All attendees have been placed on mute.

Q&A will take place at the end of each segment.

Webinar will be recorded and sent.

Use the Question Section on the webinar control panel to ask a question at anytime during the presentation.

Submit Responses via PollEverywhere
- Respond at PollEV.com/swa335
- Or text swa335 at 22333 to join, then send your answer
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>
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</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>
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<td>50% of Energy Modeling Costs (90% Design/50% Construction)</td>
<td>$250.00</td>
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<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>
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</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 EnerPHit certification offerings.

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

Go to EnergizeCT.com or call 1-877-WISE USE for more details.

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Workshop 3
High Performance Ventilation
Since 1972, Steven Winter Associates, Inc. has been providing research, consulting, and advisory services to improve the built environment for private and public sector clients.

Our services include:

- Energy Conservation and Management
- Decarbonization
- Sustainability Consulting
- Green Building Certification
- Accessibility Consulting

Our teams are based across four office locations:
New York, NY | Washington, DC | Norwalk, CT | Boston, MA

For more information, visit www.swinter.com
Learning Objectives

- Understand the principles of ventilation and air movement
- Identify various types of heat recovery ventilation equipment
- Describe occupant and building issues resulting from improper ventilation
- Develop a successful ventilation system layout plan
Overview of Presentation

1. High Performance Basics
2. Review central and individual system considerations during design & install
3. Identify testing, adjusting, and balancing issues and solutions

5 min break ~2:50 PM
Wrap Up ~4:00 PM
What is your profession?

A. Architect
B. Engineer
C. Contractor/CM
D. Owner/Developer
E. Consultant
F. Other
What is the one thing that you were hoping to learn about today? (hint: link words with an underscore)
Why are We Here

• Push for Building Electrification (Passive House as a pathway)
• Incentives available
• Benefits
  • Drastically lower energy use and operational cost savings
  • Healthy air quality from ventilation systems
  • Consistent and comfortable room temperatures without air drafts
  • Increased natural lighting and quieter acoustic conditions
  • A more resilient and comfortable building
These Trainings - Each has two parts

- **Workshop 1**: Continuous Insulation
- **Workshop 2**: Air Sealing and Insulation for Homes
- **Workshop 3**: High Performance Ventilation Systems for Homes
High Performance Basics
Goals of High Performance Buildings

- Building durability
- Energy $ reduction
- Optimal thermal comfort
- Superior indoor air quality
- Carbon emissions reductions
The SURE House
Winner of the 2015 D.O.E. Solar Decathlon
www.surehouse.org

Passive House as a Pathway to High Performance

- Thermal insulation continuity
- Thermal bridge free construction
- Solar control
- Airtightness
- Balanced mechanical ventilation
Continuous Insulation
Air-Tightness Blower Door Testing

• Basic Components
  • Gauge (manometer)
  • Shroud
  • Frame
  • Fan
Balanced Ventilation and Heat/Energy Recovery

- Provide fresh, filtered air 24 hours a day
- Heat exchanger +75% Efficient
- Highly insulated and air-sealed ductwork
Questions?
System Design Layout and Considerations
Exhaust Only

Credit: ZH Architects
Balanced Ventilation

Central System

Individual systems

Credit: ZH Architects

SWA Party Wall Blog Post:
https://www.swinter.com/party-walls/multifamily-passive-house-ventilation-design-part-1-unitized-or-centralized-hrv- erv/
Balanced Ventilation – Reminders (PH)

1. Balanced supply and exhaust within 10%
2. Supply to all living spaces
3. Exhaust from kitchens and bathrooms
4. Energy recovery > 75%
5. Supply > 62°F on winter design day

Passive House Recommendations
1. PH certified unit NOT REQUIRED, but most likely needed
2. Fan power efficiency: < 1.0 W/CFM total
3. Allow for a buffer in the energy model for additional fan energy due to duct leakage
Recommendations – for Project Success Design

- Size the ERV such that the standard operating flow rate is approximately 50% of the maximum flow of the unit to optimize efficiency.
  - Allows for additional fan capacity to overcome system leakage.
- Account for buffer in the energy model for system leakage (~10%)
  - Not accounting for leakage could cause failure to meet space conditioning and/or source energy thresholds
- Understand the energy penalty of additional system leakage on the energy model
  - As CFM flow increases, fan energy in W/cfm increases
- Combining ventilation ductwork and heating/cooling system ductwork is very difficult/impossible to construct, verify, and TAB. Avoid.
Individual Systems

- Single ERV for the home or apartment
- Exhaust from kitchens and baths
- Supplies to living rooms and bedrooms
- Supply and exhaust rates to be balanced
- Larger homes will need more duct runs (e.g. ComfoTube)
Individual Systems – Considerations

