TEAM PROFILE

PRESENTERS
- Mark Flynn
- Madison Dozzi-Perry

TEAM MEMBERS
- Sadaf Mansour
- Katherine Lishak
- Xavier Mendieta
- Shahrzad Soudian
- Stacy (Xi) Sun
- Mahsa Hatefi
- Dami Lee
- Vadim Novik
- Christopher Marleau
- Umer Khan

FACULTY ADVISORS
- Mark Gorgolewski
- Cheryl Atkinson

INDUSTRY PARTNERS
- Sustainable.TO: Architectural support
- Greening Homes: Constructability support

Sustainable.TO
Greening Homes
Cheryl Atkinson
Eastern Pine

PROJECT CONTEXT

TORONTO, ONTARIO

CLIMATE FACTORS

VALUES

• ASHREA Climate Zone .................6
• Heating Degree Days (base 65°F) ...... 6698
• Cooling Degree Days (base 65°F) ...... 427
SITE CLIMATE

SUMMER SOLSTICE

WINTER WINDS

WINTER SOLSTICE

SUMMER WINDS
PROJECT CONTEXT

2.6 MILLION PEOPLE IN TORONTO PROPER

6.0 MILLION PEOPLE IN GREATER TORONTO AREA

INFLUX OF APPROX. 100,000 IMMIGRANTS PER YEAR
PROJECT CONTEXT

PUBLIC TRANSIT

AMENITIES WITHIN 5 MIN. WALK

COMMUNITY CENTRE
MOVIE THEATRE
RECREATION + PARKS
RESTAURANT + BARS
ART GALLERY + SCHOOL
PHARMACY
GROCERY STORE + MARKET
PUBLIC TRANSIT

5 MIN. WALK
SITE
DOWNTOWN TORONTO
LAKE ONTARIO
LESLIEVILLE
PROJECT CONTEXT
DESIGN GOALS

ECO-CONSCIOUSNESS

LOW ENERGY
CONTEXT + COMMUNITY
LOW CARBON
ECONOMY + RESILIENCE
DYNAMIC DESIGN + ACCESSIBILITY
OCCUPANT COMFORT + HEALTH
BUILDING FEATURES
PROPOSED SITE PLAN

BUILDABLE AREA

APPROX. 39’ x 49’

1,910 sq. ft.

PROPERTY LINE

EASTERN AVENUE

DECK WALL

PLANTER

WALL
LEVEL TWO + THREE FLOOR PLANS
ROOF PLAN
EXTERIOR DESIGN

- Thermally Modified Beetle Kill Ash Wood
- COR-TEN Vegetation Living Walls
- Window Shading Devices With Solar Panels
- Integrated Water Run-off System (Fins)
LANDSCAPE DESIGN

- Aesthetics + Occupant Health
- Building Becomes Part Of Nature
- Permeable Paving
- Native Drought Resistance Planting
- Low Maintenance + Water Usage
- Integrated Rain Water Run-off System
LANDSCAPE DESIGN
INTERIOR DESIGN

- Emulate + Reflect Natural Elements
- Light Penetration + Diffusion
- Integrated/Built-in Furniture
- Open Concept Design
- Healthy + Durable Materials
INTERIOR DESIGN

MATERIAL CRITERIA

- RAW MATERIALS
  Resource Management / Recycled or Reclaimed Products / Organic Materials / No use of VOC Emitting Materials

- DURABILITY
  High Life Expectancy and Warranty

- WASTE
  Waste Management Programs / Recyclability / Biodegradable
• Occupant Health
• Reduce Pollution and Energy Consumption
• Consolidate Service Spaces
• Living Spaces Access to Light
• Diffused light – North facade
• Window - Wall Ratio for Energy Efficiency
• Overheating (Summer) + Solar Heat Gain (Winter)
DAYLIGHTING
ENVELOPE DESIGN

