welcome.
Buildings of Excellence: Large-Scale Passive House

February 12, 2020
Building Energy Exchange
Why a Building Decarbonization Competition?

85 x 50

New York’s 85x50 emissions reduction target will require a carbon neutral building stock, statewide.
New York State Clean Energy Goals
Climate Leadership and Community Protection Act (CLCPA)

**CLEAN ENERGY ECONOMY**
over 151,000 clean energy jobs

**RENEWABLE ENERGY**
6,000 MW of distributed solar

**RENEWABLE ENERGY/ CLEAN ENERGY STANDARD**
70% electricity from renewable energy

**RENEWABLE ENERGY**
9,000 MW of offshore wind

**CARBON-FREE**
100% clean electricity

**GHG REDUCTION**
85% reduction in greenhouse gas emissions from 1990 levels

**now**

**by 2025**

**RESILIENT and DISTRIBUTED GRID**
1,500 MW of energy storage

**ENERGY EFFICIENCY**
185 TBtu end-use savings in buildings and industrial facilities

**by 2030**

**GHG REDUCTION**
40% reduction in greenhouse gas emissions from 1990 levels

**by 2035**

**by 2040**

**by 2050**

3,000 MW of energy storage
30,000 employed in storage sector
What is “CMA”?

> In April 2019, NYC passed a package of legislation to accelerate buildings’ progress toward the City’s 80x50 target

What’s Included

> **Local Law 92 and 94**: requires roofs of certain buildings be covered in green roofs or solar PV systems

> **Local Law 95**: revises the City’s energy efficiency grade

> **Local Law 96**: establishes a sustainable energy loan program (i.e. PACE)

> **Local Law 97**: requires certain greenhouse gas emissions reductions by 2050 in buildings greater than 25,000 sq. ft.
Buildings of Excellence

$40 million
Over 3 rounds

Awards low carbon multifamily buildings that are beautiful, replicable, resilient, affordable, comfortable, and connected to the surrounding community.
Buildings of Excellence: Round 2

- Design competition targeting affordable housing
- $1M max project award
- Net Zero Energy / Low-Carbon / Passive House
- Layers on top of Standard Offer NYSERDA Incentives
- Applicants: Developers, Building Owners & Designers

**Submissions due April 22, 2020**
PASSIVE HOUSE ON A LARGE SCALE
ONWARD AND UPWARD!

Lois Arena PE
Director of Passive House Services | Steven Winter Associates

Deborah Moelis AIA CPHD
Principal | Handel Architects
This presentation is protected by U.S. and international copyright laws. Reproduction, distribution, display and use of the presentation without written permission of the speaker is prohibited.
The House at Cornell Tech, NYC

Sendero Verde, NYC
Winner - 2019
NYSERDA Buildings of Excellence

Winthrop Center, Boston

University of Toronto at Scarborough
High Rise Passive House Applied

- **Toronto**
  - Climate Zone 6
  - Residences at the University of Toronto at Scarborough

- **Boston**
  - Climate Zone 5
  - Winthrop Center

- **New York City**
  - Climate Zone 4
  - The House at Cornell Tech
  - Sendero Verde

02.12.2020 | BEEx Passive House on a Large Scale | © Handel Architects
WHAT IS PASSIVE HOUSE?

- The most rigorous of the energy focused building standards/certifications
- An overall holistic approach to the design of a building that is guided by both curtailing energy usage and increasing user comfort
- A strict quality control program during construction that assures the building is assembled as designed
## Passive House Institute (PHI) Performance Criteria for Certification

**PEUI (source) kBTU/ft²/yr**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Source Energy Allowed</td>
<td>38.1 kBtu/ft²/yr</td>
</tr>
<tr>
<td>Heating Energy Allowed</td>
<td>Max 4.75 kBtu/ft²/yr</td>
</tr>
<tr>
<td>Cooling Energy Allowed (NY)</td>
<td>Max 5.39 kBtu/ft²/yr (region specific)</td>
</tr>
<tr>
<td>Air Changes per Hour (ACH) through the facade @ 50 pascals of pressure</td>
<td>0.6 ACH 5-10 times tighter than typical</td>
</tr>
<tr>
<td>Exhaust and Supply Ventilation</td>
<td>Balanced, with energy recovery</td>
</tr>
</tbody>
</table>

*Can be adjusted for density and use.

