Project Overview
Team Introduction
Project Introduction
Design Constraints

1 ½ Garfield Ave

Don Valley Brick Works Beltline

David A. Balfour Trail
Considering a growing population...

Design is for a 12% growth over the next 10 years

**440 occupants:** 400 students ages 4 to 13, 40 staff

**Target market includes:**

- Occupants and community
- Local school board (TCDSB)
- Stakeholders in construction industry
Local Climate

Cold Climate in Toronto
ASHRAE Zone 5A

Standards

Ontario Building Code – 2019
ASHRAE 90.1 and 62.1 – 2019
Toronto Green Standard (Tier 3)
Minimizing embodied + operational carbon

Minimizing energy consumption

Maximizing usable space after retrofit

Responsible water management

Optimal occupant comfort + wellbeing

Enhanced occupant experience

Community integration
Architecture

Existing Building
Architecture

Proposed Redesign
Architecture

- Engineering
  - Comfort and Environmental Quality
  - Energy Performance
  - Embodied Environmental Impact
  - Durability and Resilience
  - Market Analysis
  - Occupant Experience
Engineering

Building Structure
Original structure

- Triple-wythe mass masonry
- Wood-framed roofs
- Wood-framed or concrete floors

New extension structure

- Glulam columns
- Glulam floor and roof joists
- Dowel-laminated timber (DLT) panels

New atrium structure

- Glulam trusses
- Glulam-framed curtain wall
- Dowel-laminated timber (DLT) roof panels
Engineering

Building Envelope
Engineering

Water Systems
Responsible water management

1. Conserving water
Water demand reduced by 52% with new fixtures.

2. Recycling water
All non-potable demand met by water recycling:

3. Restoring natural cycles
Bioswales reduce stormwater runoff while returning water to natural aquifers.
Engineering

Mechanical Systems
Hybrid ventilation strategy

Dedicated outdoor air system (DOAS)

Natural ventilation
Heating + cooling

Fan-coil units in select zones

Cooling loads driven down by:

- DOAS cooling coil
- Window shadings
- Roof PV shading
- Operable windows
Geothermal generation

- Annual heating demand: 240 MBTU
- Annual cooling demand: 40 MBTU
- System size: 19 tons
- Land requirement: 4640 sqft
Solar thermal energy

Tilt angle: 30°

- Annual System Generation: 400 MBTU
- Hot Water Requirement: 127 MBTU
- Heat to Make Up (Summer): 200 MBTU
Solar energy generation

- Solar thermal collector panels
- Roof PV
- Shaded parking PV
- Building-integrated PV cladding (BIPV)
Solar PV strategy

Roof + parking PV fixed tilt angle: 45°

Excess electricity generation: 269200 kWh annually
Architecture
Engineering
Comfort and Environmental Quality
Energy Performance
Embodied Environmental Impact
Durability and Resilience
Market Analysis
Occupant Experience
Considerations in design

- Removing old and toxic materials
- Providing thermal and air quality comfort
- Providing acoustic comfort
- Providing access to daylight
Plug + lighting load reduction strategies

- Efficient fixtures
- Occupant sensing controls
- Scheduling
- Daylight harvesting
- Sustainable use learning
Energy use intensity

Site EUI 23 kBTU/sqft/yr

TGS, Tier 3 32 kBTU/sqft/yr

Competition requirement 57 kBTU/sqft/yr

- Heating: 27.6%
- Cooling: 4.7%
- Interior Lighting: 5.0%
- Interior Equipment: 40.1%
- Fans: 17.2%
- Pumps: 5.1%
Architecture
Engineering
Comfort and Environmental Quality
Energy Performance
Embodied Environmental Impact
Durability and Resilience
Market Analysis
Occupant Experience
Minimizing carbon emissions

1. **Operational carbon minimized** by using renewable energy systems.
2. **Embodied carbon minimized** by using mass timber and other low-carbon materials.

Life Cycle Assessment using One Click LCA

Materials recovered: 33%
Materials returned: 77%
Building circularity score: **55%**
Architecture
Engineering
Comfort and Environmental Quality
Energy Performance
Embodied Environmental Impact
Durability and Resilience
Market Analysis
Occupant Experience
Durable and resilient design against...

**Future weather patterns**
- Above-code insulation
- Vapour open masonry walls against freeze-thaw

**Fire emergencies**
- Fire-rated materials
- Emergency exists
- On site muster points

**Resource shortage**
- Emergency water storage in basement

On-site muster points
Project cost: $4.2 million USD
$102 USD/sqft
New build school:
$135 - $180 USD/sqft

Annual Utility Bill Savings: 95%
Annual Savings: $43,500 USD
Grid Cashback: $19,000 USD

Over 25 years, savings + cashback totals $1.6 million USD.
Likelihood of adoption by...

