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Tom Chase
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Senior Project Manager
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Passive House Momentum Builds

- MassCEC Passive House Design Challenge
- MassSave Passive House Incentives
- Higher Points in Low Income Tax Credit ranking for Passive projects
Passive House Incentives

• 100% of the feasibility study cost up to $5,000
• 75% of energy modeling cost up to $500 per unit (cap of $20,000)
• $3,000 per unit for certification

To apply and get more information, email details of proposed building to multifhr@icf.com
Cambridge Finch Incremental Cost

1.4% increase in cost from base design

- Upgrades to ventilation/ERV
- Higher cost for Passive House consultant
- Increased insulation/thermal bridge breaks
- Upgrade to triple glazed windows
- Increased cost for PH Rater

Baseline building: very good envelope and all heat pumps for heating and cooling; shading features

A Boston or Cambridge base building might be similar, but most stretch code community base buildings would see a higher incremental cost to move to Passive levels
Up Next!

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PASSIVE HOUSE: Building Inherent Value

Fall 2018: Mass CEC Passive House Design Incentives

- 8 Passive House Affordable Projects (543 units)
FINCH CAMBRIDGE

- Owner/Developer: Homeowners Rehab
- 98 affordable family units
- Opening July 2020
Flood Resilience
Flood Resilience

2070 Storm
2030 Storm
Passive House Performance

Heating demand: 3 kBtu/ft²yr
Cooling demand: 1.28 kBtu/ft²yr
Heating load: 2.84 Btu/hr ft²
Cooling load: 2.46 Btu/hr ft²
Source energy: 5.885 kWh/Person yr
Site energy: 23.05 kBtu/ft²yr

National Median EUI for Multifamily Buildings* (kBtu/ft²/yr)

<table>
<thead>
<tr>
<th></th>
<th>Site EUI</th>
<th>Source EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUI: (kBtu/ft²/yr)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Comparison EUI results came from the National Median EUI (Energy Use Intensity) through the Energy Star Portfolio Manager:
What Does Successful Execution Require?

Builder as Partner:
Attention to the CRAFT of building

COMMUNICATION
HUMILITY
APPRECIATION
MENTORSHIP
Communication/Collaboration

- Prominently post Airtight Building signs for duration of project

- Assign one person responsibility for maintaining the air barrier

- Discuss the air barrier with all subs prior to commencement of their work
Graphic Communication
HOW DO YOU GET THERE?

Avoid Thermal Bridging

CLADDNG ATTACHMENT:
CASCADIA CLIPS

EXPOSED STEEL COLUMNS
AT DRIVE LANE

SUN SHADE ATTACHMENT TO
WINDOW HEADERS
HOW DO YOU GET THERE?

Thermal Bridging

THERM – a tool for cost-benefit analysis

COLUMN INTERFACE AT SLAB

CONTINUOUS GARAGE SLAB
Field Communication

The right amount of information at the right time
Craft – Envelope Airtightness Continuity

Caio’s Team rocking the Air Barrier
Harbor Village

- Owner/Developer: North Shore CDC
- 30 affordable family units
- Started Construction, Jan 2020
<table>
<thead>
<tr>
<th>Item/Task</th>
<th>Subcontractor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUILD ELECTRICAL INCLINE FOR TEMP POWER</strong></td>
<td><strong>GROOM</strong></td>
</tr>
<tr>
<td>FORM WALLS HH LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>FORM FOR PAD AT STAIR # 2</td>
<td>FORM UP</td>
</tr>
<tr>
<td>RECEIVE REBAR</td>
<td>GROOM</td>
</tr>
<tr>
<td>INSTALL DRAINAGE</td>
<td>LINSKEY</td>
</tr>
<tr>
<td>FINISH DIGGING FOR FOOTING AT A LINE</td>
<td>LINSKEY</td>
</tr>
<tr>
<td>FORM FOOTING AT A LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>POUR THE REST OF THE FOOTING ON A LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>POUR PAD FOR STAIR # 2</td>
<td>FORM UP</td>
</tr>
<tr>
<td>REMOVE FORMS AT FOOTINGS AND PAD</td>
<td>FORM UP</td>
</tr>
<tr>
<td>BACK FILL 1/2 OF THE WALL ON 7 LINE</td>
<td>LINSKEY</td>
</tr>
<tr>
<td>FORM WALL ON A LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>POUR WALL ON A LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>START CMU STAIR # 2</td>
<td>VAZ</td>
</tr>
<tr>
<td>FINISH DIGGING HH LINE FOR FOOTINGS, FORM AND POUR FOOTING HH LINE</td>
<td>LINSKEY AND FORMUP</td>
</tr>
<tr>
<td>POUR THE REST OF FOOTING ON HH LINE</td>
<td>FORM UP</td>
</tr>
<tr>
<td>HOPE FOR TEMP POWER</td>
<td>GROOM</td>
</tr>
</tbody>
</table>

