ALL AMERICAN ABODE
SOLAR DECATHLON
SUBURBAN SINGLE FAMILY
12 APRIL 2019
THE TEAM

12 undergraduate students
6 Academic Majors
12 different home states / countries
11 different follow on duty assignments
SFC Brown, Mrs. Brown, John and Sarah Brown:

- 10 years in the Army.
- 2 combat deployments.
- 3 family moves to Texas, Washington, and North Carolina.
- Looking to be in the Army for 10 more years.
THE PROBLEM

PROJECT GOALS

Top Army officials visit homes at Fort Bragg

Army Secretary calls military housing problems 'unconscionable'

Fort Bragg officials on Wednesday said they estimate that 1 to 2 percent of the 6,150 homes in the installation's family housing program have “significant challenges” that need to be addressed.

Fort Bragg, Corvias officials provide update to housing issues
**HOUSING MANAGEMENT**

**PROJECT GOALS**

**Bragg Dynamic:**
- 70% live off post
- 6,100 homes
- 10 unique communities
- 7 pay-grade specific
- 2,770 built before 1978

**Garrison Command:**
- Oversight and quality and control
- Reimbursed by Corvias for utilities
- In charge of Department of Public Works
- Military authority for housing

**Privatized Housing:**
- 35-year renovation plan
- Desire green building, have funding
- Construction, O&M
- Subsidized by housing allowance / federal funding
FORT BRAGG & ANZIO ACRES

**PROJECT GOALS**

- Founded: September 4th, 1918
- Population: 39,457
- Total Area: 252 sq. Mi
- Time Zone: EST
- Cumberland County, NC
- HDD: 2800
- Latitude: 35.14 N
- Sunny Days: 219
- 0.22 acre plot
- 2 adults, 2-3 kids
**Race to Zero**
Affordable Energy Net-Zero Market Ready

**Occupyant Needs**
Quality of Life Ease of Use Aesthetics

**Team Goals**
Net-Zero Home Easily Constructible Affordable Proactive Maintenance Features Smart Tech Commercial Products

**Army**
Affordable Net-Zero Initiative Complies to UCF

**Corvias Needs**
Easy Maintenance Low Upkeep Cost
EXTERIOR DESIGN

PROJECT GOALS

OPTIMIZED VIEWS

COMMUNITY CONNECTION

SOLAR PERFORMANCE

HEATING AND COOLING
Project Goals:

**Functionality**

**Efficiency**

**Simplicity**

Square Footage:

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garage</td>
<td>481 SF</td>
</tr>
<tr>
<td>Living, Dining, Kitchen</td>
<td>514 SF</td>
</tr>
<tr>
<td>Half Bathroom</td>
<td>40 SF</td>
</tr>
<tr>
<td>Laundry/Utility Room</td>
<td>45 SF</td>
</tr>
<tr>
<td>Master Bedroom</td>
<td>240 SF</td>
</tr>
<tr>
<td>Master Bathroom</td>
<td>54 SF</td>
</tr>
<tr>
<td>Master Closet</td>
<td>27 SF</td>
</tr>
<tr>
<td>First Floor</td>
<td>920 SF</td>
</tr>
</tbody>
</table>
SECOND FLOOR

FUNCTIONALITY  EFFICIENCY  SIMPLICITY

Square Footage

<table>
<thead>
<tr>
<th>Room</th>
<th>Square Footage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing</td>
<td>60 SF</td>
</tr>
<tr>
<td>Adaptable Room</td>
<td>115 SF</td>
</tr>
<tr>
<td>Full Bathroom</td>
<td>76 SF</td>
</tr>
<tr>
<td>Linen Closet</td>
<td>9 SF</td>
</tr>
<tr>
<td>Bedroom Closet</td>
<td>10 SF</td>
</tr>
<tr>
<td>Bedroom</td>
<td>126 SF</td>
</tr>
<tr>
<td>Bedroom</td>
<td>130 SF</td>
</tr>
<tr>
<td>Second Floor</td>
<td>536 SF</td>
</tr>
<tr>
<td>Attic</td>
<td>624 SF</td>
</tr>
</tbody>
</table>
PROJECT GOALS

