Matthew Tokarik, Patrick Andres, Matt Carlsson, Antonio Cunha, Mark Grimsrud, Denver Jermyn, Moe Otsubo, Matthew Suriano, Filip Tisler, Germán Vaisman. They were supported by faculty - Mark Gorgolewski, Paul Floerke, Russell Richman, Vincent Hui, Vera Straka from The Department of Architectural Science at Ryerson University.
Monthly Average Temperature

Area Plan - Solar Orientation & Prevailing Winds

Monthly Average Precipitation
Design a cost-effective response allowing the average Denver family to purchase, operate and maintain a sustainable home.

Incorporate flexible interior

Meet or exceed the requirements and standards outlined for certification by the Passive House Institute United States (PHIUS+).

Create a net-zero ready home

Employ traditional construction methods coupled with readily available on-the-market materials, finishes, equipment and appliances.

Design the building envelope to be air-tight and thermal bridge free throughout.
Frontage at Lawrence Street
Lawrence Street

Site Plan - Proposed
Row Elevation - South
CONCEPTUAL MASSING

- Multi-Purpose Space
- Outdoor Living
- Living
- Circulation

Interior Program Massing

Central Stair

- South Oriented Operable Glazing
- Interconnected Floor Space
CONCEPTUAL MASSING

- Mechanical Room
- Washrooms
- Service Wall
- Mini-Split Unit
- Kitchen
- Building Services
- Solar Shading
- Photovoltaic Ready
- Solar Shading

Polar Shading & PV Orientation
Building Axonometric
THE FLEXIBLE WORKSPACE

Centralized Island

Peninsula Counter

Work Surface Extension
**ENVELOPE ASSEMBLIES**

**Vertical Wall Assembly (R-44)**
- Fibre Cement "Ecoclad" Panel
- 1" Air Cavity
- Tyvek Weather Barrier
- 2 Layers - 3” Roxul Rigid Insulation (R-25.8)
- 1/2" Zip System Air Barrier / Vapor Retarder
- 2 x 6" Structural Stud Wall (16" O/C)
- 5-1/2" Blown Cellulose Insulation (R-21)
- 1/2" Gypsum Wall Board
- Zero VOC Paint Finish

**Roof Assembly (R-56)**
- Standing Seam Metal Roof
- 1" Air Cavity
- 2 Layers - 15lb. Roofing Felt
- 5/8" Plywood Sheathing
- EPS Rigid Insulation (R-20)
- 1/2" Plywood Sheathing
- 2 x 10" Wood Joists (16" O/C)
- 9-1/2" Blown Cellulose Insulation (R-33.25)
- 1/2" Zip System Air Barrier / Vapor Retarder
- 1" Wood Furring
- 5/8" Gypsum Wall Board Type X
- Zero VOC Paint Finish
HYGROTHERMAL ANALYSIS

Exterior Sheathing Moisture Content

Exterior Sheathing Temperature & Relative Humidity
AIR INFILTRATION
THERMAL BRIDGING

Section Detail - Third Level Terrace Door

- Triple Glazed Alpen 725 Series Door
- Wood Framed Terrace Canopy
- Galv. Metal Threshold Drain Pan
- Ensure Continuous Air Barrier

THERM Analysis

Moisture Barrier
Air Barrier / Vapor Retarder
**DESIGN GOALS**

- Thermal Comfort with Appropriately Sized System
- Minimize Capital Operating Costs
- Ecologically Conscientious Energy Source
- Control Supply and Exhaust
- Minimize Heat Loss
- Maintain Healthy Air

**PROPOSAL**

- **ENVELOPE**
- **IAQ**
- **MEP**
- **RENEWABLES**
- **FINANCIAL**
- **SUMMARY**

---

**Plumbing Plan - Level One**

- Sanitary Connection
- Water Main Connection

---

**Plumbing Plan - Level Two**

- Centralized Plumbing Stack
- Hybrid Hot Water Heater
- Home Run Manifold

---

**Plumbing Plan - Level Three**

- Multi-purpose Space

---
Thermal Comfort with Appropriately Sized System
Minimize Capital Operating Costs
Ecologically Conscience Energy Source
Control Supply and Exhaust
Minimize Heat Loss
Maintain Healthy Air
KITCHEN APPLIANCES