DESIGN STRATEGIES

- Durable Enclosure
- Material and Construction Cost
- Maximize Living Space
- Ease and Speed of Construction
  - Multiple Function Components
- Acoustical and Fire Properties
ENVELOPE DESIGN

System Type | Thermal Resistance
---|---
Roof | Accessible Flat Roof | R-73
Above Grade Walls | Structurally Insulated Panels | R-42
Basement Walls | Insulated Concrete Forms | R-30
Slab | Floating Concrete Floor | R-30
Windows | Passive House Grade | U-0.17

Envelope Air Leakage
ACH50 ≤ 0.6
**BASEMENT SLAB - POLISHED CONCRETE FLOOR (R-30)**

- **Structure:** 4” Polished Concrete
- **Heat:** 6” XPS Insulation
- **Air:** Concrete + Poly. Barrier
- **Moisture:** Crushed Gravel Underlay

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**BASEMENT WALL – INSULATED CONCRETE FORMS (R-30)**

- **Structure:** 8” Concrete
- **Heat:** (2) 3.25” EPS - ICF
- **Air:** EPS + Concrete
- **Moisture:** Gravel Backfill

Dimple Drainage Mat
**ROOF – ACCESSIBLE FLAT ROOF (R-73)**

- **Structure**: 9.5” Engineered Wood Joists
- **Heat**: 9.5” Cellulose + 8” XPS (Ext.)
- **Air**: ZIP Sheathing System + AB/WB Self Adhered Membrane
- **Moisture**: 2 Ply SBS Membrane AB/WB Self Adhered Membrane

**ABOVE GRADE WALL – SIPS (R-42)**

- **Structure**: 6.25” Structurally Insulated Panels
- **Heat**: 5.5” EPS Core + 3” Mineral Wool (Ext.)
- **Air**: SIPs + Tyvek House-Wrap
- **Moisture**: Wooden Cladding (Rain Screen) Tyvek House-Wrap
ENVELOPE DESIGN

ABOVE GRADE WALL WINDOW-Balcony Detail

ABOVE GRADE WALL WINDOW DETAIL
ENVELOPE DESIGN

THERMAL BRIDGING MITIGATION STRATEGIES

- Continuous Exterior Insulation
- Eliminate Framing Factor
- Maintain Thermal Continuity
- Assessed Locations with THERM

Above Grade Wall to Roof
\[ \Psi = -0.0325 \text{ Btu/ hr ft } \text{°F} \]

Floor to Above Grade Wall
\[ \Psi = 0.0980 \text{ Btu/ hr ft } \text{°F} \]

Above Grade Wall to Walkout Terrace
\[ \Psi = -0.0977 \text{ Btu/ hr ft } \text{°F} \]
ENVELOPE DESIGN

ENVELOPE DURABILITY STRATEGIES

- Moisture Resistant (ICF)
- Vapor Open Assemblies
- Exterior Insulation
- Transitions and Joints Air Sealed
- Assessed Enclosure with WUFI Pro

ROOF SHEATHING

EXTERIOR OSB - SIPS

MC % < 20 %

MC %

ROOF SHEATHING

MC % < 20 %
CONSTRUCTION + QUALITY MANAGEMENT

CONSTRUCTION AND QM STRATEGIES

• Construction Quality Management Plan Developed (QM3)
• Construction Schedule Outlined
• East and West Above Grade Wall Construction Procedure Developed
• Green Rating Checklists Included
  • PHUIS + Checklist
  • ENERGYSTAR Inspection Checklist
SPACE CONDITIONING

- Mitsubishi CITY MULTI ASHP System
- Multi-Split Variable Refrigerant Flow
- Individual Tenant Billing Automation
- Backup Resistance Heaters
- No Combustible Fuel
DOMESTIC HOT WATER

- ASHP Integrated
- Demand Initiated Recirculation
- Built-in Backup Heater
2012 IRC Ventilation Requirements
Balanced Continuous Ventilation @ 72 CFM Per Unit

