B.R.O.N.Z.E.

Bronzeville Residence Optimized for Net Zero Energy
Team B.R.O.N.Z.E.
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2nd year M.E. Arch. E.

Team Leader
Energy Analysis, Photovoltaic System Design, IAQ and Ventilation

Ariel White
1st year M.S. Arch. E.

Mechanical Design, Lighting Design

Elmira Hosseinkhani
3rd year M. Arch.

Architectural Design, Architectural Drawings

Lindsey Rice
5th year M.E., B.S. Arch. E.

Building Envelope Design, Architectural Details, Construction Schedule

Ezgi Bay
2nd year PhD. Arch.

Architectural Design, Architectural Drawings, Team Logo Design

Alexander Mitchell
4th year B.S. Arch. E.

Plumbing Design, Electrical Design, Mechanical Design
B.R.O.N.Z.E.

Special Thanks to:

- Faculty Advisors:
  - Edoarda Corradi
    Dell Acqua, M.S.
    Adjunct Professor
  - Brent Stephens, Ph.D.
    Associate Professor

- Industry Partners:
  - DILIGENT DESIGN GROUP
  - PHIUS
  - ASHRAE Illinois Chapter
Bronzeville

- Bronzeville is a historical African American neighborhood
- Has roots coming from jazz and creole culture
- Average Family Income: $60,000/yr
- Median Family Income: $37,000/yr
- Median Home Sale Price: $130,000
Typical lot size in Chicago are narrow and deep, approximately 70% of them have width of less than 25 ft.
The Site
Architectural Design
Design Process
Sunlight Analysis

4:00 pm
Winter Solstice

12:00 pm
Winter Solstice

7:00 am
Winter Solstice

Sunlight Analysis - Winter

6:00 pm
Summer Solstice

12:00 pm
Summer Solstice

6:00 am
Summer Solstice

Sunlight Analysis - Summer
Concept
Courtyard

SITE PLAN

LIGHTWELL

BALCONY

COURTYARD
Renderings
Elevations

SOUTH ELEVATION

WEST ELEVATION

EAST ELEVATION

ramp = 7%
Lighting and Appliances
Artificial Lighting

- 100% LED - EnergyStar
  - Philips Hue System
  - 1500 W approx.
Appliances

- DOE Zero Energy Ready Home Requirements
  - Kitchen
Appliances

▶ DOE Zero Energy Ready Home Requirements
  ▶ Laundry Room

  ▶ High Efficiency All-In-One System
    ▶ Washer
    ▶ Electric Ventless dryer
      ▶ Good for:
        □ IAQ
        □ Internal Heating Loads
Energy Analysis
Energy Analysis

- Enclosure Design
  - DOE Zero Energy Ready Home Requirements - IECC 2015

Double Wood Stud

Finalist

Single Wood Stud

The Winner!

Space Saver

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Energy Analysis

- HERS Score

Without PV

With PV

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PV System

- Heliene 96\(^M\) - 490 W/Panel (9.8 kW system)
PV System

Payback Period

- Database of State Incentives for Renewables & Efficiency (DSIRE)

