The Sponsors of Energize Connecticut, and in partnership with Connecticut Passive House, are pleased to offer Passive House & All-Electric Homes 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 Study¹</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 Modeling²</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>Certification³</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 EnEnPHIT certification offerings.

---

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

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

---

Brought to you by

---

Proud Sponsors of
The future of high-performance, all-electric homes starts here.
<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total UA Alternative Compliance or HERS Index Score</td>
<td>Total UA ≥ 75% better than 2021 IECC or HERS Index Score ≤ 55</td>
<td>Total UA ≥ 15% better than 2021 IECC or HERS Index Score ≤ 45</td>
</tr>
<tr>
<td>Heat pump for space heating</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Space Conditioning Connectivity &amp; Controls</td>
<td>Optional</td>
<td>Required</td>
</tr>
</tbody>
</table>
| Heat pump for water heating | Required | Optional | Required
| Hot Water Distribution | Required | Required |
| Envelope Infiltration Rate (ACH) | ACH50 ≤ 2.5 | CFA > 850ft²: ACH50 ≤ 4.0 CFA < 850ft²: ACH50 ≤ 5.0 | ACH50 ≤ 2.0 | CFA > 850ft²: ACH50 ≤ 3.0 CFA < 850ft²: ACH50 ≤ 4.0 |
| Duct Leakage Rate (CFM) | 2021 IECC code minimum requirements | All ductwork must be located in conditioned space |
| Balanced Ventilation Systems | Optional | Required HRV/ERV (>70% SRE / ≥40% TRE) |
| Induction Cooking | Optional | Required |
| Electric Vehicle Readiness | Required | Required |
| **Level 2**             |         |         |
| All-Electric Home Incentive Structure | Level 1 | Level 2 |
| Single Family | $7,500 | $10,000 |
| Single Family Attached | $3,000 | $5,000 |
| Multifamily | $1,500 | $2,500 |

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For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com
Single-Family and Low-Rise
Multifamily Buildings and Townhomes

WHOLE HOUSE MECHANICAL VENTILATION OPTIONS
AGENDA

- Why have “whole house” mechanical ventilation?
- What do the International Codes require?
- What are the options for providing WHMV?
- What are the “best practices”? Does climate matter?
- What are common design and installation mistakes?
- What is required for renovations?
WHY HAVE MECHANICAL VENTILATION?

- Why don’t we just make the building envelope *looser and let the home breathe*?
- How loose should it be?
- Where should we put the holes?
- How do we design “loose” for windy days?
- What about for calm days?
WHY HAVE MECHANICAL VENTILATION?

- Homes have operable windows. Why not just open the windows to let fresh air in?

When it’s 30° outside? Or 90°?
What about rainy and humid?
How many windows should I open?
And where? For how long?
WHY HAVE MECHANICAL VENTILATION?

Mechanical ventilation can be:

- Controlled,
- Predicted,
- Designed,
- Sized, and
- Measured.
HOW MUCH FRESH AIR DO WE NEED?
WHAT DO THE CODES REQUIRE?

IECC R403.6
Mandatory
Building shall be provided with ventilation

IRC R303.4
Air infiltration ≤ 5 ACH50 ...
Building shall be provided with WHMV

IRC M1505.4
Supply, exhaust, or combination
CFM = (0.01 x sf) + [7.5 x (no. bedrooms +1)]
### WHAT DO THE CODES REQUIRE?

**Table M1505.4.3(1) Continuous WHMV System Airflow Rate Requirements**

<table>
<thead>
<tr>
<th>Dwelling Unit Floor Area (SF)</th>
<th>Number of Bedrooms</th>
<th>Airflow in CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-1</td>
<td>2-3</td>
</tr>
<tr>
<td>&lt; 1,500</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>1,501 – 3,000</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>3,001 - 4,500</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>4,501 – 6,000</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>6,001 – 7,500</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>&gt; 7,500</td>
<td>105</td>
<td>120</td>
</tr>
</tbody>
</table>