ComfoAir System
- 92% Heat Recovery
- Noise Reducing Silencers
- Flexible Ducts
**ENERGY ANALYSIS**

1. **CODE COMPLIANCE MODEL**
   - WUFI PASSIVE: Ontario Building Code (OBC) 2012 compliance model - A site specific model

2. **OPTIMIZATION MODEL**
   - BEOPT: Obtain quotations for building products;
     A total of 12960 option combinations:
     - 3 Roof
     - 8 Wall
     - 4 Window
     - 9 Window to Wall Ratio
     - 5 Overhangs
     - 3 Wall sheathing

3. **DESIGN MODEL**
   - WUFI PASSIVE: Test different designs to meet PHIUS standard
     - Update the geometry
     - Collaborate with the Building Envelope and MEP

4. **REMRATE MODEL**
   - REMRATE: Generate a HERS rating for each unit
     - Consistent input with WUFI Passive
     - LEED energy score
ENERGY ANALYSIS

Eastern Pine vs. Ontario Multi-Unit Average (kBTU/SF)

<table>
<thead>
<tr>
<th>Energy Consumption Breakdown (kBTU/SF)</th>
<th>Eastern Pine</th>
<th>Ontario multi-unit average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting and Appliances</td>
<td>17%</td>
<td>18%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Cooling</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Heating</td>
<td>63%</td>
<td>50%</td>
</tr>
<tr>
<td>Total Energy Use</td>
<td>100.2 MMBTU/yr (with PV)</td>
<td>152.4 MMBTU/yr (without PV)</td>
</tr>
<tr>
<td>Reduction</td>
<td>70% Reduction from Ontario Average</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL ENERGY USE**
- 100.2 MMBTU/yr (with PV)
- 152.4 MMBTU/yr (without PV)
- 70% Reduction from Ontario Average

Total Generation: 52.2 MMBTU/yr

50 PV panels (890 sf)
Tilt 30°

6 PV panels (total 107 sf)
ENERGY ANALYSIS

Final Design Model vs. Code Compliance Model

- Peak cooling load (BTU/sf/h)
- Peak heating load (BTU/sf/h)
- Annual cooling demand (kBTU/sf/yr)
- Annual heating demand (kBTU/sf/yr)

HERS® Index

Less Energy
0
TARGET HOME (66-71)
EASTERN PINE WITHOUT PV (46-50)
EASTERN PINE WITH PV (28-32)
Standard New Home 100
Existing Homes
More Energy
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

22 Points

Final design model  PHUIS+ 2015 target  Code compliance model
FINANCIAL ANALYSIS

**Eastern Pine Construction Cost**

- **$1,315,613**
- **$211.41 /ft²**

**Code Compliant Construction Cost**

- **$1,158,057**
- **$186.09 /ft²**

**Total Cost**

- **$2,297,390.55**
- **$369.18 /ft²**

**Cost Breakdown**

- **Land Cost**
  - $400,000.00 (18%)
- **Development**
  - $581,777.01 (25%)
- **Construction Costs**
  - $1,315,613.54 (57%)
- **Fees**
  - 19%
- **Structure**
  - 18%
- **Ext. Finish**
  - 5%
- **Int. Finish**
  - 15%
- **Systems Rough-In**
  - 5%
- **DHW+ Water Fixtures**
  - 8%
- **HVAC**
  - 6%
- **Windows + Doors**
  - 6%
- **Lighting**
  - 3%
- **Appliances**
  - 5%
- **Site Maintenance**
  - 5%
- **Landscape**
  - 2%
- **Insulation**
  - 5%
- **Fixtures**
  - 8%
- **Hvac**
  - 6%
- **Int. Finish**
  - 15%
- **Systems Rough-In**
  - 5%
## Component Payback

<table>
<thead>
<tr>
<th>Component</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC/DHW</td>
<td>10</td>
</tr>
<tr>
<td>Insulation</td>
<td>17</td>
</tr>
<tr>
<td>Windows</td>
<td>21</td>
</tr>
<tr>
<td>Final Design</td>
<td>11</td>
</tr>
</tbody>
</table>