**Remarks/Notes:**
- **MIX** 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- **WEEKLY MIX** 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

**Subcontractors must notify Groom Construction Project Manager or Superintendent within 24 hours of missing the Pre-Walk Look Ahead Schedule to meet this schedule.**
STAIR 2 SEQUENCE

1. FOUNDATION:
   WATERPROOFING

INSTALL LIQUID APPLIED
WATERPROOFING AT OUTSIDE
FACE OF ALL FOUNDATION
WALLS AND FOOTINGS PART OF
STAIR 2 STRUCTURE. IF
STRUCTURE IS CONTINUOUS
PAST STAIR 2, CONTINUE
WATERPROOFING FOR 24"
STAIR 2 SEQUENCE

1. FOUNDATION: WATERPROOFING
2. STEEL POSTS
3. CMU WALLS
4. INTUMESCENT PAINT ON STEEL AS AIR BARRIER
1. Foundation: Waterproofing

2. Steel Posts

3. CMU Walls

4. Intumescent Paint on Steel AS Air Barrier

5. Sub Grade Insulation Min 48" Below Grade

STAIR 2 SEQUENCE

Mech

Parking

Lobby

Commercial Space
1. FOUNDATION: WATERPROOFING

2. STEEL POSTS

3. CMU WALLS

4. INTUMESCENT PAINT ON STEEL AS AIR BARRIER

5. SUB GRADE INSULATION MIN 48" BELOW GRADE

6. SUB SLAB INSULATION, VAPOR BARRIER, LAPS UP, SLAB POURED

DO WE NEED?

MECH

PARKING

COMMERCIAL SPACE

8. INSULATION ABOVE GRADE, & SPRAY FOAM UNDERSIDE OF DECK
1. FOUNDATION: WATERPROOFING
2. STEEL POSTS
3. STRUCTURAL CMU WALLS
4. INTUMESCENT PAINT & STRUCTURAL THERMAL BREAKS
5. STRUCTURAL THERMAL BREAKS
6. VERTICAL SUB GRADE
7. SUB SLAB INSULATION
8. VAPOR BARRIER, LAPS UP, SLAB Poured
9. AIR BARRIER ON CMU
10. METAL STUDS AND NON STRUCTURAL CMU WALLS WITH AIR BARRIERS

DETAILS AT DOORS

11. INSULATION ABOVE GRADE, & SPRAY FOAM UNDERSIDE OF DECK
LAUNDRY ROOM SEQUENCE

1. Structure in place.

2. Non-structural wall in place.

3. Air barrier applied to inside face of all 6 sides of room.
   - Self-adhered air barrier at walls.
   - Waterproofing membrane at floor, tie into floor drain.
   - Tape transition between wall and floor.
   - Spray foam at intersection in cross section.
   - Wrap into openings for doors and windows.