**Ventilation Rate** = \(0.01A_{\text{floor}} + 7.5(N_{\text{br}} + 1)\)
WHAT ABOUT LOW-RISE MULTIFAMILY BUILDINGS?

2018 I-Codes

**IMC 403.1**
- Supply, exhaust, or combination
- Supply and exhaust approx. equal

**IMC 403.3.3.1**
- Continuous outdoor airflow rate
- \[ Q_{OA} = 0.01 \times A_{floor} + 7.5 \times (N_{BR} + 1) \]

**IMC 403.3.3.2**
- Corridors, common areas
- Min. 0.06 cfm/sf Floor Area
WHAT ABOUT CODE REQUIREMENTS FOR LOCAL EXHAUST?

2018 I-Codes

- Requirements for kitchen and bath exhaust are the same for single-family and multifamily buildings and townhomes.

<table>
<thead>
<tr>
<th></th>
<th>Minimum Required Local Exhaust Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kitchens</strong></td>
<td>100 cfm intermittent</td>
</tr>
<tr>
<td></td>
<td>25 cfm continuous</td>
</tr>
<tr>
<td><strong>Bathrooms, toilet rooms</strong></td>
<td>50 cfm intermittent</td>
</tr>
<tr>
<td></td>
<td>20 cfm continuous</td>
</tr>
</tbody>
</table>
## Fan Efficacy – IECC Table R403.6.1

<table>
<thead>
<tr>
<th>Fan Location</th>
<th>Minimum Air Flow Rate (CFM)</th>
<th>Minimum Efficacy (CFM/Watt)</th>
<th>Maximum Air Flow Rate (CFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRV or ERV</td>
<td>Any</td>
<td>1.2 cfm/watt</td>
<td>Any</td>
</tr>
<tr>
<td>Range Hood</td>
<td>Any</td>
<td>2.8 cfm/watt</td>
<td>Any</td>
</tr>
<tr>
<td>In-Line Fan</td>
<td>Any</td>
<td>2.8 cfm/watt</td>
<td>Any</td>
</tr>
<tr>
<td>Bathroom, Utility Room</td>
<td>10</td>
<td>1.4 cfm/watt</td>
<td>&lt; 90</td>
</tr>
<tr>
<td>Bathroom, Utility Room</td>
<td>90</td>
<td>2.8 cfm/watt</td>
<td>Any</td>
</tr>
</tbody>
</table>
## WHAT CHANGED IN THE 2021 CODES?

### IECC Residential

<table>
<thead>
<tr>
<th>Total Building Performance Path</th>
<th>ERI Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Air leakage testing - ≤ 5 ACH50 <strong>OR</strong></td>
<td></td>
</tr>
<tr>
<td>• ≤ 0.28 cfm per sf enclosure area</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air leakage ≤ 0.30 cfm/sf enclosure area</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Attached single-family and multifamily</td>
</tr>
<tr>
<td>• Dwelling units &lt; 1,500 sf</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate Zones 7 &amp; 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Balanced heat or energy recovery required</td>
</tr>
<tr>
<td>• Min. 65% sensible heat recovery</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Testing required for all mechanical ventilation</td>
</tr>
<tr>
<td>• Exception: some range hood installations</td>
</tr>
</tbody>
</table>

For more information, visit [Building America Solutions Center](#).
### WHAT CHANGED IN THE 2021 CODES?

#### IECC Residential

<table>
<thead>
<tr>
<th>Fan Location</th>
<th>Airflow Rate Rate Minimum (CFM)</th>
<th>Minimum Efficacy (CFM/Watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRV, ERV</td>
<td>Any</td>
<td>1.2 cfm/watt</td>
</tr>
<tr>
<td>Inline supply or exhaust fan</td>
<td>Any</td>
<td>3.8 cfm/watt</td>
</tr>
<tr>
<td>Other exhaust fan</td>
<td>&lt; 90</td>
<td>2.8 cfm/watt</td>
</tr>
<tr>
<td>Other exhaust fan</td>
<td>&gt; 90</td>
<td>3.5 cfm/watt</td>
</tr>
<tr>
<td>Air handler that is integrated</td>
<td>Any</td>
<td>1.2 cfm/watt</td>
</tr>
</tbody>
</table>
WHAT CHANGED IN THE 2021 CODES?