- ERV placement (ceiling or wall mounted)
- Access to unit
- Ducting layouts & ceiling conflicts
- Adequate space to allow for duct sealing
- Sealing of exterior ERV ports
- Room pressure balancing
- Exterior grille cleaning
- Blower door testing, prep
Individual Systems – ERV Placement

- Wall mounted (closet) vs. ceiling mounted
- Floor space consideration for a cabinet vs ceiling space with potential conflicts
Individual Systems – ERV Closets
Individual Systems – Ceiling Mounted
Individual Systems – Ducting Layouts / Conflicts
Individual Systems – Space for Duct Sealing

- Mastic visible on the ceiling is never a good sign!
- Round duct, face the seams down so they can be sealed rather than pinning to the ceiling.
Individual Systems – Room Pressure Balancing

- Transfer grilles / jump ducts for bedroom pressure balancing
- Required final testing by Verifier for PHIUS requirements
- Would also apply for central systems
Individual Systems – Potential Issues

- Cramped ERV closets
- Difficulty in properly air sealing and insulating exterior wall connections
- 2x wall penetrations, per apartment
- Future maintenance and access to apartments for filter changes
Individual Systems – Potential Issues

- Future maintenance (filter changes, exterior intake port cleaning)
**Individual Systems – Blower Door Testing Prep**

- Need to block of all intake and exhaust ports prior to the whole building blower door test
Central Systems

- Central ventilation rather than individual units allows for easier access and maintenance.
- High efficiency PH certified units typically selected and installed
- Demand control ventilation (DCV) can be implemented to reduce rates when common areas are unoccupied (e.g. gym, community room)
- DX coil can be added to ERV supply to help with pre-conditioning and dehumidification
Central Systems – Sample Layout
• Duct sealing to be visually inspected before being wrapped with any insulation
• Beyond visual, projects are required* to utilize Aeroseal duct sealing technology
Duct Sealing – Ventilation Riser (No Sealing)
Duct Sealing – Ventilation Riser (No Sealing)

Total Flow: 45.9 (1 of 1 devices)
Env Pressure: 49.9
on 1 channel

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<tr>
<td>Disk</td>
<td>Disk 1</td>
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<tr>
<td>Flow</td>
<td>45.9</td>
</tr>
</tbody>
</table>
Duct Sealing – Manual Sealing
Duct Sealing – Manual Sealing (Testing After)
Duct Sealing – Testing After Closer View
Duct Sealing – Seams Sealed minus Back Seam

Total Flow: 23.5 (1 of 1 devices)
Env Pressure: 50.0
on 1 channel

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<td>Disk</td>
<td>Disk 1</td>
</tr>
<tr>
<td>Flow</td>
<td>23.5</td>
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</table>
Duct Sealing – Fog Testing on Site
Aeroseal Duct Sealing

- “Duct sealing from the inside”
- Developed by LBNL in 1994
- Pressurized aerosolized particles forced through the duct systems and build up at leak locations
- No need to manually locate leakage
- Verification of leakage rate
- Can seal leaks up to ½”
Aeroseal Duct Sealing

Before

After
Aeroseal Duct Sealing - Specs

- Don’t do it too early!
- Ensure all components of duct system are installed so all areas receive the sealant.
- Ensure allowable leakage targets are known by the installer.

**Aeroseal Duct Sealing Specification**

*Fractional Leakage*

c. Following completion of air handling unit installations, duct repairs, and duct sealing, test all ductwork to ensure that the air distribution system is properly sealed.

i. The supply ducts shall have air losses of less than 3% of the total air flow volume measured at the fan or air-moving device.

ii. The return ducts shall have air losses of less than 3% of the total air flow volume measured at the fan or air-moving device.

iii. The exhaust ducts shall have air losses of less than 5% of the total air flow volume measured at the fan or air-moving device.

iv. Ducts shall be leak tested at a static pressure that is as close as possible to the system average operating static pressure. Duct test pressure should not exceed the lesser of the duct static pressure construction class, the duct system design static pressure or 2.5 in. w.g.
Other System Components

- Sound level – ventilation system must not be noisy.
  - \( \leq 25 \text{ db(A)} \): supply air to rooms
  - \( \leq 30 \text{ db(A)} \): rooms in non-residential buildings and exhaust air rooms in residential buildings
- High quality F7 filters (MERV 13-14) to filter incoming air pollutants.
- Duct insulation for intake and exhaust ducts with vapor tight seal. R-8.
- Ductwork behind registers needs to be thoroughly sealed.
- A means of balancing air flows is critical. One strategy is to use Constant Airflow Regulators (CARs).
Application and Design

The CAR is a constant airflow regulator designed to save significant amounts of energy and money by precisely controlling airflow in HVAC systems, regardless of static pressure, and still providing high indoor air quality (IAQ). The CAR is composed of high-quality ABS plastic. It contains a self-regulating, non-wearing and spring-returned design to maintain a factory-set airflow pressure. These CARs are designed to operate in a pressure range of 10-30" W.G. (250-750 Pa) and can be used in both static and dynamic conditions. They automatically adjust for variable air pressure caused by building pressure, thermal expansion, duct build-up, and other variable factors. This constant airflow regulator can cost-effectively improve the performance of HVAC systems in high-rise buildings, without the requirement for on-site balancing, electrical protection, or maintenance costs. All CARs are certified by UL-1007 and have UL-2443 listings. An electronic airflow regulator, eCAR, is designed to work in conjunction with the CAR to maintain a constant airflow under normal conditions.