INTERIOR DESIGN
MECHANICAL SYSTEMS

Geothermal Heat Pump - WaterFurnace 5 Series 500A11-026
- COP 4.5
- EER 26
- Horizontal loop

A.O. Smith 50-Gal Electric Heat Pump Hot Water Heater
- 3.42 EF
- 10-year lifespan

Fantech ERV 2004N Series
- 225 cfm
- 75% effective at 0 degrees C
- 52% effective at 95 degrees F
- Humidity control
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Outdoor Level (NAAQS)</th>
<th>Ventilation Threshold (For best health) (Vent at rate required for room)</th>
<th>Ventilation Threshold (0 occupants) (Vent at rate required for room)</th>
<th>Emergency Ventilation Threshold (Vent at max allowable rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>350 ppm</td>
<td>800 ppm</td>
<td>&gt;1000 ppm</td>
<td>&gt; 2000 ppm</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>0-0.1 ppm</td>
<td>9 ppm</td>
<td>&gt;70 ppm</td>
<td>&gt;150 ppm</td>
</tr>
<tr>
<td>PM-2.5</td>
<td>0 -0.035 ppm</td>
<td>0.012 ppm</td>
<td>&gt; 0.055 ppm</td>
<td>&gt; 0.1 ppm</td>
</tr>
<tr>
<td>Radon</td>
<td>0.4 pCi/L</td>
<td>&gt; 0.4 pCi/L</td>
<td>0.4 pCi/L -4 pCi/L</td>
<td>&gt; 4pCi/L</td>
</tr>
<tr>
<td>Humidity</td>
<td>&lt;30% - &gt;60%</td>
<td>&lt;30% - &gt;60%</td>
<td>&lt;30% - &gt;60%</td>
<td>&lt;30% - &gt;60%</td>
</tr>
<tr>
<td>Temperature</td>
<td>62-74 F Winter 72-80 F Summer</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- Based on researched standards for each pollutant.
- Automated maintenance of comfort levels throughout the home.
- Required ventilation provided while being as energy efficient as possible.
PLUMBING SYSTEM

PROJECT GOALS

First Floor Plumbing Layout

Red dots on each level indicate the pipes running from the 1st and 2nd story.

Rainwater recovery system

Inflow and outflow for the house.

Second Floor Plumbing Layout
**Rainwater Recovery:**
- 6000+ Gallons per year recovered
- Use for clothes washing and toilet flushing.

**Drain Water Heat Recovery:**
- Up to 67.5% efficient system
- Placed on each shower fixture.
- 12.5 kW of heat recovery

**Low Flow Plumbing Fixtures:**
- 42% reduction from baseline
- EPA Water Sense Qualified

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Flow Rate</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet</td>
<td>1.1/1.6 gpf</td>
<td>3 gpf</td>
</tr>
<tr>
<td>Shower</td>
<td>1.8 gpm</td>
<td>2.1 gpm</td>
</tr>
<tr>
<td>Bathroom Faucet</td>
<td>1.2 gpm</td>
<td>2.2 gpm</td>
</tr>
<tr>
<td>Kitchen Faucet</td>
<td>1.5 gpm</td>
<td>2.2 gpm</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>2.8 WF</td>
<td>3-5 WF</td>
</tr>
</tbody>
</table>
PLUG LOADS

Highlights:
- Energy Star Appliances
- Energy Monitoring
- Smart Plugs
- Electric Car Charging

KEY:
- Smart 15 amp Plug
- 15 amp Plug AFCI enabled
- 20 amp Plug
  - GFCI enabled
- 20 amp Plug
- 220 Volt Plug

First Floor

Second Floor

Note: Design meets NEC and was reviewed by certified electrician
PV ARRAY

Highlights:
- Direct Energy Sellback
- 10,279.2 kWh/yr
- $2.45/Watt
- Pending full UFC compliance*

*Note: UFC takes precedent over NEC
LIGHTING

PROJECT GOALS

Highlights:
• DC LEDs – driver efficiency
• Energy Star Choices
• Smart dimming capability
• PV integration
• Seasonal Affectiveness Disorder

KEY
- Switch
- 16W Vanity Light
- 9W Outdoor Recessed Downlight
- 10W Recessed Downlight
- 14W Ceiling Diffuser
- IMA-1000W 48 V AC-DC Converter
SMART CONTROL AND SHADING