IRC Chapter M1505
IMC 403.3.2.1

- Ventilation rate can be reduced by 30% if the following comply:
  - A ducted system supplies ventilation air directly to each bedroom and one or more of the following:
    - Living room
    - Dining room
    - Kitchen
  - AND
  - The WHMV system is a balanced system.
WHAT CHANGED IN THE 2021 CODES

IECC Commercial

Multifamily Dwelling Units

- Energy recovery ventilation
- Cooling – 50% enthalpy energy recovery
- Heating – 60% enthalpy recovery
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Efficacy w/filter</td>
<td>• Balanced ventilation</td>
<td>• Envelope air leakage: 0.6 ACH50</td>
</tr>
<tr>
<td>• Sone rating</td>
<td>• MERV 13 filtration</td>
<td>• User-controlled ventilation</td>
</tr>
<tr>
<td>• LED or fluorescents</td>
<td>• Bath fans – 30 minute auto-on</td>
<td>• All rooms directly or indirectly ventilated</td>
</tr>
<tr>
<td></td>
<td>• Range hoods exhaust to outside</td>
<td>• Noise: ≤ 25 db(A)</td>
</tr>
</tbody>
</table>
WHAT IS ASHRAE 62.2?

\[ Q_{\text{tot}} = 0.03A_{\text{floor}} + 7.5 \,(N_{\text{br}} + 1) \]

\[ Q_{\text{tot}} = 0.01A_{\text{floor}} + 7.5 \,(N_{\text{br}} + 1) \]
WHAT ARE THE OPTIONS FOR WHMV?

Exhaust-Only - Pros

- Exhaust Only
- Inexpensive
- “Easy” to Design and Install Correctly
WHAT ARE THE OPTIONS FOR WHMV?

Exhaust-Only - Cons

Pulls in “Fresh Air” Through Infiltration

Potential for Condensation

Radon? Contaminants?

De-Pressurizes Home
APPROPRIATE CLIMATES FOR EXHAUST-ONLY VENTILATION

Marine (C) Dry (B) Moist (A)

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star,
Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
WHAT ARE THE OPTIONS FOR WHMV?

Supply-Only - Pros

- Supply Only
- Inexpensive
- Easy to Design and Install Correctly
- Inhibits entry of outdoor pollutants
- Can be filtered

basc.pnnl.gov
WHAT ARE THE OPTIONS FOR WHMV?

Supply-Only - Cons

- Pushes Air Out Through Building Envelope
- Brings in hot/cold/moist air
- Potential for condensation
- Uncertain distribution
- Can feel drafty
APPROPRIATE CLIMATES FOR SUPPLY-ONLY VENTILATION

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
WHAT ARE THE OPTIONS FOR WHMV?

Balanced Ventilation - Pros

~ equal supply & exhaust airflow

No induced exfiltration or infiltration

No depressurization/pressurization

No impact on combustion
WHAT ARE THE OPTIONS FOR WHMV?

Balanced Ventilation - Pros

- Designed points of supply & exhaust
- Supply air can be filtered
- Designed to minimize comfort issues

Source: California Energy Commission
WHAT ARE THE OPTIONS FOR WHMV?

Balanced Ventilation - Cons

- More expensive
- Harder to design properly
- Pre-conditioning of incoming air?
APPRIOPRIATE CLIMATES FOR BALANCED VENTILATION

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
- Bethel, Northwest Arctic, Dillingham,
- Southeast Fairbanks, Fairbanks N. Star,
- Wade Hampton, Nome, Yukon-Koyukuk,
- North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
WHAT ARE THE OPTIONS FOR WHMV?

Balanced with heat/energy recovery - Pros

- Equal supply & exhaust airflow
- Semi pre-heated/cooled supply air
- Semi dehumidified supply air
- No pressurization/depressurization
WHAT ARE THE OPTIONS FOR WHMV?

