TEAM INTRODUCTION

22 students
8 majors
1 university
PROJECT SUMMARY

OVERVIEW
Deep energy retrofit
Existing Student Housing
Multi-family
PROJECT LOCATION

Urbana, IL
Climate Zone: 5B
PROJECT LOCATION
WHY RETROFIT?

- 82.0% Single Family Detached
- 6.1% Single Family Attached
- 3.3% Apartments in 2-4 unit buildings
- 5.7% Apartment in 5 or more unit buildings
- 2.9% Mobile Homes

Source: US Energy Information Administration

- 256.5 b sqf
  Residential building in the US

- 14.6 b sqf
  Multifamily homes in the US
WHY RETROFIT? (Retrofit vs. New Construction)

**Design Goals & Project Context**

- **Basecase** -9%
  - Advanced Case -12%

- **Climate Change**
- **Human Health**
- **Resource Depletion**
- **Ecosystem Quality**

- **Basecase** - 17%
  - Advanced Case -20%

- **Demolition**
- **Renovation**

- **Basecase** - 24%
  - Advanced Case -28%

- **Waste (lb/sf)**

- **Graphs and charts** illustrating comparisons between retrofitting and new construction in terms of environmental impact.
RESILIENCY - THE FOUR R’s

Since the resilience chart for asset (or community) ‘A’ shows smaller area than the area in resilience chart for asset (or community) ‘B’, it can be concluded that the resilience of ‘A’ is higher than the resilience of ‘B’.
LOCALIZING RESILIENCY IN URBANA, IL

DESIGN GOALS & PROJECT CONTEXT
PROGRAM

Living

Bedroom

Solar Chimney

Circulation

Mechanical and Plumbing Cores

Patio
SUSTAINABILITY DIAGRAM
SITE PLAN
EAST ELEVATION
INTERIOR DESIGN
CONSTRUCTABILITY
Debt to Income Ratio Calculation

Annual Median Family Income (MFI) $ 54,916
Monthly Household Debt (0.5% MFI) $ 34
Operations and Maintenance Costs $ 24
Monthly Utility Costs $ 10
Property Tax $ 369
Insurance $ 10
Mortgage Payment $ 718

Home Ownership Affordability Target 38%
Calculated Debt to Income Ratio 25%

Financing Breakdown
Annual Interest Rate 3.9%
Years 30 years
Payments per Year 12
Number of Payments 360
Down payment $ 305,644
Principle Amount $1,222,575
Monthly Payment $ (5,746)

Property Tax Calculation
Property Tax Rate 2.32%
Annual Property Tax $ 35,455
1. Moisture penetrates the diffusion-open internal insulation system
2. Water can condensate in the bonding layer behind the insulation board
3. The insulation board absorbs this moisture and actively distributes it within the system
4. By unburdening the system (e.g., through airing) the moisture balance is maintained within the insulated interior, thereby positively influencing drying.
PROPOSED WALL SECTION DETAILS
HYGROTHERMAL ANALYSIS

ENVELOPE DURABILITY ANALYSIS
HVAC DESIGN PRINCIPLES/SYSTEMS

• Eliminated ASHP from design
  • CERV to handle heat supply to all spaces
    • Individual bedrooms + open living space
    • Simplifies layout, downsizes system
  • CERV with GeoBoost for heating
    • CERV placed in mechanical room in each unit
    • Geo-loop: HDPE piping for 300' main loop, circulating propylene glycol + water mixture
    • Taco 009 Cartridge Circulator Pump per CERV
  • Panasonic FV-30 WhisperLine air blowers
    • 100-175 cfm, MERV-13 filter
    • Total airflow supply: 160 cfm for 4BR, 130 cfm for 3BR, 100 cfm for 2BR
    • Total airflow exhaust: 110 cfm for 3/4BR, 80 cfm for 2BR
HVAC SYSTEMS OVERVIEW

Coefficient of Performance (COP) 2.4 (without fan power) / 1.9 (with fan power)
Energy Efficiency Ratio (EER) = 8.6 Btu/W-hr
Total Cooling Capacity = 1079 W
Compressor Power = 450 W
Fan Power = 120 W
Lat. = 133 W Sens. = 947 W

Coefficient of Performance (COP) 3.5 (without fan power) / 2.7 (with fan power)
Energy Efficiency Ratio (EER) = 12.7 Btu/W-hr
Total Cooling Capacity = 1342 W
Compressor Power = 381 W
Fan Power = 120 W
Lat. = 231 W Sens. = 1110 W

Coefficient of Performance (COP) 3.1 (without fan power) / 2.4 (with fan power)
Energy Efficiency Ratio (EER) = 11.1 Btu/W-hr
Total Cooling Capacity = 1165 W
Compressor Power = 377 W

Coefficient of Performance (COP) 5.4 (without fan power) / 4.0 (with fan power)
Energy Efficiency Ratio (EER) = 19.3 Btu/W-hr
Total Cooling Capacity = 1803 W
Compressor Power = 335 W
Fan Power = 120 W