Highlights:

- Automated Control
- Z-wave implementation
- Sensing
- Energy Savings
- Improved Livability
PROJECT GOALS

NETWORK RESILIENCY

Highlights:
- Network & device segregation.
- Speed
- Security

Wavelength Comparison

First Floor
Second Floor
ENERGY PERFORMANCE

PROJECT GOALS

HERS® Index

More Energy

Existing Homes

Standard New Home

100

Zero Energy Home

This Home 32

Without PV

This Home -14

With PV

Annual Energy Cost

Design Loads

Home Improvements and Effect on Energy Consumption
Energy Dynamic:

- Army Net-Zero initiative
- Smart Tech impact
- Overproducing Energy: 3000 kWh/yr
- Energy Storage
- Virtual Power Plant
FINANCIAL ANALYSIS

Realistic
• Tangible estimates through team members and industry experts, based on sound decisions

Affordable
• Within the housing allowance of the soldiers and families that live there

Feasible
• Able to easily replicate All-American Abode in construction and costs

Forecast
• Effectively determine the cost of All-American Abode for the next five years
REALISTIC CONSTRUCTION METRICS

Present Building Cost: $194,418
Sale Price: $264,911
Construction Time: 108 days
Corvias Profit: $37,237

<table>
<thead>
<tr>
<th>Walls</th>
<th>Value Measure</th>
<th>Swing Weight</th>
<th>Global Weight</th>
<th>Stickbuilt</th>
<th>SIP</th>
<th>ICF</th>
<th>Xi Walls</th>
<th>Perfect Score</th>
<th>Weighted Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Cost</td>
<td>8</td>
<td>0.286</td>
<td>36000</td>
<td>20000</td>
<td>40000</td>
<td>40000</td>
<td>20000</td>
<td>Stickbuilt Sip ICF Xi Walls Ideal Solution</td>
</tr>
<tr>
<td></td>
<td>Thickness (in)</td>
<td>5</td>
<td>0.179</td>
<td>5</td>
<td>6.5</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>17.857 13.736 11.161 11.161 17.9</td>
</tr>
<tr>
<td></td>
<td>Installation Time (days)</td>
<td>5</td>
<td>0.179</td>
<td>22</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1.623 17.857 11.905 17.857 17.857</td>
</tr>
<tr>
<td>Total Weight</td>
<td>28</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51.723 95.879 70.089 65.625 100.0</td>
</tr>
</tbody>
</table>

Scoring Function: 

```
"=(RawScore/PerfectScore)*GlobalWeight"
```

Decision: SIP (Structurally Insulated Panel) from ACME Panel
FEASIBILITY AND AFFORDABILITY

Housing Allowance:
  - Annual: $17,568
  - Monthly: $1,464
  - Average salary for a senior enlisted soldier: $57,000

Monthly Payments:
  - Mortgage: $1,316
  - Payback on construction: $798

Competition:
  - Median Fayetteville House Value, 3BR (Zillow): $139,200
  - Building for a different market
    - Affordable for military, within housing allowance
    - Younger soldiers live in the barracks
TIMELINE AND FORECASTING

- Fisher Index to model inflation and OMB Circular discount rate to bring back to 2019 dollars.

- Build Year 0-1: $264,911
- Build Year 1-2: $276,556
- Build Year 2-3: $288,728
- Build Year 3-4: $301,444
- Build Year 4-5: $314,727
Relevant Project Data and Cost Estimates

- Structure: 1,456 S.F. home on 0.22 acres.
- HERS Score = -14, construction cost = $194,418 and $42 per month in utility costs.
- Excess photovoltaic energy produced offsets Fort Bragg’s utility bill.

Project Technical Specifications

- Envelope: SIPs walls (R = 21) and roofing (R = 21), insulated slab-on-grade (R = 7).
- Glazing: Pella windows: U-0.28 (R-3.6) with sliding glass door of U-0.3 (R-3.3).
- Smart Features: Sensors and actuators to monitor and control water, air quality, etc., controlled via Mobile App.
- Energy Production: 7,440 Watt PV Array
- 42 percent reduction in water usage
- LEED Platinum
END OF STORY

- It is bigger than SFC Brown
- The military family
- Diversity of the occupant
- Balance: Needs vs People