Suburban Single-Family Home
Our Team

Supporting Organizations
- PHRC
- Hamer Center
- EEHR

Faculty Advisors

Team Leaders

Team Members
TEN CONTESTS

The occurrence of these icons throughout the book indicates that the adjacent section includes information relevant to the noted contest. Some sections may have one or more icons associated with it.
CURRENT CCHLT HOUSEHOLDS

- **SINGLE**
  - 2 single mothers, both have 1 young child
  - 2 single parents, one has a special needs child
  - 1 disabled individual, divorced, adult children need at home when young
- **SINGLE PARENT**
  - 2 single parents, 1 has 2 teenagers, 1 has two
  - grandchildren, 1 has one has a special needs child
  - 2 married with no kids
- **MARRIED COUPLE**
  - 3 married with children/grandchildren, one has 2 teenagers, one has two grandchildren, 1 has one has a special needs child
  - 2 married with no kids
“At Centre County Housing and Land Trust, our mission is to strengthen communities through the development and stewardship of permanently, affordable homes for people of low- to moderate-income.”
Existing Woodycrest Park

Thompson Place
Typical Thompson Place Floor Plan

- Great inclusion of kitchen, living, dining core
- Inefficient systems used (Electric Baseboard)
- Lack of connection to other homes or community spaces
Architecture

Typical Thompson Place Lot

- Lack of connection to other community, no interaction created
- Home orientation creates inefficient energy production if Solar PV is added
- Great Backyard Space
Design Constraints

State College Climate Zone: 5A

Houses are within 20° off True South to maximize solar gains
CCHLT

80-120% Centre County MFI

$60,759-$91,138

Ownership spans 7-25+ years

No foreclosures

Typical CCHLT Family

- 2 adults, 28 years old

- College degrees

- 1-2 young children

- First time homeowner
Design Priorities

1. Sense of Community
   - CCHLT
   - ECOmmunity

2. Quality of Life
   - CCHLT
   - Solar Decathlon

3. Affordability
   - CCHLT
   - Solar Decathlon

4. Flexibility
   - CCHLT
   - ECOmmunity

5. Operational and Embodied Energy
   - ECOmmunity
   - Solar Decathlon

6. Constructability and Material Life Cycle
   - CCHLT
   - Solar Decathlon

7. Innovation
   - Solar Decathlon
   - ECOmmunity

8. Aesthetics
   - ECOmmunity

9. Resilience
   - Solar Decathlon
The Social Core
THE POD
Programmatic Elements

POD CONNECTING ROAD
HOUSE UNIT W. CAR PORT
POTENTIAL COMMUNITY SPACE
POTENTIAL PROPERTY LINE
POLLINATOR/VEGETAL GARDEN
The Social Core
Floor Plan

1. bedroom
2. kitchen/living
3. bathroom
4. mudroom
5. bedroom
6. mechanical room
7. master bath
8. master bedroom
9. carport
10. washer/dryer
11. refrigerator

146 sf
554 sf
40 sf
79 sf
149 sf
14 sf
88 sf
157 sf
240 sf
Diagram of Flexible Modules
Backyard
Park View
Living Room Interior
Kitchen Interior
Design Consideration

(3) Affordability
CCHLT
Solar Decathlon

(5) Operational and Embodied Energy
ECOmmunity
Solar Decathlon

(6) Constructability and Material Life Cycle
CCHLT
Solar Decathlon
**Research**

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>R-Value</th>
<th>Density</th>
<th>Embodied Energy</th>
<th>Embodied Carbon</th>
<th>Blowing Agent (GWP)</th>
<th>Constructibility</th>
<th>Affordability</th>
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<tr>
<td>R/In</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fiberglass Batt</td>
<td>3.3 per inch</td>
<td>1</td>
<td>2.8</td>
<td>0.0165</td>
<td>None</td>
<td>Simple 1 - 5 Technical</td>
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<td>Dense-Pack Cellulose</td>
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<td>72</td>
<td>0.0377</td>
<td>Water (GWP=1)</td>
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<td>Open-Cell Spray Foam</td>
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<td>Rockwool Batt</td>
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<td>XPS</td>
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<td>89</td>
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<td>HFC-134a (GWP=1,430)</td>
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<td>89</td>
<td>0.0307</td>
<td>Pentane (GWP=7)</td>
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<td>Rigid Rockwood</td>
<td>4 per inch</td>
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<td>0.0455</td>
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<td>Polyisocyanurate</td>
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<td>72</td>
<td>0.0284</td>
<td>Pentane (GWP=7)</td>
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<td>Expanded Cork Board</td>
<td>3.6 per inch</td>
<td>7.5</td>
<td>4</td>
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<td>None</td>
<td></td>
<td>$0.29</td>
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</table>

*Avoiding the Global Warming Impact of Insulation* Alex Wilson, Scott Gibson / Fine Homebuilding
Wall Construction