RESULTS

12,936 kWh per Year *

<table>
<thead>
<tr>
<th>Month</th>
<th>Solar Radiation (kWh/m²/day)</th>
<th>AC Energy (kWh)</th>
<th>Energy Value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2.76</td>
<td>755</td>
<td>79</td>
</tr>
<tr>
<td>February</td>
<td>3.55</td>
<td>858</td>
<td>90</td>
</tr>
<tr>
<td>March</td>
<td>4.25</td>
<td>1,123</td>
<td>117</td>
</tr>
<tr>
<td>April</td>
<td>5.24</td>
<td>1,275</td>
<td>133</td>
</tr>
<tr>
<td>May</td>
<td>6.01</td>
<td>1,434</td>
<td>150</td>
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<tr>
<td>June</td>
<td>6.08</td>
<td>1,386</td>
<td>145</td>
</tr>
<tr>
<td>July</td>
<td>6.31</td>
<td>1,449</td>
<td>151</td>
</tr>
<tr>
<td>August</td>
<td>5.42</td>
<td>1,267</td>
<td>132</td>
</tr>
<tr>
<td>September</td>
<td>4.93</td>
<td>1,131</td>
<td>118</td>
</tr>
<tr>
<td>October</td>
<td>4.08</td>
<td>1,018</td>
<td>106</td>
</tr>
<tr>
<td>November</td>
<td>2.64</td>
<td>669</td>
<td>70</td>
</tr>
<tr>
<td>December</td>
<td>2.09</td>
<td>571</td>
<td>60</td>
</tr>
</tbody>
</table>

Annual 4.45 12,936 $ 1,351

Payback just for PV: 13 Years

Payback w. rebates: 6 Years

Annual Savings

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Enclosure Performance
Enclosure Performance

Walls

- 2x6 Wood Framing: Dense Packed Cellulose Cavity Insulation
- Continuous Insulation: 4” Graphite Polystyrene Rigid Insulation
- Rainscreen Facade: Vinyl Siding over Furring Strips
Enclosure Performance

Wall Thermal Performance

<table>
<thead>
<tr>
<th>Nominal R-Value</th>
<th>Effective R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-42</td>
<td>R-37</td>
</tr>
<tr>
<td>R-22 (5.5 inch x R-4/ Inch of Dense Pack Cellulose)</td>
<td>THERM Model</td>
</tr>
<tr>
<td>R-20 (4 inch x R-5/ Inch of Graphite Polystyrene)</td>
<td>Extreme Winter Conditions</td>
</tr>
<tr>
<td></td>
<td>Interior: 68F, Exterior: 0F</td>
</tr>
</tbody>
</table>

![Diagram of temperature distribution](image)
Enclosure Performance

Roof

- 2x10 Roof Joists: Dense Packed Cellulose Cavity Insulation
- Continuous Insulation: 5” Graphite Polystyrene Rigid Insulation
- Roof Finish: White Fully Adhered Membrane
## Enclosure Performance

### Roof Thermal Performance

<table>
<thead>
<tr>
<th>Nominal R-Value</th>
<th>Effective R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R-62</strong></td>
<td><strong>R-53</strong></td>
</tr>
<tr>
<td>R-37 (9.25 inch x R-4/ Inch of Dense Pack Cellulose)</td>
<td>THERM Model</td>
</tr>
<tr>
<td>R-25 (5 inch x R-5/ Inch of Graphite Polystyrene)</td>
<td>Extreme Winter Conditions</td>
</tr>
<tr>
<td></td>
<td>Interior: 68F, Exterior: 0F</td>
</tr>
</tbody>
</table>

[Image of thermal performance graph]

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Enclosure Performance

Moisture Evaluation - WUFI

- Relative Humidity does not reach 100%, wall and roof section both OK.
Enclosure Performance

Parapet

- Air Barrier is Continuous
- Waterproof Membrane Below Coping
Enclosure Performance

Basement Walls

- R-10 GPS Continuous, Thermal Break Between Foundation and Slab
- Framed 2x4 Walls with R-13 Batt Insulation
- Vapor Barrier Below Insulation, Capillary Break at Foundation Base
Enclosure Performance

Slab on Grade

- R-10 GPS Thermal Break Between Foundation and Slab
- Vapor Barrier Below Insulation, Capillary Break at Foundation Base
Enclosure Performance

Window Selection

Triple Pane, Insulated Frame
Alpen High Performance Zenith ZR-6/625 Series Fiberglass Windows

Three Window Style Types:

- Fixed High Profile
- Casement: Egress for Bedrooms
- Awning/ Tilt Out
Enclosure Performance