4. Rigid insulation at walls. Insulation below laundry room.

5. Install MEP & dryers.

6. Install wall to separate make up air, gasket dryers at edges.

7. Install windows and doors.
<table>
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<tr>
<th>Item/Task</th>
<th>Subcontractor</th>
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</thead>
<tbody>
<tr>
<td>dig the rest of HH line for footing</td>
<td>limsky</td>
<td></td>
</tr>
<tr>
<td>dig for footing along Elm street</td>
<td>limsky</td>
<td></td>
</tr>
<tr>
<td>finish forms and pour wall on A line</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>tie rebar at stair #2</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>install forms at walls at stair #2</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>remove forms on wall at A line</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>back fill wall at A line</td>
<td>limsky</td>
<td></td>
</tr>
<tr>
<td>Bring water lines into site from main</td>
<td>limsky</td>
<td></td>
</tr>
<tr>
<td>pour walls at stairs #2</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>remove forms at stair R 2</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>form walls on HH line</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>start CMU at stair #2</td>
<td>viz</td>
<td></td>
</tr>
<tr>
<td>pour walls at HH line</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>remove forms on wall on HH line</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>form footings and pad at Elm and stair #1</td>
<td>form up</td>
<td></td>
</tr>
<tr>
<td>water proof and back fill HH wall</td>
<td>limsky</td>
<td></td>
</tr>
<tr>
<td>waterproof and passive house work at stair #2</td>
<td>waterproofing CO</td>
<td></td>
</tr>
<tr>
<td>Take video of work at stair #2</td>
<td>groon</td>
<td></td>
</tr>
<tr>
<td>back fill at stair #2</td>
<td>limsky</td>
<td></td>
</tr>
</tbody>
</table>
Craft: Pipe/Penetration Airtightness

First Try – Not Approved

Second Try – Approved

Ian Russell - Plumber
Testing/Verification
Craft – Envelope Airtightness Continuity
Craft – Envelope Thermal Continuity
Craft: Pipe/Penetration Insulation
Craft – Interior Compartmentalization

Not Approved

Approved
# Commissioning/Monitoring

You are not alone – we are a team

<table>
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<th>Role</th>
<th>Company</th>
</tr>
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<tbody>
<tr>
<td>Architect</td>
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<tr>
<td>MEP/FP</td>
<td>Petersen Engineering</td>
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<td>NEI General Contracting – (CPHC added to team)</td>
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<td>Energy Modeler &amp; CPHC</td>
<td>Linnean Solutions</td>
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<td>JSR Adaptive Energy Solutions</td>
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<td>New Ecology</td>
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<td>Building Enclosure Associates</td>
</tr>
<tr>
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<td>Sustainable Engineering Solutions</td>
</tr>
</tbody>
</table>
James Petersen
PE
james@petersenengineering.com
603-436-4233 x111
Three Ventilation Approaches

• Local
• Floor-by-floor
• Central – Finch
Local Ventilation - Schematic
Local Ventilation – Sample Equipment

23 in x 31 in x 34 in
60 CFM
Floor-by-Floor Ventilation – Schematic
Floor-by-Floor Ventilation – Sample Equipment

55 in x 67 in x 16 in
700 CFM
Central Rooftop Ventilation - Schematic
Central Rooftop Ventilation – Sample Equipment

Central ERV
1000s CFM

Constant Airflow Regulator
What is an Air-to-Air Heat Exchanger?
Representative System Comparison – WUFI

Assumptions: 80% sensible efficiency, 0.6 W/CFM (central and semi-decentralized) 0.5W/CFM (decentralized), includes duct heat transfer
Local Ventilation - Considerations

🌟 • All equipment and ductwork within dwelling unit compartment – COVID-19 appeal

😭 • Minimizes duct work
  • Easy to balance
  • No Fire/Smoke Dampers
  • Tenant responsible for energy use
  • Quarterly filter changes
  • Sidewall exterior wall penetrations
  • Floor space within dwelling unit
  • More pieces of equipment
  • Insufficient dehumidification
  • Electric resistance pre-heat

ERAV EACH APARTMENT
Floor-by-Floor Ventilation – Schematic

- No floor-to-floor shafts
- Bolt on cooling coil - dehumidification
- Accessible without entering dwelling units
- Relatively Simple Ductwork
- Floor-by-floor mechanical rooms
- Early design space coordination required
- More equipment than central approach
- Less manufacturer choices available
- Slight risk of virus spread by cross contamination – COVID-19
Central Rooftop Ventilation - Schematic

- Commercial grade equipment – lots of manufacturers, mature market
- Customizable (efficiency, filtering, economizing, tempering, dehumidification)
- True dedicated outdoor air system (DOAS)
- Fewer Pieces of equipment
- Selection software
- Complex duct system
  - Duct sealing critical
  - CAR dampers required for balancing
  - Critically reliant on good duct design
- Equipment outside of envelope
- Corridor ceiling space
- Fire/Smoke Dampers
- Slight risk of virus spread by cross contamination – COVID-19
## Considerations - Summary