**Toronto Catholic District School Board**

- TCDSB Energy Conservation Plan
- Toronto targets net-zero emissions by 2050

**Construction industry**

- Considered constructability, local and available materials, costs
- Phased 14-month timeline that keeps school in session during the year

**Intended occupants**

Design around the goal to provide comfortable and enjoyable spaces to learn
Architecture
Engineering
Comfort and Environmental Quality
Energy Performance
Embodied Environmental Impact
Durability and Resilience
Market Analysis
Occupant Experience
User experience:

- Safe + inclusive design
- Biophilic design
- Preservation of history and traditions

Learning experience:

- Learning stations
- Vegetable gardens
- Community partnership

Outdoor study space

Evergreen Brick Works
Thank you

U.S. Department of Energy
Solar Decathlon

Ryerson University
Faculty of Architectural Science
Existing School Site Layout
Redesigned Site Layout
Ground Floor Plan

Existing

Retrofit/ Redesign
Sections

- Vertical Shadings
- Acoustic paneling grid
- Skylights
- Glulam Columns
- Horizontal Shadings
- Atrium
Outdoor Study Space
Retrofit Considerations

- Poor insulation
- Poor water shedding
- Cracked mortar
- Uninsulated basement slab causes moisture problems
- Double-glazed aluminum windows also cause child safety hazards
- Preserving brick façade
Retrofit Envelope

Walls Above Grade: R-38
Walls Below Grade: R-22
Ground Slab: R-17
Roof: R-42
Glazing: R-4.5

Ψ = -0.14
Ψ = -0.01
Ψ = 0.006

RH in Stud Wall
< 80% in summer
< 50% in winter
New Extension Envelope

Walls Above Grade  R-41
Ground Slab        R-37
Roof               R-52
Glazing            R-5.0
Foundation Walls   R-22
Glazing

- Argon-filled triple-glazed low-e units
- Double-hung with locked bottom sashes for child safety
- Operable skylights in atrium
- U-factors between 0.04 to 0.06 BTU/hsqft
- SHGC of 0.46 for passive solar heating
- SHGC of 0.23 for south façade and atrium
Envelope Sections: Retrofit Wall to Roof

Assembly Control Layers
- **Primary Bulk Water**
- **Air and Secondary Bulk Water**
- **Class II Vapour Semi-Impermeable**
- **Class III Vapour Semi-Permeable**

THERM Thermal Bridging Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>U-Value (BTU/hft²F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>0.026</td>
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<tr>
<td>Horizontal</td>
<td>0.026</td>
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Ψ-Factor = -0.14 BTU/hft²F
Lowest Interior Surface Temperature = 32.2°F (17.9°C)
Envelope Sections: Retrofit Wall to Wood Floor

Assembly Control Layers
- Primary Bulk Water
- Air and Secondary Bulk Water
- Class II Vapour Semi-Impermeable
- Class III Vapour Semi-Permeable

THERM Thermal Bridging Analysis

Component | U-Value (BTU/hft2°F)
--- | ---
2-D | 0.013
Vertical | 0.026
Horizontal | 0.117

Ψ-Factor = -0.01 BTU/hft°F
Lowest Interior Surface Temperature = 34.0°F (18.9°C)
Envelope Sections: Extension Wall to Floor

Assembly Control Layers
- Primary Bulk Water
- Air and Secondary Bulk Water
- Class II Vapour Semi-Impermeable
- Class III Vapour Semi-Permeable

THERM Thermal Bridging Analysis

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<tr>
<td>2-D</td>
<td>0.010</td>
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<tr>
<td>Vertical</td>
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<tr>
<td>Horizontal</td>
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Ψ-Factor = 0.00 BTU/hft²F
Lowest Interior Surface Temperature = 34.4°F (19.1°C)
New fixtures achieve a **52% reduction** in potable and non-potable water use, meeting Toronto Green Standards Tier 3.
Hybrid ventilation strategy

Required total outdoor air rate 13800 cfm or 2.13 ACH
Heating + cooling

Cooling loads driven down by:
- DOAS cooling coil
- Window shadings
- Roof PV shading
- Operable windows

Peak heating load 220 kBTU/hr
Peak cooling load 110 kBTU/hr
Daylighting

Atrium Annual Average: 3540 Lux

Library Annual Average: 500 Lux
Multipurpose Annual Average: 250 Lux

Second-Floor East and West Classrooms
Annual Average: 400 to 700 Lux
Resilience Against Future Weather

Toronto’s **Future Weather**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Current (2000-09)</th>
<th>Future (2040-50)</th>
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<tbody>
<tr>
<td>Daily Temperature Maximum</td>
<td>37°</td>
<td>44°</td>
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<tr>
<td>Hot Days above 30°</td>
<td>20</td>
<td>66</td>
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<tr>
<td>Extended Heat Waves per year</td>
<td>0.6</td>
<td>2.5</td>
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<tr>
<td>Daily Rainfall Maximum</td>
<td>66</td>
<td>166</td>
</tr>
</tbody>
</table>

**Changing Weather Patterns**

- Increasing temperatures
- Fewer snow events
- More summer storm precipitations
- More frequent heat waves

**Effects**

- Overheating risk
- High wind driven rain
- Snow loads
- Freeze-thaw deterioration
Water Resiliency

3100 gallons of water storage required for all occupants for one week