---

02.12.2020 | BEEx Passive House on a Large Scale | © Handel Architects
WHY PASSIVE HOUSE?

Reduce carbon emissions, lower green house gasses, combat global warming.

Reduce energy needed to operate a building by 60-80%

Provide superior thermal comfort, indoor air quality and acoustics.

Improve health of inhabitants

Increase durability of building materials

Ease compliance with government mandates (new laws, codes, standards)
Localization Law 97
Passive House Standard for Energy Efficiency

130 kbtu/ft² IECC 2018 Average

Greenhouse Gas Emissions

With Current NY Energy Sources

With 70% Renewable Electricity by 2030

With Current NY Energy Sources

With 70% Renewable Electricity by 2030

0.0095

0.0051

0.0028

0.0014

Local Law 97 2024-2029 Limit (Group R)

Local Law 97 2030-2034 Limit (Group R)

Local Law 97 2035 Limit

38* kbtu/ft²

*Can be adjusted for density and use.

New York State Energy Research and Development Authority-Energy 2018
New York Local Law 97 of 2019
New York Climate Leadership and Community Protection Act

02.12.2020 | BEEx Passive House on a Large Scale | © Handel Architects
HOW TO ACHIEVE PASSIVE HOUSE?

Enclosure: Roofs, Walls, and Foundation
Provide a robust, high performance enclosure to achieve:

• Air tightness

• Windows with exceptionally low U-Values.

• Continuous insulation and thermal bridge free detailing leading to high R-Values

MEP Systems
• Provide a high performance, low energy heating and cooling system

• Ventilate all habitable spaces with constant fresh air with heat recovery

• Balance exhaust and supply ventilation within 10% of one another

• Specify energy efficient equipment, lighting and appliances
The House: Project Summary

PROJECT SUMMARY

Area: 270,000 GSF / 25,083 GSM
26 Stories
270' / 25m to Roof
352 Units, 500 Beds
10,600 GSF/Floor / 984 GSM/Floor

USERS

Graduate Students
PhD Candidates
Post Doctoral
Faculty

02.12.2020  |  BEEx Passive House on a Large Scale |  © Handel Architects
• Experience of entire team applying PH to a large scale

• Supply stream
  - Efficient ERVs/HRVs
  - PH compliant aluminum windows & storefronts
  - Thermal break materials
  - PH level exterior doors
  - Small enough heating/cooling equipment

• Heating & cooling controls – desire to provide each room w/ individual control

• Code conflicts
  - Ventilation flow rates,
  - Refrigerant line lengths in dwelling units,
  - Ventilation of shafts – elevator, stairs
  - Fire rated windows

• Height challenges for VRF line lengths

• Air barrier validation during construction

• Very dense building – Source EUI target needs adjusting
Typical Floor
16 Units per Floor
Low Surface to Volume Ratio

16 Units per Floor

Freestanding house

Typical studio apartment at the house

Only one surface of this apartment is exposed.
The House at Cornell Tech

Enclosure

<table>
<thead>
<tr>
<th>Component</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>R-50</td>
</tr>
<tr>
<td>Walls</td>
<td>R-19 Average</td>
</tr>
<tr>
<td>Windows</td>
<td>U-0.18</td>
</tr>
<tr>
<td>Slab Edge</td>
<td>R-10+</td>
</tr>
<tr>
<td>Cantilevered Floors</td>
<td>R-40</td>
</tr>
</tbody>
</table>

- Airtightness
- Thermal Continuity
- Eliminate Thermal Bridging

WEST  SOUTH
Panelized Wall System

High performance triple glazing

Prefabricated metal panel rain-screen facade supported off of structural steel studs, anchored to concrete slab