Recirculation Heating

Ventilation Heating

Recirculation Cooling

Ventilation Cooling

Conditioning Module
HVAC SYSTEMS OVERVIEW

Basement Floor Plan

Typical Floor Plan
HVAC SYSTEMS OVERVIEW
WHOLE-HOUSE ENERGY SIMULATION RESULTS

[Diagram showing energy simulation results for different building scenarios with links to LINK0in Locale and Photovoltaic Panels.]
WHOLE-HOUSE ENERGY SIMULATION RESULTS
WHOLE-HOUSE ENERGY SIMULATION RESULTS
PHOTOVOLTAIC MODULES

• **Sunpower SPR-X21-255**
  - Nominal Efficiency: 21.5%
  - Maximum Power: 254.666 Wdc
  - Max Power Voltage: 42.8 Vdc
  - Max Power Current: 5.9 Adc
  - Open Circuit Voltage: 51 Vdc
  - Short Circuit Current: 6.3 Adc

• **Advantages:**
  - Highest Efficiency
  - Proven Technology
  - Thousands Sold
  - 25 Years Warranty
MICRO-INVERTER

Enphase Energy: C250 220V

- Weighted Efficiency: 96.4%
- Maximum DC Input Voltage: 60 Vdc
- Nominal Output AC Voltage: 220 Vac

Advantages:
- Low loss due to shading, debris or snow
- Reduces module to module mismatch
- More resistant to whole system failure
- Monitoring of each solar panel via powerline communication
- Simple design, installation, and management
PV SYSTEM DESIGN

107 Panels (27 kW)
- 180° South at 29° Tilt
- Annual Energy Production 37,700 kWh
- $ 70,580
- Offsets 92% of total consumption
ELECTRICAL WIRING DESIGN
LED LIGHTING BACKUP POWER

Diagram:
- PV System
- Battery
  - Tesla Powerwall 6.4 kWh
- SMA Sunny Boy Storage 2.5
- Distribution Panel
- Grid
- Loads
- kWh

Available as of March 2016.
DOMESTIC HOT WATER

Save Energy and Water
Reduce the wait time for hot water
Return the ambient-temperature water back to the heater

- Shortest pipe run length
- Better loop location
- CPVC SCH 40 tubing

- Refrigeration 5%
- Lighting 5%
- Cooling 6%
- Other 24%
- Water Heating 18%
- Space Heating 42%
DOMESTIC HOT WATER

- 50-gallon water heater
- Energy Factor 3.25>2.0
- Save $370-$490 water heating cost annually
- Four operating modes

Team LINKoln chose the GeoSpring™ Hybrid Electric Water Heater model # GEH50DFEJSR.

<table>
<thead>
<tr>
<th>Tank Capacity</th>
<th>Tank Diameter</th>
<th>Tank Height</th>
<th>Energy Factor</th>
<th>Fuel Type</th>
<th>First Hour Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 gal.</td>
<td>21.75 in.</td>
<td>59.5 in.</td>
<td>3.25</td>
<td>Electric</td>
<td>67 gal.</td>
</tr>
</tbody>
</table>

GeoSpring™ Hybrid Electric Water Heater
DOMESTIC HOT WATER PLAN

- Hot Water Delivery System Layout
- 0.5 gallons storage limit in piping satisfied
- ASPE acceptable performance of 10 seconds waiting for hot water
WATER SAVING

<table>
<thead>
<tr>
<th>Fixtures</th>
<th>Manufacturer</th>
<th>Model#</th>
<th>Price</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen Faucet</td>
<td>Delta</td>
<td>B2310</td>
<td>$85.35</td>
<td>1.80 gpm @ 60 psi</td>
</tr>
<tr>
<td>Bath Faucet</td>
<td>Delta</td>
<td>21C154</td>
<td>$102.80</td>
<td>0.50 gpm</td>
</tr>
<tr>
<td>Tub &amp; Shower</td>
<td>Delta</td>
<td>T13420-SO H2OT</td>
<td>$126.80</td>
<td>1.50 gpm @ 80 psi</td>
</tr>
<tr>
<td>Toilet</td>
<td>Nepon</td>
<td>Foam-Flush Toilet</td>
<td>$126.80</td>
<td>3-ounce</td>
</tr>
</tbody>
</table>

- Energy Star products
- Acceptable prices

- Based on the water fixture we selected, we calculated the flow rate. Compared with fixtures of IPC/UPC (CODE), our apartment can save almost 50% portable water usage.
RAINWATER COLLECTION

- Collecting water
  Average monthly precipitation. Urbana, IL. (inches)

- Precipitation is on an average around 3.43” of rainfall every month.
- The estimated catchment area for the roof is 3500 ft² and for the parking place is 13298 ft².

