly

Perforated foundation drain
**Interior:**

- **Visual Lighting Design software was used** to create these plans.
- The floor plan layouts show the FC (footcandles) value throughout each room, and the layout of the chosen lights.
- The goal is to create a lighting layout that is within the allowable light power density (LPD) for increased efficiency and meets all standards outlined in the IBC.

**Unit Type A**  
**Unit Type B**  
**Unit Type C**  
**Unit Type D**  

*Halo led downlights*  
*The Haiku Gen 4 52”*
ENVELOPE DETAILS

**CONTROL LAYER KEY:**

- Moisture/Vapor/Air Barrier
- Thermal Control
- Air Gap/Drainage Layer

![Diagram of envelope details with layers and materials indicated.](image-url)
Dew Point Analysis:

Increase the exterior insulation value, reduce the cavity insulation value or a combination of both to achieve an optimal condition.

![Graph showing temperature variations](image)

**Green line is well above the red dashed line**
With R-20.5 (5.5 inches thick) insulation outside of the wall cavity, then the fluid applied product then sheathing then wall stud.

![Graph showing temperature variations](image)

**Green line - Condensation IN the wall from December to February**
With R-20.5 (5.5 inches thick) insulation inside of the wall cavity.

Window Flashing Sequence:

1. Remove Existing Window
2. Cut Modified "T" into housewrap
3. Apply Still Flashing and Glue
4. Install Window and head flashing
5. Apply Head Flashing
6. Tape Cuts Over Head Flashing
**USG fire rated Sheetrock**
- Meets 2030 ASHRAE standards
- 75% recycled material, 100% biobased
- Low energy/carbon emissions in manufacturing

**Thermafiber**
- Biobased, mineral wool
- Formaldehyde free
- Water resistant (maximizes envelope efficiency)

**PAC-clad composite façade panels**
- Made with 96% recycled aluminum

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**WR Meadows fluid applied membrane**
- Quick installation
- Protects from moisture, air, and vapor
• Quaker’s products are locally made.
• Manufacturer of residential and commercial products.
• Provides increased thermal, structural, and sound transmission performance properties.

Team Site Visit to Quaker

• Adaptable to needed specifications.
• Ideal for low- to mid-rise applications.
• Utilizes thermal barrier technology to address extreme climactic conditions.

1600UT SYSTEM™ 1 CURTAIN WALL

• The curtain walls provide cross ventilation in the building.
• In all areas of egress.
• Integration of GLASSvent window system allows for operable windows.
• The glass is fritted to prevent bird collisions.
We created a parametric script on Grasshopper.

Using construction materials, quantities, window aperture, shading, and local climate data.

Achieved a baseline EUI of 32 without any photovoltaic systems.
We calculated our HERS score by unit layout with RemRate using the black box method, in which we isolated each apartment unit and modeled the exterior walls to mimic their adiabatic nature.

To accurately model the efficiency of our Trane HVRF system, we customized a Ground Source Heat Pump to match our system's tonnage, COP, EER, and capacity. Our largest and smallest apartment unit models obtained an average HERS score of 38 without PV and 0 with PV.
Battery Backup:

- The battery backup facility is a 10 feet by 20 feet
- Highly ventilated, concrete room
- Located 20 feet from the building outside due to the possibility of explosions
- Two-way entry
- Signs with advice on safety guidelines and work procedures in battery room

- **LightHAUS will be considered a microgrid** that acts as a single controllable entity relative to the central grid.
- In case of interruptions during natural disasters and extreme weather conditions designing.

Implementing Strategies:

- Avoid Peak Grid Usage.
- Providing battery back-up on site for grid interruptions and managing peak loads.
- Install meters that allow for rate structures incentivizing lower electricity use at peak hours.
- Preheating water throughout the day to avoid peak usage.
• Embodied & operational carbon

• Passive strategies

• Cost vs. Quality

Steel:

Largest carbon contributor:

Sustainable process:

Local recycled steel scrapyards
• Obtain grade C steel

Electric Arc Furnace (collaborate with local fabricator)
• Saves 90% of steel dust typically lost
• 88% less carbon emissions than traditional Blast Air Furnace

Custom columns, beams, and joists
• 100% recycled material
• Fully recyclable at EOL
**Green Walls**

- SemperGreenwall systems in the atriums.
- Connects its users with nature and the environment.