Wall (R-32)
- 5/8" GWB
- 2x6 Advanced Framing
- 5 1/2" R-3.7 per Inch Dense-Pack Cellulose (Thermal Barrier)
- 1/2" ZIP Sheathing with Taped Joints
- (Air/Vapor Barrier and Drainage Plane)
- 3" R-4 per Inch Rigid Rockwool Insulation (Thermal Barrier)
- 1/2" Furring Strips for Rain Screen and Drainage
- 1/2" Lapped Vinyl Siding with 4" Nails
  into the Studs and Sealant Applied (to maintain continuous air barrier)

- **Continuous Thermal Barrier**
- **Continuous Air/Vapor Barrier**

Rockwool Insulation  XPS Insulation
Wall Construction

WUFI Hygrothermal Analysis
Building Envelope Resiliency

2050 WUFI Hygrothermal Analysis
Foundation Construction

- Continuous Thermal Barrier
- Continuous Air/Vapor Barrier

Embodied Energy Comparison

- 3" XPS
- 3" Rockwool
Roof Construction

Roof (R-49)
- 5/8" GWB
- 2x10 trusses with 10" R-3.7 per inch Dense-Pack Cellulose (Thermal Barrier)
- 1/2" 2x6 Sheathing with Taped Joints (Air/Vapor Barrier)
- 3" R-14 per inch Rigid Rockwool Insulation (Thermal Barrier)
- 1/2" Plywood Board
- T Acoustical Soft Baffle (for venting over the sheathing)
- 1/2" Plywood Board
- Asphalt Shingles

Unvented Roof - Rigid Insulation Ratio Analysis

Temp. of Condensing Surface = [ΔT x R-Value Ratio] + Monthly Mean Exterior Temperature

<table>
<thead>
<tr>
<th>Inside Temp.</th>
<th>Monthly Mean Exterior Temp.</th>
<th>ΔT</th>
<th>Temp. of Condensing Surface</th>
</tr>
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<tbody>
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<td>Oct. 70°F</td>
<td>51.5°F</td>
<td>18.5°F</td>
<td>56°F</td>
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<td>Nov. 70°F</td>
<td>42°F</td>
<td>28°F</td>
<td>49°F</td>
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<tr>
<td>Dec. 70°F</td>
<td>31.5°F</td>
<td>38.5°F</td>
<td>41°F</td>
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<tr>
<td>Jan. 70°F</td>
<td>35°F</td>
<td>35°F</td>
<td>44°F</td>
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<tr>
<td>Feb. 70°F</td>
<td>36°F</td>
<td>34°F</td>
<td>44°F</td>
</tr>
<tr>
<td>Mar. 70°F</td>
<td>39°F</td>
<td>31°F</td>
<td>47°F</td>
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<tr>
<td>Apr. 70°F</td>
<td>44.5°F</td>
<td>22.5°F</td>
<td>50°F</td>
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</table>

Rigid Insulation R-Value: 12
Total Assembly R-Value: 49
R-Value Ratio: 0.245
Ventilation

RenewAire - GR 90 ERV
Ventilation

Ventilation Plan w/ ERV Location

RenewAire - GR 90 ERV
Heating and Cooling

LG Condenser Model
LMU480HV

LG Mini Split Model
LMN079HVT

Heating and Cooling Plan w/ Zones identified
Heating and Cooling

SITE ENERGY USE (MMBtu/yr)

- Furnace: 74.5 MMBtu/yr (32.3 Heating, 42.2 Cooling)
- Electronic Baseboard: 66.9 MMBtu/yr (25.7 Heating, 41.2 Cooling)
- Mini-Split: 49.4 MMBtu/yr (9.5 Heating, 40.3 Cooling)

Space Conditioning

- Heating
- Cooling

Mini-split space conditioning system reduced energy usage the most

Heating and Cooling Plan w/ Zones identified

- Zone 1
- Zone 2
- Zone 3A
- Zone 3B
- Zone 4
Plumbing

Sanden SANCO2
Heat Pump Water Heater

Water Tank (Indoor)
Model SAN-83SSAQA

Condenser Unit (Outdoor)
Model GS3-45HPA

Highlighted “Wet Core” Walls in Plan
Plumbing

PEX-A Supply Piping

PVC Waste piping

Highlighted “Wet Core” Walls in...
Window Types

SITE ENERGY USE (MMBTU/YR)

- CLEAR, DOUBLE, AIR: 66.9
- LOW-E, DOUBLE, AIR: 66.5
- LOW-E, TRIPLE, ARG: 61.3
- LOW-E, DOUBLE, ARG: 63.5

WINDOW PANE

- Heating

Window panes have an impact on heating energy use. Key factor is to reduce heat leaking in cooling days.

The energy model suggests Triple-pane glass filled with Argon, but it might not be cost-effective.