Exhaust-Only Ventilation

Heat Recovery Ventilation
WHAT ARE THE OPTIONS FOR WHMV?

Balanced with heat/energy recovery - Cons

- More expensive
- Somewhat harder to design
- Somewhat harder to install
APPROPRIATE CLIMATES FOR HRVS/ERVS

Marine (C)  Dry (B)  Moist (A)

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star,
Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
OPTIONS FOR DUCTING MECHANICAL VENTILATION

Direct to/from living space
- Effective
- Measurable
- Comfort issues?

Incorporates central AHU
- Reduced ductwork and labor
- Not measurable
- Expensive to operate
CONTROL OPTIONS FOR MECHANICAL VENTILATION

Code required: Automatic timer with manual over-ride:

- Continuous
- Intermittent

Optional: CO2 demand control
WHAT ABOUT MULTIFAMILY BUILDINGS?
MULTIFAMILY BUILDINGS

Individual fans in each dwelling unit

Central fan serving multiple dwelling units

Ventilation air pulled from corridor or adjacent dwelling unit
BEST (AND WORST) PRACTICES FOR WHMV

Fans poorly located
BEST (AND WORST) PRACTICES FOR WHMV

Fans and ductwork improperly fastened and sealed
BEST (AND WORST) PRACTICES FOR WHMV

Looooong Duct Runs

Convoluted Duct Runs
BEST (AND WORST) PRACTICES FOR WHMV

Ducts properly fastened and sealed
BEST (AND WORST) PRACTICES FOR WHMV

Properly supported

Straight, uncompressed runs
Always a good idea to insulate and air seal!

As you tighten the home, don’t forget about ventilation!
KITCHEN REMODEL

- **PM$_{2.5}$**: typically ~10-20x the EPA 24-hour outdoor guideline (35 μg/m$^3$)
- **NO$_2$**: Exposure from gas stoves frequently exceeds ~100 PPB 1-hour limit

Qualities to look for in a range hood:

- Fan speeds
- Exhaust air flow rate
- Thermostat control
- Ducted to the outdoors (code-required)
- Timer?
- Quiet
KITCHEN REMODEL

IRC – Where provided:

• Ducted to outdoors
• 100 cfm intermittent; 25 cfm continuous
• Makeup air if:
  • > 400 cfm and
  • Unsealed combustion equipment in the conditioned space

ASHRAE 62.2 - Required

• Demand-controlled (manual or automatic) or continuous
• 100 cfm (Demand controlled)
• 5 ACH (Continuous)
• If continuous, readily-accessible manual control required.
Bath fans are always a good idea!

- Eliminate moisture
- Eliminate condensation
- Reduce mold potential
- Reduce deterioration of finishes
BATH REMODEL

IRC – Required if no operable window

- Ducted to outdoors
- 50 cfm intermittent; 20 cfm continuous

ASHRAE 62.2 – Required always

- Demand-controlled (manual or automatic) or continuous
- 50 cfm Demand controlled
- 20 cfm (Continuous)
- If continuous, readily-accessible manual control required.
BATH REMODEL

Noisy, old bath fan

Flex duct poorly installed

Terminates where???

[Images of bathroom renovations: noisy fan, poorly installed duct, unclear termination point]
BATH REMODEL

New efficient, quiet bath fan

Straight, hard ducted run

Properly terminated
WHAT ABOUT WHOLE-HOUSE MECHANICAL VENTILATION FOR EXISTING HOMES?
Air sealing techniques can reduce air leakage to the point that contaminants with known health effects such as formaldehyde, volatile organic compounds, and radon are sealed into the house.

Ventilation also helps control moisture, which can lead to mold growth and structural damage.

Code compliance problems. Study shows 48 percent of bathroom exhaust fans evaluated failed to meet ASHRAE 62.2 required airflow.

As the “old” saying goes….Build tight and ventilate right.
THANK YOU!

NEWPORT PARTNERS, LLC

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JNEBBIA@NEWPORTPARTNERSLLC.COM