Cast in-place concrete structural system
Panelized Installation

The House at Cornell Tech

02.12.2020  |  BEEx Passive House on a Large Scale |  © Handel Architects
Exterior Wall Composition

- Continuous air/water barrier/permeable vapor barrier
- Thermally broken aluminum frame
- Panelized Rainscreen Metal Cladding Systems
- Continuous permeable/impermeable smart vapor retarder
- 2”-5” Mineral Wool
- 6” Mineral Wool

PH AIRTIGHT LAYER
PH CERTIFIED AREA
Theory vs. Practice

Before Panel Supports Sealed

After Panel Supports Sealed
Thermal Bridge Free Design

- All details must be reviewed and modeled by PH consultant
- Too much thermal bridging can result in condensation and comfort issues
- This can completely undermine the exterior insulation of the building
Eliminate Thermal Bridging
<table>
<thead>
<tr>
<th>Schedule 4: Material Schedule</th>
<th>ISO-1</th>
<th>Schock - ISO-1</th>
<th>ISO-3</th>
<th>General Plastics</th>
<th>T-1</th>
<th>Vapor Permeable/Impermeable Tapes</th>
<th>V-1</th>
<th>Vapor Retarder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative Materials</td>
<td>Thermal isolators - Steel to Steel. Concrete to concrete available. Parapet isolators too.</td>
<td>Load bearing thermal isolator. Pre-cut and pre-drilled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The House at Cornell Tech</td>
<td>Windows &amp; Door openings</td>
<td>1. Inside face of exterior wall in contact with vapor barrier 2. Inside face of exterior wall in contact with vapor barrier 3. Inside face of exterior wall in contact with vapor barrier 4. Interior walls adjacent to hammerhead shear walls</td>
<td>Inside face of exterior wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

© Handel Architects
## Innovative Materials

<table>
<thead>
<tr>
<th>Schedule 4: Material Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B-1</strong></td>
</tr>
<tr>
<td><strong>CMU-2</strong></td>
</tr>
<tr>
<td><strong>G-1</strong></td>
</tr>
<tr>
<td><strong>GS-1</strong></td>
</tr>
</tbody>
</table>

- **Thermal Clip assembly with thermal studs/isolators.** Improves performance by 60 - 90%.
- **Insulated CMU Block**
  - 12" Block - R22
  - 10" Block - R20
  - 8" Block - R6
- **Vapor Permeable Gasket**
  - Incoming conduit & pipes
  - Install in sequence!
- **Warm Edge IGU Glass Spacers**
  - Can lower IGU U values by approx .04 as compared to standard aluminum spacer.
b. Field Test requirements for Passive House Certification by Owner’s consultant:

1). Air leakage testing will be conducted using blower door equipment from Minneapolis Blower Door at a test pressure of 50 Pascals (1.044 psf). The building will be both pressurized and depressurized at this test pressure. Total air leakage of the structure cannot exceed an average value from both tests of 0.12 cfm/ft² of facade area - fixed or operable - resulting in an air change rate of no more than 0.6 air changes per hour at 50 Pascals (ACH50). This value is based on 100% Design Development plan documents.

2). Thermal Performance:

1). Thermal component of joint movement shall be based on minimum material temperature increase of 200 degrees F and decrease of 180 degrees F relative to nominal condition. Assume entire cross section has uniform temperature. Components including adhesives and sealant shall be capable of withstanding, without failure, design temperatures with simultaneous specified loads. For thermal design other than joint movement, design winter surface temperature is -20 degrees F. Design summer surface temperature shall be at least 180 degrees F. All components including adhesives and sealants shall be capable of withstanding (and remain durable) without failure design temperatures with simultaneous specified loads.

2) Opaque Wall Areas: Overall R-30/R-18 as per locations indicated on Architectural drawings. Modeling using an accepted software tool showing compliance with these thermal performance levels is required.

