The Sponsors of Energize Connecticut, and in partnership with Connecticut Passive House, are pleased to offer *Passive House Initiative* to support workforce development and help transform the energy efficiency and building construction industries in Connecticut.

For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com
Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more
## Passive House Incentive Structure for Multi-Family
(5 Units or More)

<table>
<thead>
<tr>
<th>Incentive Timing</th>
<th>Activity</th>
<th>Incentive Amount</th>
<th>Max Incentive (Per Unit)</th>
<th>Max Incentive (Per Project)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Construction</td>
<td>Feasibility Study(^1)</td>
<td>Up to 100% of Feasibility Study Costs</td>
<td>N/A</td>
<td>$5,000.00</td>
</tr>
<tr>
<td></td>
<td>Energy Modeling(^2)</td>
<td>75% of Energy Modeling Costs (Before 90% Design Drawings)</td>
<td>$500.00</td>
<td>$30,000.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% of Energy Modeling Costs (90% Design/50% Construction)</td>
<td>$250.00</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Post Construction</td>
<td>Certification(^3)</td>
<td>Up to 100% of Certification Costs</td>
<td>$1,500.00</td>
<td>$60,000.00</td>
</tr>
</tbody>
</table>

---

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant.
2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.
3. Certification may be either through PHIUS, PHI, or EnersPHit certification offerings.

---

Next steps you can take...
Contact your Energy Efficiency Representative or

Go to [EnergizeCT.com](https://www.energizect.com) or call 1-877-WISE USE for more details.

Brought to you by

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[![CNG](https://www.energizect.com/images/CNG.png)](https://www.energizect.com)
[![SCG](https://www.energizect.com/images/SCG.png)](https://www.energizect.com)
[![UI](https://www.energizect.com/images/UI.png)](https://www.energizect.com)

Proud sponsors of


Part of the AVANGRID Family
MULTI-FAMILY PASSIVE HOUSE

LESSONS LEARNED FROM THE FIRST GENERATION OF PROJECTS

Monte Paulsen | CPHC, PHI Building Certifier
Andrew Steingiser | RA, CPHC
Monte Paulsen

PHI accredited Building Certifier.
Leads the Passive House team at RDH.
Consulting for 7 million+ sf of Passive House.
A Pattern Language from Passive House:
   Four part workshop
   Through Passive House Canada
Co-Founder:
   Passive House Canada
   PHPP Users Group and the Global
   Passive House Happy Hour
Andrew Steingiser

Registered Architect in Massachusetts.
Certified Passive House Consultant (PHIUS).
Leads Passive House Consulting for RDH Boston.
Passive House MA Board of Directors.
Agenda

• Local Requirements + Incentive Programs
• Architects + Engineers are Responsible for Adaptation
• Case Studies + Lessons Learned
• Cost + Timeline
• Q+A
Making buildings better for 20+ Years

6 Million + SF of high-performance project experience

New Construction + Existing Buildings

Focus on building science & building enclosures

Projects across North America

300+ people

9 offices
Integrated Service Areas

• Building Enclosure Consulting
  [Panelization, Mass Timber, Deep Retrofit...]

• Energy + Sustainability
  [Including site verification]

• Façade Consulting + Structural Engineering

• Maintenance + Capital Planning

• Material Science + Research

• Investigation + Litigation Support

• Building Enclosure Commissioning

We make buildings better through the integration of science, design and construction expertise
Early Phase Building Science

1. Switch the Design Process from Reactive to Proactive

2. Make the milestones match the metrics

3. Make the key decisions early with the whole team

4. Optimize the variables for what matters to the project
   [Performance, Cost, Carbon, Climate Resiliency...]

1. Design Process
2. Milestones to Match the Metrics
3. Early-Stage Key Decisions
4. Optimize Decisions
LOCAL REQUIREMENTS + INCENTIVES
Decarbonization in MA

March 26, 2021 Governor Baker signed into law:

- 50% carbon emissions reduction by 2030
- 75% carbon emissions reduction by 2040
- Net Zero carbon emissions by 2050
Proposed Code in MA