**Irresistible Stair**

- To promote a healthy behavior within the building we have designed an irresistible stair in the residential atrium.
- Modeled after Bullitt Center.
Smoke Control
- 1’ glass smoke curtain is included around the ceiling perimeter of each level of the atrium with a solid guard wall around the opening at each level.
- Doors connecting the residential and commercial zones are hold-open doors.
- There is a fan unit on the roof of each atrium for mechanically assisted smoke evacuation in larger amounts.

Fire Suppression
- A standard wet pipe fire sprinkler system with temperature control heads is used.
- A 7 foot by 7-foot control center is located on the ground floor with exterior access.
Occupants will use a **building automation system (BAS)** phone application to interact with building settings. This will allow users to understand the building and its consumption.

- Includes set points for temperatures and humidity.
- Notifies users of optimal times to open windows for air quality through the local **weather station air quality index** and **Carbon Dioxide sensors in the building**.
- Shows the energy contributed to the eco-gym.
- Lighting control.
- Allows residents to connect to speakers in the market to enjoy music (music selection will be limited to prohibit explicit content).
- Community forum.
- Schedule for learning center.
- Also includes other residential portal characteristics.
**INTERIOR MATERIALS**

Low VOC paint

Improve and maintain indoor air quality.

All specified materials and FF&E are thoughtfully selected to align with the project goals of affordability, health, well-being, and aesthetics.

Formaldehyde-free, and all paints, adhesives, and coatings contain low to no VOCs.

**Interior Flooring**

- 100% recycled Mohawk flooring
- 52% recycled content carpet
MARKET ANALYSIS

Existing Multi-Family Housing Near Site

Brookside Midtown
Average Rent: $800 - $1200
5 Min. walking distance

Orr Street Lofts
Average Rent: $550 - $740
5 Min. walking distance

North Village Lofts
Average Rent: $550 - $695
4 Min. walking distance

Brookside Downtown
Average Rent: $1000 - $1400
12 Min. walking distance

Belvedere Apartments
Average Rent: $385 - $645
13 Min. walking distance

University of Missouri campus
- Student dorms
- Dorm rent: $800-$1000/month

Current international student concentration
- Off-campus apartments
- Apartment rent: $500-$700/month

Typical non-international student housing
- Apartment rent: $800-$1200/month

Shuttle systems:
Avg. Hours: 7 AM - 8 PM

0.4 Miles from Campus
2 min. drive
9 min. walk

1.9 Miles from Campus
5 min. drive
42 min. walk

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2 min. drive
9 min. walk

1.9 Miles from Campus
5 min. drive
42 min. walk
COST ESTIMATE

- Total O&M costs: $2,460,000
- Total rent collected: $90,324,000
- Total loans paid: $212,965,389
- Total profits: $45,296,400

Current Target Market Concentration

- $570/Bedroom
- 1.9 Miles from Campus
- 5 min. drive
- 42 min. walk
- Shuttle systems: Avg. Hours: 7 AM - 8 PM

Units Available within 15 minutes of campus

- $550-$1850 per room

Rebates, taxes, credits:
- Low-income tax credit
- Solar energy federal tax credit
- Local and federal limited sustainable building tax credits

Year 1
- Interest balance: $6,341,709
- Principal balance: $1,001,925
- Ending balance: $90,047,345
- Net profit: $0

Year 29
- Interest balance: $271,029
- Principal balance: $7,072,605
- Ending balance: $0
- Net profit: $0

Year 60
- Interest balance: $0
- Principal balance: $0
- Ending balance: $45,396,400
- Net profit: $0

TOTAL COST $65M
COST AFTER REBATE $48M
COST PER SQFT $266
COST PER BED $650

Architecture | Engineering | Envelope | Efficiency | Grid | Interactivity | Life Cycle | Health | Market | Community
The design includes several amenities that catalyze accessibility to food, learning, and physical/mental health.

- Green walls
- Strategic view corridors
- Agrivoltaic garden

Access to resources
Close range to other international food markets

Proximity to campuses
University of Missouri, Stephens, Columbia college

Walkability of the site

Community engagement
Eco gym, food market, gardens, Learning center (professional development - City of Refugee)

EV Charging & rideshare:

- The proximity of LightHAUS reduces the burden of resource insecurity.
- Residents will still need to travel for additional supplies.
- On the North end of the building is an electric vehicle rideshare station.
- The City of Columbia offers grants for EV stations, allowing implementation without increasing our budget or rent.