3) There shall be no interior condensation on visible surfaces or those that would wet insulation when the wall is subjected to 0°F exterior, 68°F interior (+/-2°F), 30% interior relative humidity, 15 mph exterior wind.
Heating & Cooling

- Height challenge
- Individual control
- Zoning
- No heat recovery
- Switch over seasons
VRF: Heating & Cooling

Evaporator in all bedrooms & living rooms

North Side Refrigerant

South Side Refrigerant

Condenser
A Market Niche to be Filled (one of many...)

1 Ton Evaporator

1/4 Ton Evaporator
Lessons Learned

The House

Ceco Door Trio-E
Insulated Steel
Stiffened Door

Ceco Door Mercury
Thermal Break Frame

R Value Frame: 2.4
R Value Door: 2.56
R Value Door/Frame: 28

Sendero Verde

Ceco Door Mercury
Thermal Break Frame

R Value Frame: 2.4
R Value Door: 2.56

© Handel Architects
Balanced Ventilation with Heat Recovery

- All bedrooms and living rooms require supply air, balanced within 10% of exhaust
- Conflict in codes regarding amount of Ventilation: LEED / CODE / PH
- Delivery methodology:
Change to the Building Code
Mechanical Exhaust Ststym

- Permission by DOB to combine toilet and kitchen exhaust from multiple apartments, which is not typically allowed by NYC code.
- Collect vertical risers into one large horizontal duct
- Necessary for proper balancing and operation of ERV

Section of the Code:

501.5.1. Single or combined mechanical exhaust systems from bath, toilet, urinal, locker, service sink closets and similar rooms shall be independent of all other exhaust systems.
Airtightness
Quality Control During Construction

Control of Scope of work

- Bid/Buy documents need to be sure to cover passive house requirements
- Not enough to say “follow spec”
- Work with contractor and trades to make sure full scope is included in buy to meet passive house requirements
- Contracts / Change orders

Trades Affected by PH Requirements

- **Exterior Sealing**
  - Exterior Panel Fabricator
  - Window Supplier
  - Carpenter
  - Mason
  - Caulker

- **Interior Sealing**
  - Mechanical
  - Electrical
  - Plumbing

- **Heating / Ventilation / Airside Contractor**

- **MEP Equipment and Lighting Supplier**
# Site Inspection Checklist

## Unique Conditions

<table>
<thead>
<tr>
<th>Item #</th>
<th>Inspection</th>
<th>Detail Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U3</td>
<td>Below Grade Wall – Insulation</td>
<td>100% CD – 08/25/17</td>
</tr>
</tbody>
</table>

**Description:**
See Wall Type 9, 6” (approved by ZHA) or 8” of Owens Foamular 400; insulation continuous at benched area; must be inspected before Preprufe is installed.

## Images

![Cellar Plan – A-100.01](image1)

- **9**: EXTERIOR WALL (BELOW GRADE) 4 HR FIRE RATED  TABLE 720.1.(2) #4-1.1
- **BENCHED AREA: A-315.00**
- **6” of XPS @ S, N, E**
- **5” of XPS @ West**

## Checklist developed during construction documents

- Instructions provided to inspector for items to inspect
- Details provided to assist on-site inspection
- Photos annotated to help guide visual inspection

---

Rigid insulation install, all seams are tight – can’t fit a beer coaster.

---

02.12.2020 | BEEx Passive House on a Large Scale | © Handel Architects
Quality Control Pays Off
Final Blower Door Test

• Final Blower Door Test results for The House were .15 Air Change/Hour (ACH).
• Passive House requirements allow a maximum .6 ACH.