Specialized Opt-in Code (Net Zero) - Commercial

- Large Multi-Family
- Passive House: Electric Heat or Electrification ready
- Passive House: All Electric or Electrification ready
- All other Commercial Building Types
- Gas or other fossil fuel: All stretch code efficiency requirements, Solar on roof where feasible, Electrification-ready (pre-wiring)
- All-Electric: All stretch code efficiency requirements

Source: DOER
# Incentives in MA

## Passive House Incentive Structure for Multi-Family (5 units or more)

<table>
<thead>
<tr>
<th>Incentive Timing</th>
<th>Activity</th>
<th>Incentive Amount</th>
<th>Max. Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Construction</td>
<td>Feasibility Study</td>
<td>100% of Feasibility costs</td>
<td>$5,000</td>
</tr>
<tr>
<td></td>
<td>Energy Modeling</td>
<td>75% of Energy Model cost</td>
<td>$500/unit, max. $20,000</td>
</tr>
<tr>
<td></td>
<td>Pre-Certification</td>
<td>$500/unit</td>
<td></td>
</tr>
<tr>
<td>Post-Construction</td>
<td>Certification</td>
<td>$2,500/unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net Performance Bonus</td>
<td>$0.75/kWh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$7.50/therm</td>
<td></td>
</tr>
</tbody>
</table>
Passive House in MA

Passivehouse & Multi-family – Recent Success

Over 6,500 Passivehouse units since 2017

What is Passivehouse? A building standard that includes:
- Super-efficient building envelope (approx. HERS 34)
- Improved indoor air quality with high performance ventilation

Net impact: Improved health, comfort, resiliency, and building quality, reduced HVAC equipment sizing, and low cost to maintain and operate

- Passivehouse Growth. Passivehouse is rapidly growing in 6+ unit multi-family with over 6,500 units in the Mass Save® incentive program pipeline versus less than 20 in 2018.
- 133 MA firms have Certified Passivehouse consultants, $1.7m for Mass Save training of 3,600 people in 2022-2024.
- Multi-Family. Passivehouse becomes most cost-effective for multi-family buildings, but standard can be used for all buildings.

Source: DOER
Decarbonization in CT

March 26, 2021 Governor Lamont signed law:

• 45% carbon reduction by 2030
  o Below 2001 levels
## Incentives in CT

### Passive House Incentive Structure for Multi-Family (5 Units or More)

<table>
<thead>
<tr>
<th>Incentive Timing</th>
<th>Activity</th>
<th>Incentive Amount</th>
<th>Max Incentive (Per Unit)</th>
<th>Max Incentive (Per Project)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Construction</td>
<td>Feasibility Study&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Up to 100% of Feasibility Study Costs</td>
<td>N/A</td>
<td>$5,000.00</td>
</tr>
<tr>
<td></td>
<td>Energy Modeling&lt;sup&gt;2&lt;/sup&gt;</td>
<td>75% of Energy Modeling Costs (Before 90% Design Drawings)</td>
<td>$500.00</td>
<td>$30,000.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% of Energy Modeling Costs (90% Design/50% Construction)</td>
<td>$250.00</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Post Construction</td>
<td>Certification&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Up to 100% of Certification Costs</td>
<td>$1,500.00</td>
<td>$60,000.00</td>
</tr>
</tbody>
</table>

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant.
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3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.
## RDH Passive House Feasibility Studies

### PASSIVEHOUSE REQUIREMENTS

<table>
<thead>
<tr>
<th>Category</th>
<th>Requirement</th>
<th>Specific</th>
<th>Target</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heating demand</strong></td>
<td>Specific</td>
<td>4.06</td>
<td>5.8</td>
<td>826,976.26</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>5.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>826,976.26</td>
</tr>
<tr>
<td><strong>Cooling demand</strong></td>
<td>Sensible</td>
<td>3.3</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Latent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specific</td>
<td>4.23</td>
<td>8.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>8.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>858,182.06</td>
</tr>
<tr>
<td><strong>Heating load</strong></td>
<td>Specific</td>
<td>4.46</td>
<td>5.9</td>
<td>903,759.77</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>903,759.77</td>
</tr>
<tr>
<td><strong>Cooling load</strong></td>
<td>Specific</td>
<td>2.96</td>
<td>3.2</td>
<td>590,287.4</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>590,287.4</td>
</tr>
<tr>
<td><strong>Source energy</strong></td>
<td>Specific</td>
<td>5.292</td>
<td>5.470</td>
<td>7,710,192.29</td>
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<tr>
<td></td>
<td>Target</td>
<td>5.470</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>7,710,192.29</td>
</tr>
</tbody>
</table>