Moffat Compact Refrigerator
389 kWh/yr

Blomberg Concealed Dishwasher
210 kWh/yr

Miele Cooktop
235 kWh/yr

Zephyr Savona Rangehood

Whirlpool Oven (Built-in)
197 kWh/yr

Annual Primary Energy Consumption
36.1 kWh/m² - yr

Passive House Recommended
50.0 kWh/m² - yr
DAYLIGHTING & SHADING STRATEGY

Solar Optimized Shading Canopies

Summer Sun

Winter Sun
### Photovoltaic Integration

- **Total Energy Consumption**: 3,800 kWh/yr
- **Total Energy Generation**: 3,010 kWh/yr
- **Total PV Capacity**: 2.4 kW
- **Gross Cost (Incl. Install & Tax Credit)**: $7,622
- **Pay Back Period**: 10 yrs
- **Net Cash Flow - 25 yrs**: $15,500
CONSTRUCTION COST ESTIMATE

Total Construction Cost: $181,000
Cost / ft²: $145
High Performance Premium: 9.0%
## AFFORDABILITY ANALYSIS - PITIU METHOD

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Principal + Interest</td>
<td>$1,467.94  / $17,615.28 /yr</td>
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<tr>
<td>Taxes (Property)</td>
<td>$2,250 /yr</td>
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<tr>
<td>Insurance</td>
<td>$1,875 /yr</td>
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<tr>
<td>Utilities</td>
<td>$632 /yr</td>
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<tr>
<td>Debt Repayment</td>
<td>$375 /yr</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$24,597 /yr</strong></td>
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</table>
AFFORDABILITY ANALYSIS - ANNUAL HOUSING EXPENSES

Median Family Income (MFI)  
City of Denver  

Typical Housing Expenses (33%)  

Harvest Home  

Critical Components Replaced Twice in 30 years  

$75,000

$25,000 /yr

$24,597 /yr

$403 Net Annual Cash Flow
RATING SYSTEMS

Passive House Institute US

REM/Rate™
The Home Energy Rating Tool

U.S. Green Building Council
LEED
USGBC

HARVEST HOME | RU
### THE PASSIVE HOUSE STANDARD

<table>
<thead>
<tr>
<th></th>
<th>Heat Demand kBTU/ft(^2) - yr</th>
<th>Cooling Demand kBTU/ft(^2) - yr</th>
<th>Primary Energy Demand kBTU/ft(^2) - yr</th>
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<tbody>
<tr>
<td>Passive House Standard</td>
<td>4.75</td>
<td>4.75</td>
<td>38</td>
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<tr>
<td>Harvest Home</td>
<td>2.4</td>
<td>1.74</td>
<td>37.82</td>
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</table>

- **Passive House Standard**
  - Heat Demand: 4.75 kBTU/ft\(^2\) - yr
  - Cooling Demand: 4.75 kBTU/ft\(^2\) - yr
  - Primary Energy Demand: 38 kBTU/ft\(^2\) - yr

- **Harvest Home**
  - Heat Demand: 2.4 kBTU/ft\(^2\) - yr
  - Cooling Demand: 1.74 kBTU/ft\(^2\) - yr
  - Primary Energy Demand: 37.82 kBTU/ft\(^2\) - yr
HERS RATING - REM/Rate Software

Harvest Home - Initial Construction

Harvest Home - On-site Photovoltaic Panels

DOE Competition Target (58)
LEED FOR HOMES

Innovation & Design Process 6
Location & Linkages 7
Sustainable Sites 17
Water Efficiency 14
Energy & Atmosphere 28
Materials & Resources 10
Indoor Environmental Quality 8
Awareness & Education 1

TOTAL 91 Points

THE HARVEST HOME

37 Points Certified
52 Points LEED Silver
67 Points LEED Gold
82 Points LEED Platinum
<table>
<thead>
<tr>
<th></th>
<th>AVERAGE COLORADO RESIDENCE</th>
<th>THE HARVEST HOME</th>
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</thead>
<tbody>
<tr>
<td>HERS Rating</td>
<td>100</td>
<td>40</td>
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<tr>
<td>Passive House U.S.</td>
<td>N/A</td>
<td>Certified</td>
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<tr>
<td>LEED Certification</td>
<td>N/A</td>
<td>Platinum - 91 pts</td>
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<tr>
<td>Annual Energy Consumption</td>
<td>102,000 kBTU/yr</td>
<td>23,600 kBTU/yr</td>
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<tr>
<td>Annual Heating + Cooling Cost</td>
<td>$1,551 /yr</td>
<td>$632 /yr</td>
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<tr>
<td>Gross Area</td>
<td>2,082 sf</td>
<td>1,175 sf</td>
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<tr>
<td>Construction Cost / ft²</td>
<td>$120 - $300 /sf</td>
<td>$146 /sf</td>
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