4 TIMES TIGHTER THAN REQUIRED!
SENDERO VERDE

TEAM
Jonathan Rose Companies
L+M Development Partners
Acacia Network
Handel Architects
Steven Winter Associates
Cosentini
DeSimone Consulting Engineers
Vidaris
Sendero Verde: Project Summary

PROJECT SUMMARY
Overall: 812,250 GSF / 75,460 GSM
Residential: 627,646 GSF / 58,310 GSM
Community Facilities: 150,110 GSF / 13,394 GSM
Commercial: 34,494 GSF / 3,204 GSM
698 Affordable Units

USERS
High School Students
Residents
Seniors
Health Clinic Users
PROJECT CHALLENGES

- Supply chain – small enough equipment
- Steel stud back up wall – thermal bridge mitigation at window heads and sills
- Sequencing of façade vs. window install & air barrier continuity
- Duct run conflicts between ERV’s & VRF in unit
- Height impacts on ERV fan power
- Very dense building – Source EUI target needs adjusting
## Enclosure

<table>
<thead>
<tr>
<th>Component</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>R-40</td>
</tr>
<tr>
<td>Walls</td>
<td>R-20 Effective</td>
</tr>
<tr>
<td>Windows</td>
<td>Operable - U: 0.149</td>
</tr>
<tr>
<td></td>
<td>Fixed U: 0.134</td>
</tr>
<tr>
<td>Cantilevered Floors</td>
<td>R11</td>
</tr>
</tbody>
</table>

**NORTH ELEVATION**

**WEST ELEVATION**
**Exterior Wall Composition**

- **PH AIRTIGHT LAYER**
- **PH CERTIFIED AREA**
- **NON-CERTIFIED AREA**

**Sendero Verde**

- 3” Mineral Wool
- 6” Mineral Wool
- Hand set Face Brick, Jumbo Norman
- Over Site-Built Metal Stud Back-Up
- 4.5” to 6.5” EIFS Cladding
- CMU Block & Plank Structural System

**Diagram Details**

- Continuous air/water barrier/permeable vapor barrier
- Liquid applied impermeable vapor barrier
- Liquid applied vapor permeable air barrier and waterproofing

**Dimensions**

- Sendero A: 1'-7"
- Sendero B: 1'-6" to 1'-8"
Ventilation
Balanced Ventilation with Heat Recovery Central Systems

SENDERO VERDE BLDG A: CENTRAL RISER
Heating & Cooling

1 Floor Mounted Air Handling Unit in Each 1-2- & 3-bedroom Apartment.

1 Wall Mounted Air Handling Unit. Unit Serves Each Studio.

Condenser
VRF Diagram
Rooftop Design

SOUTH SIDE DISTRIBUTION STRATEGY

- CONDENSER FARM AT BULKHEAD ROOF LEVEL
- REFRIGERANT LINES COLLECTED BELOW ROOFTOP AMENITY SLAB
- REFRIGERANT RISER SERVING EACH LINE OF UNITS
- TWO RISERS SHARE A PLUMBING CHASE WHEN POSSIBLE

NORTH SIDE DISTRIBUTION STRATEGY

- CONDENSER LOCATED AT SETBACK ABOVE RISER
- SINGLE HORIZONTAL TRANSFER BELOW ROOFTOP AMENITY SLAB
- REFRIGERANT RISER SERVING EACH LINE OF UNITS
- TWO RISERS SHARE A PLUMBING CHASE WHEN POSSIBLE
STUDENT RESIDENCE AT UNIVERSITY OF TORONTO SCARBOROUGH

TEAM
University of Toronto Scarborough
Fengate Asset Management
Handel Architects
Steven Winter Associates
Integral Group
RWDI Consultant Company
Finnegan Marshall
Student Residences: Project Summary

PROJECT SUMMARY

Area: 270,000 GSF / 25,083 GSM
9 Stories
112' / 210m to Roof
369 Suites, 752 Beds
28,500 GSF/Floor / 2,369 GSM/Floor

USERS

Undergraduate Students
Student Residences: Project Challenges

• Supply chain – PH compliant windows for climate zone 6
• Colder climate leading to stricter window criteria
• Dining hall – very high energy intensity for commercial kitchens
• Conflict between U of T energy efficiency requirements, building type and Passive House criteria
• Incredibly dense building – Source EUI target needs adjusting
Passive House Air Source VRF Vs 4 Pipe Fan Coil

- Evaluate systems to study if performance meets/exceeds ASHRAE 2013 (as amended by SB.10) by 40%
- Keep lighting, misc. electric/gas, equipment, DHW, and PH envelope steady.