Note: Source Energy does not include any offsets from renewable energy sources.
ARCHITECTS + ENGINEERS ARE RESPONSIBLE FOR ADAPTATION
Carbon Emissions and Global Temperature

Observed changes in climate over the last 2020 years

Variations in atmospheric carbon dioxide levels and global average temperature

Carbon dioxide levels
Atmospheric concentration [ppm]

Global temperature change
Relative to pre-industrial levels [°C]
Oceans absorbing 90% of the heat for now

Global ocean heat content, 1940-2021

The Information is Out There
The Information is Out There

- 2/3 of Boston’s GHG emissions come from Buildings

Transitions Needed for Decarbonization:
- Electrification of space and water heating
- Invest in building envelope to drive down costs to consumers and the grid
- Use decarbonized energy sources
Current and future emissions matter.

About 2 feet of sea level rise along the U.S. coastline is increasingly likely between 2020 and 2100 because of emissions to date.

Failing to curb future emissions could cause an additional 1.5 - 5 feet of rise for a total of 3.5 - 7 feet by the end of this century.

Source: NOAA
Our Locality + Circumstances

Boston, 2018
Standard of Care

The Architect shall perform its services consistent with the professional skill and care ordinarily provided by architects practicing in the same or similar locality under the same or similar circumstances. The Architect shall perform its services as expeditiously as is consistent with such professional skill and care and the orderly progress of the Project.
Every Building Needs a Plan

• Plan to adapt to flooding, overheating, poor air quality.
• Plan to reduce greenhouse gas emissions to zero.
• Plan to strategize response for future carbon penalties.
• Plan to prepare for Natural Gas bans and retrofit mandates.
• Plan to tackle these costly mandates in affordable steps over time.
Mitigation?
CASE STUDIES
# Wheaton College, Pine Hall

<table>
<thead>
<tr>
<th>SGA</th>
<th>Architect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>45,000 gsf</strong></td>
<td>Building Area</td>
</tr>
<tr>
<td><strong>$21.5m</strong></td>
<td>Construction Cost</td>
</tr>
<tr>
<td><strong>$466.00</strong></td>
<td>Cost/SF</td>
</tr>
<tr>
<td><strong>178</strong></td>
<td>Total Beds</td>
</tr>
<tr>
<td><strong>253 sf/bed</strong></td>
<td>Area/Student</td>
</tr>
<tr>
<td><strong>$120,800</strong></td>
<td>Cost/Bed</td>
</tr>
<tr>
<td><strong>26.6</strong></td>
<td>Design EUI</td>
</tr>
</tbody>
</table>
Wheaton College, Pine Hall
Wheaton College, Pine Hall
Layout Mechanical First/ Centralized ERV
Brise Soleil
Williams College, Garfield House

<table>
<thead>
<tr>
<th>SGA Architect</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,500 gsf Building Area</td>
</tr>
<tr>
<td>$9.5m Construction Cost</td>
</tr>
<tr>
<td>$575.00 Cost/SF</td>
</tr>
<tr>
<td>40 Total Beds</td>
</tr>
<tr>
<td>413 sf/bed Area/Student</td>
</tr>
<tr>
<td>$237,500 Cost/Bed</td>
</tr>
<tr>
<td>28.2I Design EUI</td>
</tr>
</tbody>
</table>
Williams College, Garfield House
Williams College, Garfield House
Brise Soleil