Double-pane w. Argon is recommended for acceptable thermal performance and lower cost.
### Lighting Energy

<table>
<thead>
<tr>
<th>Lighting Type</th>
<th>Energy Use (MMBTU/YR)</th>
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<tbody>
<tr>
<td>Lithonia - LTIKSQ LED Linear Track Light</td>
<td>67.4</td>
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<tr>
<td>Commercial Electric - LED Recessed Light</td>
<td>66.0</td>
</tr>
<tr>
<td>Feit Electric - Exterior LED Wall Light</td>
<td>65.8</td>
</tr>
<tr>
<td>100% LED</td>
<td>66.6</td>
</tr>
</tbody>
</table>

#### Energy Breakdown:
- **Heating**
- **Lighting**

100% LED is suggested for less energy cost on lighting.
Site Energy Usage

HERS Index

ENERGY STRATEGIES

SITE ENERGY USE (MMBTU/YR)

BASELINE

CURRENT MODEL

ERV, MINI-SPLIT

ENVELOPE ADJUSTED

ARGON-FILLED GLASS

LED LIGHTING

67

51.9

39.2

38.0

37.9

37.6

HERS Index

Existing Homes

Standard New Home

Thompson Place Home

ECOMmunity Home without Solar Array

ECOmmunity Home 73kW Solar Array

ENERGY STRATEGIES:

- Hot Water
- Heating
- Cooling
- Heating Pump
- Cooling Fan
- Lights
- Appl.
- Vent Fan
- Misc
Energy Resilience and Future Proofing

LG Chem RESU10H Back-up Battery

Sunpower X21-350-BLK-D-AC Solar Panels

HERS Index

- Existing Homes
- Standard New Home
- Thompson Place Home
- ECOmmunity Home without Solar Array
- ECOmmunity Home 7.3kW Solar Array
Total Embodied Energy
(Breakdown by Assembly Group)
Design Priorities

- Affordability
- Quality of Life
- Resilience
- Flexibility
CCHLT Land Trust Model

CCHLT works with 80-120% Median Family Income (MFI)
CCHLT Land Trust Model

CCHLT works with 80-120% Median Family Income (MFI)

MFI in PA is $75,949
CCHLT Land Trust Model

CCHLT works with 80-120% Median Family Income (MFI)

MFI in PA is $75,949

CCHLT works with people who make between $60,759 and $91,138
## Cost Breakdown

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<th>Cost Without Add-On</th>
<th>Cost With Add-On</th>
</tr>
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<tr>
<td>Construction</td>
<td>$103,287.04</td>
<td>$137,095.98</td>
</tr>
<tr>
<td>Labor</td>
<td>$33,719.14</td>
<td>$57,219.14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$137,006.18</strong></td>
<td><strong>$194,315.12</strong></td>
</tr>
<tr>
<td>Cost Per Square Foot</td>
<td>$86.71</td>
<td>$122.98</td>
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## Cost Breakdown

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LG Chem
RESU10H
Back-up Battery

Sunpower X21-350-BLK-D-AC Solar Panels
Financial Analysis

Cost Breakdown

- Foundation: $32,714.44
- Exterior Walls: $14,037.20
- Interior Walls: $8,557.66
- Interior Finishes: $17,425.56
- Roof: $22,274.67
- Appliances: $4,960.00
- Lighting: $1,484.00
- Windows: $3,794.00
- Doors: $2,446.00
- Plumbing: $5,846.00
- MEP: $18,597.65
- Fees: $5,077.00
- Labor: $33,719.14
## Monthly Payment

### Cost of Home without Add-ons

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
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<tr>
<td>Salary at 80% MFI</td>
<td>$60,759</td>
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<tr>
<td>House Cost without add-ons</td>
<td>$137,006.19</td>
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<tr>
<td>Mortgage Term</td>
<td>30 years</td>
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<tr>
<td>Interest Rate</td>
<td>3.94%</td>
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<tr>
<td>Down Payment</td>
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<tr>
<td>Monthly Mortgage Payment</td>
<td>$629.00</td>
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<tr>
<td>Monthly Energy Cost</td>
<td>$58</td>
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<tr>
<td>Real Estate Taxes</td>
<td>$200.00</td>
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<tr>
<td>Insurance</td>
<td>$50.00</td>
</tr>
<tr>
<td>Private Mortgage Insurance</td>
<td>$114.17</td>
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<tr>
<td>CCHLT Land Lease</td>
<td>$15.00</td>
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<td><strong>Total Monthly Payment</strong></td>
<td><strong>$1,066.17</strong></td>
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<td><strong>Debt to Income Ratio</strong></td>
<td><strong>21.06%</strong></td>
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### Cost of Home with Add-ons

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<th>Item</th>
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<td>$60,759</td>
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<td>House Cost with add-ons</td>
<td>$194,315.13</td>
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<tr>
<td>Mortgage Term</td>
<td>30 years</td>
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<td>Interest Rate</td>
<td>3.94%</td>
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<td>Real Estate Taxes</td>
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<td>Private Mortgage Insurance</td>
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<td>CCHLT Land Lease</td>
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<td><strong>Total Monthly Payment</strong></td>
<td><strong>$1,321.93</strong></td>
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<tr>
<td><strong>Debt to Income Ratio</strong></td>
<td><strong>27.19%</strong></td>
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At Centre County Housing and Land Trust, our mission is to strengthen communities through the development and stewardship of permanently, affordable homes for people of low- to moderate-income.
Create a Sense of Community

Improve the Quality of Life

Work to Create Affordable Local Housing for Members of the Penn State Community

Optimize CCHLT Output