40% better than ASHRAE is not achievable for this building type (high rise multi-family)

ASHRAE does not allow the design to take credit for:
- Air Tightness
- Lower plug loads
- Ventilation efficiency
Ground Floor Plan

- Dining
- Office
- Campus Safety
- Residence Life
- Residential Facilities
- Event/Kitchen/Servery
- BOH
- Circulation

University of Toronto

02.12.2020 | BEEx Passive House on a Large Scale | © Handel Architects
Typical Floor Plan
University of Toronto at Scarborough

96 people per floor
28,500 GSF/floor / 2,647 SM/floor
## Enclosure

<table>
<thead>
<tr>
<th>Component</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>R-40</td>
</tr>
<tr>
<td>Walls</td>
<td>R-30 Avg.</td>
</tr>
<tr>
<td>Windows</td>
<td>U: 0.13</td>
</tr>
</tbody>
</table>
Exterior Wall Composition

- PH AIRTIGHT LAYER
- PH CERTIFIED AREA

Continuous Air/Water Barrier/
Permeable Vapor Barrier

Permeable Vapor Retarder

6" Mineral Wool

Standing Seam Metal Rainscreen
Over Site-Built Metal Stud Back-Up
Ventilation

Central:
RISER PER SUITE
Exhaust Air
Fresh Air
ERV

University of Toronto
02.12.2020  |  BEEx Passive House on a Large Scale |  © Handel Architects
Heating & Cooling

- System is zoned vertically, based on orientation
- Limited individual control
## Cost Comparison - VRF vs. 2/4 Pipe Fan Coil

<table>
<thead>
<tr>
<th></th>
<th>UTSC</th>
<th>Comparable 1</th>
<th>Comparable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suite Count</strong></td>
<td>342</td>
<td>204</td>
<td>172</td>
</tr>
<tr>
<td><strong>GFA - Fit out space (m²)</strong></td>
<td>26,690</td>
<td>17,422</td>
<td>17,076</td>
</tr>
<tr>
<td><strong>GFA / Suite (m²)</strong></td>
<td>78.0</td>
<td>85.4</td>
<td>99.3</td>
</tr>
<tr>
<td><strong>Common area %</strong></td>
<td>42%</td>
<td>40%</td>
<td>43%</td>
</tr>
<tr>
<td><strong>Mechanical System</strong></td>
<td>Air-Cooled VRF</td>
<td>4-Pipe FCU</td>
<td>2-Pipe FCU</td>
</tr>
<tr>
<td><strong>Plumbing $/m² (ex Site)</strong></td>
<td>$359.95</td>
<td>$398.95</td>
<td>$314.00</td>
</tr>
<tr>
<td><strong>Plumbing $/Suite</strong></td>
<td>$28,090.83</td>
<td>$34,071.11</td>
<td>$31,173.63</td>
</tr>
</tbody>
</table>
Doing radically **more** with radically **less**

- 2088 GWP
- 675 GWP
- 1 GWP

**REDUCTION**
2088%

- R-410A
- R-32
- Transition
- R-1233ZD
- York Chiller Plant

© Handel Architects
Doing radically **more** with radically **less**

- **60 Watt Incandescent**: 0.06 kWh
- **60 Watt Compact Fluorescent**: 0.016 kWh
- **60 Watt LED Equivalent**: 0.008 kWh

**REDUCTION ~750%**
Doing radically more with radically less

Early 1950’s Fleet
1998 Fleet
Tesla

Avg. 12 MPG
Avg. 22 MPG
Avg. 100 MPG

750% IMPROVEMENT

Source: Consumer Reports 2016
Doing Radically More With Radically Less

- Median Energy Use of All NYC Buildings over 200,000 sq. ft.: 129.4 kBTU/SF/YR (PEUI)
- Energy Use of Passive House Buildings: 38.1 kBTU/SF/YR (PEUI)

*Can be adjusted for density and use

60-80% REDUCTION
PROTECT THIS HOUSE
discussion.