WALL ASSEMBLY #1
FASBEEK-TIM BEHIND PLATE
STAINLESS STEEL KNIFE-PLATE
WELDED TO PLATE
BOLTED THROUGH HEADER

SHADING DEVICE AS SPECIFIED
BOLTED TO KNIFE PLATE
METAL DRIP EDGE HEMMED

WINDOWS SILL EXTENSION
ATTACHED TO WINDOWS FRAME

FIBER GLASS TRIPLE GLAZED
WINDOWS UNIT

WINDOW HEAD SHADING DETAIL, TYP.
3' = 1'-0"
Other lessons
Bunker Hill Housing

27 Acres
Site
3,287,000 SF
Housing
2,699
Units
Bunker Hill, Building M

Stantec
Architect

Leggat McCall
Client

93,320 gsf
Building Area

102
Units
Bunker Hill, Building F

Stantec
Architect

Leggat McCall
Client

191,131 gsf
Building Area

249
Units
Compact Form, Low Window/Wall Ratio

Building M

Building F

Images: Stantec
Standing Panels

Images: Stantec
Mass Timber Moisture Risks

Mass timber components

Mass timber connections

Mass timber assemblies
Mass Timber Moisture Management

Intermediate floor/ Waterproof floor Moisture Management Design Tool

- Finished floor
- Cementitious topping
- Acoustic Mat
- High Moisture Protection
- CLT

**Recommended**
- Factory installed fully adhered 45mil EPM Membrane (XMP) with factory applied CLT "flash step" edge protection

**Field Applied Protection**
- Do Nothing
  - Factory applied CLT "flash step" edge protection

**Exposure**: High (when no floor allowed)
**Duration**: 7 days (until floor above is installed)
**Weather/Season**: Fall – Regular Rain

**Risk Assessment**
- With facade installation coupled
  - Optimal
- Optimal +

**Risk Assessment**
- With facade installation without windows, openings covered w/ WRB (to allow increased drying)
  - Optimal
  - Optimal +

**Next Steps**
- Raise pads on pallets and provide fans and heaters for all options.
- Project team to discuss and select protection options based on desired risk levels.
- Depending on collection, site drainage plan, contingency plan and interface detailing will vary.
Windows with Purpose

Architect: Stantec
Bakers Place, Madison WI

Michael Green Architecture/
Angus Young
Architect

The Neutral
Project
Client

287,832 gsf
Building Area

23.84
Site EUI
Bakers Place, Madison WI
PHIUS Targets

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2018

Heating demand
specific: 4.06 kBtu/ft²yr
target: 5.8 kBtu/ft²yr
total: 826,976.26 kBtu/yr

Cooling demand
sensible: 3.3 kBtu/ft²yr
turbulent: 0.93 kBtu/ft²yr
specific: 4.23 kBtu/ft²yr
target: 8.4 kBtu/ft²yr
total: 858,182.06 kBtu/yr

Heating load
specific: 4.46 Btu/hr ft²
target: 5.9 Btu/hr ft²
total: 903,759.77 Btu/hr

Cooling load
specific: 2.96 Btu/hr ft²
target: 3.2 Btu/hr ft²
total: 599,287.4 Btu/hr

Source energy

Note: Source Energy does not include any offsets from renewable energy sources.
The Edison, Milwaukee WI

Michael Green Architecture/
Angus Young
Architect

The Neutral Project
Client

252,950 gsf
Building Area

24.06
Site EUI
The Edison, Milwaukee WI
**PHIUS Targets**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Certificate criteria:</th>
<th>PHIUS* 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating demand</td>
<td>Specific</td>
<td>4.15 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>5.8 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>706,886.06 kBTU/yr</td>
</tr>
<tr>
<td>Cooling demand</td>
<td>Sensible</td>
<td>2.55 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Latent</td>
<td>0.24 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Specific</td>
<td>2.79 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>7.3 kBTU/ft²/yr</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>476,284.28 kBTU/yr</td>
</tr>
<tr>
<td>Heating load</td>
<td>Specific</td>
<td>4.52 Btu/hr ft²</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>5.8 Btu/hr ft²</td>
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<tr>
<td></td>
<td>Total</td>
<td>770,513.73 Btu/hr</td>
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<tr>
<td>Cooling load</td>
<td>Specific</td>
<td>2.6 Btu/hr ft²</td>
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<td></td>
<td>Target</td>
<td>2.7 Btu/hr ft²</td>
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<td>Total</td>
<td>443,866.02 Btu/hr</td>
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<tr>
<td>Source energy</td>
<td>Total</td>
<td>1,754,105.16 kWh/yr</td>
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<tr>
<td></td>
<td>Specific</td>
<td>4,715 kWh/Person yr</td>
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<tr>
<td></td>
<td>Target</td>
<td>5,519 kWh/Person yr</td>
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<tr>
<td></td>
<td>Total</td>
<td>5,984,664.48 kWh/yr</td>
</tr>
<tr>
<td></td>
<td>Specific</td>
<td>35.1 kWh/ft²/yr</td>
</tr>
</tbody>
</table>

Note: Source Energy does not include any offsets from renewable energy sources.
Hanging Panels
What I learned the hard way from my first multi-family Passive House

Monte Paulsen
Passive House Specialist
RDH Building Science

mpaulsen@rdh.com
Harding Heights
Smithers, B.C.