- Water Usage

<table>
<thead>
<tr>
<th>Category</th>
<th>Estimated Usage gal/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faucet</td>
<td>5160</td>
</tr>
<tr>
<td>Toilet</td>
<td>4872</td>
</tr>
<tr>
<td>Shower</td>
<td>9552</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>384</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>1392</td>
</tr>
<tr>
<td>Leaks</td>
<td>4704</td>
</tr>
<tr>
<td>Other</td>
<td>1008</td>
</tr>
<tr>
<td>Indoor hot</td>
<td>8056.11</td>
</tr>
<tr>
<td>Total indoor</td>
<td>27024</td>
</tr>
<tr>
<td>Outdoor</td>
<td>969</td>
</tr>
</tbody>
</table>

- Rainwater Catchment: Roof & Ground.
- Used for flushing (Roof)
- Used for irrigation (Ground)
- Cistern located outside of the apartment
RAINWATER COLLECTION

• Reclaimed water collection and reuse

<table>
<thead>
<tr>
<th>Rainwater collection</th>
<th>Highest gal/month</th>
<th>Lowest gal/month</th>
<th>Average gal/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>10647.3</td>
<td>4472.7</td>
<td>7483.6</td>
</tr>
<tr>
<td>Parking</td>
<td>40453.6</td>
<td>16993.8</td>
<td>28433.5</td>
</tr>
<tr>
<td>Reuse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flushing gal/month</td>
<td>4972</td>
<td></td>
<td>969</td>
</tr>
<tr>
<td>Irrigation gal/month</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• The average monthly rainwater collection can satisfy flushing usage
• For the month with lowest rainfall, it demands only 500 gallons of potable water
• Cistern Storage is 5000 gallons: two 2635 gallons cisterns LxWxH=140 in. x 90in. x 72in.
• Parking place: 1000 gallons cistern: LxWxH=90 in. x 78in. x 55in.
APPLIANCES LIST

- Energy Star
  - Fridge + Freezer
  - Dishwasher
  - Clothes Dryer
  - Washing machine
- Energy Efficient
  - Induction Range (400 kWh/yr)
  - Clothes washer (109 kWh/yr)
  - Dishwasher (258 kWh/yr)
  - Clothes dryer (531 kWh/yr)
- Cost Efficient

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Cost</th>
<th>Brand</th>
<th>Energy Consumption</th>
<th>Energy Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothes Dryer</td>
<td>$943.2</td>
<td>Whirlpool WED99HE DW</td>
<td>531.0 kWh/yr</td>
<td>Yes</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>$799.2</td>
<td>Whirlpool WFW95HE DW</td>
<td>109.0 kWh/yr</td>
<td>Yes</td>
</tr>
<tr>
<td>Induction Range (with Oven)</td>
<td>$179.10</td>
<td>GE PHB920SS</td>
<td>Stovetop 1: 3.7kW</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stovetop 2: 2.5kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stovetop 3: 1.8kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stovetop 4: 2.5kW</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Stovetop 5: .1 kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oven Bake: 2.85 kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oven Broil: 3.8 kW</td>
<td></td>
</tr>
<tr>
<td>Microwave</td>
<td>$310</td>
<td>LG LMV2031S</td>
<td>1kWh</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>121.545kWh/year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(assuming 20 min/day)</td>
<td></td>
</tr>
<tr>
<td>Refrigerator + Freezer</td>
<td>$200.0</td>
<td>LG LTCS24223S</td>
<td>501kWh/year</td>
<td>Yes</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>$538.2</td>
<td>LDF7774ST</td>
<td>258 kWh/yr</td>
<td>Yes</td>
</tr>
</tbody>
</table>
APPLIANCES/INTERIOR DESIGN
HOME AUTOMATION SYSTEM

DOMESTIC HOT WATER, LIGHTING & APPLIANCES

[Diagram showing various smart home devices and components, including SmartThings Hub, Touchscreen Deadbolt, Zen Thermostat, Smoke and CO Detector, Fluid, Neurio, and LINKON App.]
Durable Resistive Touchscreen
Anti-pick shield
LED backlight
Remote control
SMARTTHING HUB AND APP

• Heart of your home
• Sensor, light, and lock control
• Automate your home's lighting and save money on energy costs
• Simple Set-up
• Controlled through your smart phone with SmartThings app
LINKON APP

- Easy Installation
- Increase Awareness
- Understand Usage
- Consumption habits and behavior
- Set Goals
- Detect Leaks
- Signature-water consumption

![Image of LINKON app interface showing water and electricity consumption breakdowns.](image-url)
INNOVATION

❖ Roof Garden
❖ Three Rain Gardens (North-East, South-East, and West)
❖ Double skin facade on south
  ➢ Highly exposed to rain runoff
  ➢ Walls need to dry out and adding such component on south side will increase the drying rate as well as it eliminates concerns of freeze thaw damage
❖ Hybrid interior Insulation Retrofit
❖ Applying water repellent coats on all exterior building elements, specifically bricks
❖ Selling out extra water collected on ground for irrigation purposes in neighborhood
❖ Application and Design of CERV in multifamily buildings
❖ Enhancing building resiliency
Thank You
LINKoln Locale

TEAM LINKoln

U.S. DEPARTMENT OF ENERGY RACE TO ZERO STUDENT DESIGN COMPETITION