Window Detail

- Outward Orientation
Mechanical

- Air sourced vs water-sourced heat pump
- Vertical pipe loop
- Ductless VRF Mini Split System
  - Reduces Duct cost and Energy losses
- Ecobee3 Smart Thermostat- occupancy sensors, local weather data
HEATING OR COOLING

HEATING AND COOLING
Plumbing

- Water heater- GE Geospring
  - 3.25 Energy Factor
  - 70% more efficient than a standard electric 50-gallon water heater
  - Provides the same amount of hot water as a traditional 50-gallon standard electric water heater with 69 gallons first-hour delivery
  - Electronic controls with 4 operating modes plus a vacation setting
  - Recirculation loop
Plumbing

- All fixtures are low flow, balanced with the architectural design of the house

<table>
<thead>
<tr>
<th>Plumbing Fixtures</th>
<th>Model #</th>
<th>Flow Rate (GPM)</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>Delta Trinsic Pulldown Faucet</td>
<td>9959-DST</td>
<td>1.80</td>
<td>Kitchen Sink</td>
</tr>
<tr>
<td>Delta Trinsic Lav Faucet</td>
<td>559LF-TP</td>
<td>1.2</td>
<td>Bathroom Lavs</td>
</tr>
<tr>
<td>Delta Prelude Toilet</td>
<td>C41901-WH</td>
<td>1.28 GPF</td>
<td>Bathrooms</td>
</tr>
<tr>
<td>Delta Trinsic Tub and Shower Trim</td>
<td>T17T459-H20</td>
<td>2</td>
<td>Bathrooms</td>
</tr>
</tbody>
</table>

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IAQ and Ventilation
IAQ and Ventilation

- Ventilation Requirements - ASHRAE 62.2 (2013)

- Whole-House: Zehnder Novus 300
  Up to 177 cfm

- Bathrooms: WhisperCeiling FV-05VQ5
  Up to 50 cfm

- Kitchen: 400 cfm, non recirculating

- Garage:
  - ENERGY STAR: Air barrier installed at the exterior and interior vertical surface of the wall insulation.
  - Completely separated from house

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IAQ and Ventilation

- Interior Design

- Armstrong - Oak Butterscotch
  - CARB requirements

- Sherwin-Williams - ProMar 200 Zero VOC
Financial Analysis
Financial Analysis

NAHB Financial Spreadsheet

Construction Cost: $ 259,730

Sales Price: $ 400,384
Financial Analysis

Estimated Family Income: $52,250
Financial Analysis

- Rebates

<table>
<thead>
<tr>
<th>Rebates</th>
<th>State of Illinois</th>
<th>Federal</th>
<th>Final Rebates</th>
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</thead>
<tbody>
<tr>
<td>PV Solar</td>
<td>$4,375.00</td>
<td>$5,250.00</td>
<td></td>
</tr>
<tr>
<td>Geothermal (ComEd)</td>
<td>$6,500.00</td>
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</tr>
<tr>
<td>Smart Thermostat (ComEd)</td>
<td>$100.00</td>
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<td></td>
</tr>
<tr>
<td>Insullation (ComEd)</td>
<td>$400.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appliances (ComEd)</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duct Sealing (ComEd)</td>
<td>$300.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$11,775.00</strong></td>
<td><strong>$5,250.00</strong></td>
<td><strong>$17,025.00</strong></td>
</tr>
</tbody>
</table>

- Reduces sales price to **$383,359 from $400,384**

Sales Price: $383,359
Innovation

- Energy Analysis driven design
- Narrow Site
  - Limits usable roof area for PV and exposed faces
- Architectural Strategies
  - Courtyard Lighting
  - Lightwell
  - Split Levels
- Combination of Traditional & New Technologies
  - Standard Wood Framing & Thick Continuous Graphite Polystyrene Insulation
  - Space conditioning and ventilation are separate systems
  - Follows the footprint and organization of the Traditional Chicago Home
Thank You