Cornerstone Architects
Yellowridge Construction
Smith + Anderson
RDH Building Science

Cold climate
Seniors Housing
19 small suites
Designed to be capable of either modular or on-site construction
Harding Heights
Harding Heights
Mechanical Systems

VENTILATION
- Two HRVs per floor
- Each serves 3-4 suites

DHW
- Three Sanden C02 systems
- Storage in AC back-up tanks

HEAT
- AC baseboards
July 2018: Mayor cuts ribbon, seniors move in, big smiles until...
Aug-Sept 2018 temperatures in Harding Heights
Seven factors that contributed to overheating

- **No operable exterior shading**
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted

Operable exterior shades would have kept the building comfortable even if the other seven mistakes had persisted.
Seven factors that contributed to overheating

- No operable exterior shading
- **Fixed shading inadequate**
- Tree removed
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted
Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- **Tree removed**
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted
Lesson: Multi-family buildings need exterior shading.
Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- **Glazing substitution**
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted

→ Euroline 4700 specified (Delta, BC)
  → G value of 0.40 specified

→ Kleerwall PassiV supplied (Ireland)
  → G value of 0.61 supplied
Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- **Insect screen substitution**
- Warm ducts = No night flush
- Weather warmer than predicted

→ Because there were no screens, most residents closed windows at night. This prevented natural night flush

→ People are doing the same during smoke events.
Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- Insect screen substitution
- **DHW tanks warmed ducts**
- Weather warmer than predicted
Seven factors that contributed to overheating

• No operable exterior shading
• Fixed shading inadequate
• Tree removed
• Glazing substitution
• Insect screen substitution
• Warm ducts = No night flush
• Weather warmer than predicted

The 30-year average August temperature for Smithers is 14.2°C

In 2018, August averaged 16.4°C

→ August 2017: 17.0°C
→ August 2016: 16.0°C
→ August 2015: 13.9°C
→ August 2014: 15.5°C
→ August 2013: 16.4°C
→ August 2012: 14.5°C
→ August 2011: 12.6°C
→ August 2010: 15.0°C
The midpoint of most 30-year climate files is 1985. Care to guess what the top movie & show were that year?

Are we designing Passive House & Step Four buildings for a Marty McFly climate?
Lesson: Six factors that affect summer comfort

OUTSIDE the BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.
Heat Island Effects
limit night cooling

Urban heat mapping by researchers at Simon Fraser University identified several hotspots in Vancouver where, when coupled with vulnerable populations, the risk of heat-related illness and mortality is higher. The city's hottest areas also tend to have the lowest tree canopy. Increasing tree canopy in these areas is one way to reduce vulnerability to heat in these locations.
Lesson: Six factors that affect summer comfort

OUTSIDE the BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

INSIDE the BUILDING

OCCUPANT DENSITY
Small units produce higher IHG/m² than large units.
Occupant density is a key consideration in social housing

**24 RESIDENTS**

21 refrigerators. 30+ televisions. 20 computers. 60 meals per day? 20 showers?

**4 RESIDENTS**

2 refrigerators? 5 televisions? 4 computers? Two meals per day? Four showers?
Lesson: Six factors that affect summer comfort

OUTSIDE the BUILDING

- **SOLAR GAIN**
  Shading, SHGC, glazing area.

- **TEMPERATURE**
  Model for 2050 & 2080, not 1985.

- **URBAN HEAT ISLAND**
  Most multiunit on infill sites.
  Effects greater than climate change.

INSIDE the BUILDING

- **OCCUPANT DENSITY**
  Small units produce higher IHG/m² than large units.

- **DHW HEAT LOSS**
  Don’t put DHW in same room as HRV.
  Shorten DHW runs.