## Monthly Affordability Analysis

<table>
<thead>
<tr>
<th>Unit</th>
<th>Unit Cost</th>
<th>Expect. Income</th>
<th>Afford. Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>B01</td>
<td>$298,661</td>
<td>$93,693</td>
<td>27%</td>
</tr>
<tr>
<td>B02</td>
<td>$298,661</td>
<td>$93,693</td>
<td>27%</td>
</tr>
<tr>
<td>101</td>
<td>$264,200</td>
<td>$58,000</td>
<td>37%</td>
</tr>
<tr>
<td>102</td>
<td>$206,765</td>
<td>$58,000</td>
<td>31%</td>
</tr>
<tr>
<td>201</td>
<td>$402,043</td>
<td>$93,693</td>
<td>34%</td>
</tr>
<tr>
<td>202</td>
<td>$402,043</td>
<td>$93,693</td>
<td>34%</td>
</tr>
<tr>
<td>203</td>
<td>$425,017</td>
<td>$93,693</td>
<td>35%</td>
</tr>
</tbody>
</table>

### Monthly Operation

#### Whole Building

<table>
<thead>
<tr>
<th>Code Compliant</th>
<th>Utility</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2035.18</td>
<td>$182.52</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eastern Pine</th>
<th>Utility</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$735.79</td>
<td>$376.05</td>
<td></td>
</tr>
</tbody>
</table>
FINANCIAL ANALYSIS

30 YEAR LIFE-CYCLE COSTS
(with PV Costs/Payback)

$0 $2 $4 $6

Year 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Eastern Pine
Code Compliant
CONCLUSION

“Through innovative design, the form, fabric, and function of Eastern Pine develops a connection between inhabitants, their home, community, and the natural world.” – True North Design
• HVAC Specifications: Mini-Split indoor units for heating and cooling and ASHP DHW system with integrated VRF system. Mitsubishi -PURY-P72TKMU Outdoor unit.

• Electric resistance backup heaters.

• Ventilation: HRV

• Zehnder ComfoAir200 with 92% Heat Recovery

<table>
<thead>
<tr>
<th></th>
<th>OBC 2012</th>
<th>ENERGystar v3.1</th>
<th>Final Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior wall (exposed to air)</td>
<td>R24 (Rsi-4.33)</td>
<td>R20 (Rsi-3.55)</td>
<td>R42 (Rsi-7.4)</td>
</tr>
<tr>
<td>Exterior wall (exposed to earth)</td>
<td>R20 (Rsi-3.55)</td>
<td>R20 (Rsi-3.55)</td>
<td>R29 (Rsi-5.1)</td>
</tr>
<tr>
<td>Roof</td>
<td>R31 (Rsi-5.46)</td>
<td>R49 (Rsi-8.63)</td>
<td>R73 (Rsi-12.9)</td>
</tr>
<tr>
<td>Slab</td>
<td>R10 (Rsi-1.76)</td>
<td>R15 (Rsi-2.64)</td>
<td>R32 (Rsi-5.7)</td>
</tr>
<tr>
<td>Window</td>
<td>U-0.32 (U1.82)</td>
<td>U-0.27 (U1.53) any SHGC</td>
<td>U-0.17 (U0.97), SHGC 0.57</td>
</tr>
<tr>
<td>Skylight</td>
<td>U-0.49 (U2.78)</td>
<td>-</td>
<td>U-0.17 (U0.97), SHGC 0.37</td>
</tr>
<tr>
<td>Door</td>
<td>U-0.32 (U1.82)</td>
<td>Opaque: 0.17, &lt;1/2 lite: 0.25, &gt;1/2 lite: 0.3</td>
<td>U-0.28 (U1.6), SHGC 0.56</td>
</tr>
</tbody>
</table>

Table 9.0.1. OBC 2012 and ENERGystar v3.1 requirement [2] [3]