<table>
<thead>
<tr>
<th>Local</th>
<th>Floor-by-Floor</th>
<th>Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>All equipment and ductwork within dwelling unit compartment – COVID-19</td>
<td>No floor-to-floor shafts</td>
<td>Commercial grade equipment – lots of manufacturers, mature market</td>
</tr>
<tr>
<td>Minimizes ductwork</td>
<td>Bolt on cooling coil - dehumidification</td>
<td>Customizable and additional features</td>
</tr>
<tr>
<td>Easy to balance</td>
<td>Accessible without entering units</td>
<td>Selection software</td>
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<tr>
<td>No Fire/Smoke Dampers</td>
<td>Relatively simple ductwork</td>
<td>True DOAS system</td>
</tr>
<tr>
<td>Tenant responsible for energy use</td>
<td></td>
<td>Fewer pieces of equipment</td>
</tr>
<tr>
<td>Floor space within dwelling unit</td>
<td>Floor-by-floor mechanical rooms</td>
<td>Complex duct system</td>
</tr>
<tr>
<td>Quarterly filter changes</td>
<td>Early design space coordination</td>
<td>Duct sealing critical</td>
</tr>
<tr>
<td>Sidewall ext. wall penetrations</td>
<td>More equipment than central</td>
<td>CAR Dampers required for balancing</td>
</tr>
<tr>
<td>More pieces of equipment</td>
<td>Slight risk of virus spread by cross-contamination – COVID-19</td>
<td>Fire/Smoke Dampers</td>
</tr>
<tr>
<td>Insufficient dehumidification</td>
<td></td>
<td>Corridor ceiling space</td>
</tr>
<tr>
<td>Electric resistance pre-heat</td>
<td></td>
<td>Equipment outside envelope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slight risk of virus spread by cross-contamination – COVID-19</td>
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Up Next!

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Senior Project Manager
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</tbody>
</table>
Compartmentalization
# Compartmentalization Testing

<table>
<thead>
<tr>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (F)</td>
<td>10</td>
</tr>
<tr>
<td>Perimeter (LF)</td>
<td>125</td>
</tr>
<tr>
<td>Area (SF)</td>
<td>857</td>
</tr>
<tr>
<td>Enclosure (SF)</td>
<td>2,964</td>
</tr>
<tr>
<td>Volume (CF)</td>
<td>8,570</td>
</tr>
<tr>
<td>Threshold: 0.3 CFM50/SF of Enclosure</td>
<td>889</td>
</tr>
</tbody>
</table>

| Test result (CFM)        | 638   |
| Result CFM50/SF of Enclosure | 0.22  |
| ACH50                    | 4.47  |
Compartmentalization Testing
Thermal Imaging - Compartment
# Duct Testing

<table>
<thead>
<tr>
<th>Unit</th>
<th>Allowable Duct Leakage (CFM25)</th>
<th>Tested Duct Leakage (CFM25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>306</td>
<td>36</td>
<td>22</td>
</tr>
<tr>
<td>308</td>
<td>52</td>
<td>25</td>
</tr>
<tr>
<td>309</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>310</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>406</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>409</td>
<td>29</td>
<td>25</td>
</tr>
</tbody>
</table>
Thermal Imaging – Thermal Bridges
Thermal Imaging – Exterior
Thermal Imaging – Pre/Post C.I.
Solar PV

System Size: 105,070W DC
Estimated Annual Production: 116,628 kWh

Gross Price: $294,196
Price per Watt: $2.92
Federal Tax Credit: $0
Federal Depreciation: $0

Annual Electricity Value: $13,226
Annual SMART Incentive Value: $24,737

Simple Payback: 7.75 years
Monitoring and Optimization

Systems Monitored through NEI ”Box” and Dashboard
- VRF, exterior units and in unit setpoints and temperatures – via API
- Central Water Meter (hourly)
- DHW Usage and Boiler and Pumps -
- Electronic Tempering Valve and DHW Recirculation Temp

Service Provided
- All sensors, cellular modem, and uninterruptible power supply
- Custom Dashboard
- Fault Detection
- Custom E-mail Alerts
- Historical Trend Logs
- Optimization Recommendations
Monitoring and Optimization