- **LIFESTYLE VARIATION**
  How residents live and play affects IHGs significantly.
Lesson: Six factors that affect summer comfort

OUTSIDE the BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

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Model for 2050 & 2080, not 1985.

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DHW HEAT LOSS
Don’t put DHW in same room as HRV.
Shorten DHW runs.

LIFESTYLE VARIATION
How residents live and play affects IHGs significantly.
Most summer comfort modelling ignores four of these

**OUTSIDE the BUILDING**

**SOLAR GAIN**
Shading, SHGC, glazing area.

**TEMPERATURE**
Model for 2050 & 2080, not 1985.

**URBAN HEAT ISLAND**
Most multiunit on infill sites.
Effects greater than climate change.

**INSIDE the BUILDING**

**OCCUPANT DENSITY**
Small units produce higher IHG/m² than large units.

**SYSTEM HEAT LOSS**
Don’t put DHW in same room as HRV.
Shorten DHW runs.

**LIFESTYLE VARIATION**
How residents live and play affects IHGs significantly.

We would like to discuss revising the criteria
Skeena Residence at University of British Columbia in the Okanagan (UBCO)
Skeena Residence

> Public Architecture
> AME Group
> RDH Building Science
Challenge

> High exhaust rate in laundry room required make-up air and a separate air tightness zone
Challenge

> Lack of point-of-delivery inspection resulted in some windows being replaced
1075 Nelson

> WKK Architecture (Tom Wright)
> IBI Group
> Integral Group
> RDH Building Science
“A Passive House that does not look like a Passive House”

> Hanging panels with pre-installed windows
> Large Swegon HRVs in pairs.
> The tallest planned Passive house on Earth
Marpole Community Center

> City of Vancouver
> Diamond Schmitt
> Integral Group
> RDH Building Science
We’re discussing underground parking

Parkades represent the largest share of embodied carbon in a mass-timber building.

The cars that park in these underground spaces also contain embodied carbon, and their use releases operational carbon.

Negotiating with municipalities to reduce the size of parkades—or eliminate them altogether—may be the largest step any team can take to reduce emissions.
We’re discussing Internal Heat Gains

What are the Internal Heat Gains of a basketball game?
Of a typical workout?
We’re discussing Primary Energy

- **Average for Arts, Entertainment, Recreation**: 824 kWh/m².a
- **West Vancouver Community Centre 2010**: 296 kWh/m².a
- **Clayton Community Centre (early stage)**: 139.7 kWh/m².a
- **Clayton Community Centre (currently)**: 91 kWh/m².a
Vancouver Art Gallery

> Herzog & De Meuron
> Perkins + Will
> Integral Group
> RDH Building Science
RDH has modelled more than 100 details for this project.
Vancouver Art Gallery

> Mass Timber & Concrete structure
> Never-before cladding approach
> Complicated program: Restaurants, daycare, studios, workshops.
> Must achieve 50% humidity 24/7/365

> But we are not alone...
Three precedents for the new VAG...

1. Hereford Archive and Record Centre

➔ First repository designed to the new standard for archival materials storage, PD 5454

➔ First Passive House Archive in the UK (2015)
Hereford Archive and Record Centre

Hereford Archive and Record Centre

March 2016 (no heating since June)

Temperature (°C): 15°C
Humidity (%RH): 50%
2. Museum of Bavarian History

→ Regensburg, Germany
→ 7,712 m² (83,000 s.f.)
→ 300,000 visitors/year
→ Opened 2019
Museum of Bavarian History
Air curtains improve capture efficiency

On the left – hood without air curtain spilling convective plume from hot appliance into the kitchen. On the right – hood with activated air curtain operating at C&C airflow.
Closed coolers consume far less energy
Just to put refrigerator energy use in context…

Energy Use Per Person in Africa vs. a Typical American Refrigerator

Annual kilowatt-hours of electricity consumed per capita, 2017

SOURCE: INTERNATIONAL ENERGY AGENCY AND ENERGY FOR GROWTH HUB
3. Longfor Sunda Exhibition Hall

Gaobeidian, China

1,484 m²

Opened 2018
02 Thermal-Bridge-Free Construction

Thermal-Bridge-Free Construction

Passive House employs continuous insulation throughout its entire envelope to block thermal conduction between indoor and outdoor. However, in certain situations, thermal bridges exist in connecting areas such as walls, windows, etc. A thermal-bridge-free or minimized paneling is an effective method to reduce building heat loss.
COST + TIMELINE
I’ve been asked the same two questions about once a week for the past decade:

#1. How much more does it cost to build a multi-family building to the Passive House Standard?

#2. What does a Certified Passive House project do to your existing milestones and timeline?
The first seven projects in BC

Passive House & Step Four

Three climate zones

We didn’t know what we were doing!

Years later... Passive House Network survey

“First costs between 1% and 8% over baseline.”

“The most obvious determinant of increased cost appears to be the experience of the project design team, and not the size of the building”
Today, costs are better managed

1.4 to 2.8%
Actual costs (not estimates) from 8 low and mid-rise PH projects around Massachusetts

1.9 to 2.9%
Detailed cost estimate by Consigli technical consultant

Pennsylvania Housing Authority (2015-2018)
-1.1% less
Actual costs (not estimates) from 74 PH projects and 194 non-PH projects

Since 2019, Mass Save provides technical assistance, training and $3,000/unit in incentives for multi-family Passive House construction

Data & graphics from Massachusetts Department of Energy Resources
Today, costs are better managed

Data & graphics from Massachusetts CEC
To save money, write a concise OPR

Write a concise Owner’s Project Requirements document with specific objectives for adaptation, mitigation, and compliance.

Don’t just list objectives in the OPR. Name cost-effective strategies that align with your value objectives for the project.

If you need to hire a consultant or work through a process to help you define objectives and name strategies, do it before you hire a table full of advisors.

Hire architects, engineer, and key consultants with a track record of delivering the objectives you have named. The best candidates will respond well to your OPR.

If your Step Four, Passive House, or all-electric project is their first such project, you will pay for their beginners mistakes.
To save money and drama, set specific milestones

Owner's Project Requirements
- Hire experienced builder & consultants.
- Set milestones that match your performance objectives.

Pre-Design

- Schematic Design

Design Development

- Construction Docs
- Draw first the details that matter most
- First energy model sets targets (Include 20% buffer)
- Identify windows & ventilation systems
- Second energy model includes all details. (10% buffer)

Pre-Construction

- Construction kickoff
- Review specification for inconsistencies
- PH training for site supervisors, identify air barrier supervisor
- Meet to discuss VE process

Construction

- Site visits & testing
- Enclosure reviews
- Mechanical reviews
- Ventilation commissioning
- Receive energy and embodied carbon approval.

Occupancy

- Training for residents & managers
- Debrief on lessons learned
- Final blower door tests
"There's your first Passive House. Then there's the rest."

ARCHITECTURE OF THE FOSSIL FUEL AGE

ARCHITECTURE OF THE ANTHROPOCENE

Call to Adventure
First Passive House project
Refusal of the Call
“It’s Too Expensive”
Crossing the Threshold
Passing CPHD exam
Trials, Tribulations
Code Officials
Despair, Hopelessness
DSR & Change Orders

Death & Rebirth
Client wants to drop building certification

Return with New Gifts
Building Certification Plaque

Resurrection
Blower Door Test

The Road Back
DSR letter issued

Atonement
Confession to Building Certifier

Revelation
10 kWh/m²a is easier & cheaper

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THESE ARE THE TRUE CONSTRAINTS

ADAPTATION
Wildfire smoke
Overheating
Sea level rise
Overland flooding
Extreme storms
Heat waves
Pandemics

URBANIZATION
Mass migration
Urban populations
Work at home
Shelter in place
Social isolation

MITIGATION
Embodied carbon
Operational emissions
Waste emissions
Upstream emissions

PV & Storage
Elevate or Relocate
Patterns to guide design
Electrification

Large Apartments
Walkable Bikeable
Midrise Rental
Simple Form
Wood Frame

AFFORDABILITY
Homelessness
Underhoused
Land prices
Resiliency
Operation costs

Credit: Monte Paulsen, RDH Building Science

Please email comments to mpaulsen@rdh.com
Thank you.

Monte Paulsen | mpaulsen@rdh.com
Andrew Steingiser | asteingiser@rdh.com

For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com