Standard Construction

- CARs are designed to operate in a pressure range of 10-30" W.G. (250-750 Pa)
- They can be used in static and dynamic conditions
- Automatic adjustment for variable pressure causes by building pressure, thermal expansion, duct build-up, and other variable factors
- CARs are certified by UL-1007 and have UL-2443 listings
- An electronic airflow regulator, eCAR, is designed to work in conjunction with the CAR to maintain a constant airflow under normal conditions
Ventilation – Kitchen Filtration

• MERV 13 minimum for ERVs
• MERV 3 or washable mesh at kitchen grille locations (PHIUS)
• Kitchen grilles 6’ minimum distance from stoves in plan view (PHIUS)
Exterior Exhaust and Intake Placement
Questions?
5 Minute Break
What’s wrong with this photo?
What do you see wrong? Image 1
What item(s) do you see wrong, Image 1? (hint: link words with an underscore)
What do you see wrong? Image 2
What item(s) do you see wrong, Image 2? (hint: link words with an underscore)
What do you see wrong? Image 3
What item(s) do you see wrong, Image 3? (hint: link words with an underscore)
What do you see wrong? Image 4
What item(s) do you see wrong, Image 4? (hint: link words with an underscore)
What do you see wrong? Image 5
What item(s) do you see wrong, Image 5? (hint: link words with an underscore)
What do you see wrong? Image 6
What item(s) do you see wrong, Image 6? (hint: link words with an underscore)
What do you see wrong? Image 7
What item(s) do you see wrong, Image 7? (hint: link words with an underscore)
Testing, Adjusting, Balancing (TAB)
Ventilation Tolerances

• Total supply and exhaust are at least 100% of design values and within 10% of each other
  • For PHIUS, minimums especially on exhaust side must be met.
• Air flow measurements at ERV units (traverse) in addition to all grille measurements. Kele FXP measurement for individual ERVs by Verifier.
• Wattage measurement of ERVs
• TAB Requirements
  • Third party (certified air balancing professional)
  • Recommend pre-meeting with TAB contractor to discuss expectations
**TAB Scope of Work**

- **Level of involvement** can depend on the size and extensiveness of the project.
- Single family home, single ERV – balancing could be done by the equipment manufacturer.
- For larger, more complex buildings or systems:
  - **Communication** between balancer, manufacturer's representative, mechanical contractor, controls contractor.
  - **Plan far ahead** to schedule all parties.
  - Be sure that specifications state that balancer must work with manufacturer's rep and/or controls contractor during TAB work.
  - Typically, the TAB contractor is a sub of the HVAC contractor.
The TAB contractor needs to submit the following before starting:

- Their intended procedures
- A blank project specific report
- Marked-up drawings for engineer and consultant review

BEFORE any on-site work, confirm TAB contractor is aware of ALL required measurements.

As much as possible, verifier to be on site the same day as the TAB work begins to ensure all parties are on the same page.
TAB Process

- Engage a certified third party balancing professional (NEBB, AABC, TABB)
  - Have a pre-meeting with the balancer to discuss procedures and expectations
  - Identify flow measuring devices acceptable for the project

- Unitized ERV’s – access strategy must be developed in ERV closet to access the ducts to test for air flows at the unit
  - Some units have built in pressure taps, potentially.

- Central ERV’s
  - Built in display. Straight runs of duct for traverse.

- CAR damper access strategy must be developed
  - CAR dampers typically need fine tuned adjustments by the TAB contractor and factory pre-sets have been insufficient in meeting PHIUS tolerances
Key Findings of LBNL Report - 47382

“Extensive laboratory tests and several field tests have shown that commercially available standard flow hoods do not meet the accuracy criteria for many of the diagnostics that flow hoods are often used for. Their RMS errors are typically in the 20% to 30% range compared to accuracies of 10% or better required for most distribution system diagnostics. In particular, they are inadequate for use in estimating duct leakage, air handler flow and individual register flows for room load and comfort.”

“The laboratory results for the reference active flow hood show an RMS error of only 2%.”
TAB – Instruments

**ANSI/RESNET/ICC 380-2019**
Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems

*American National Standards*

Powered flow hood
**CARs & TAB**

- Placement in duct and physical accessibility. TAB contractor needs to be able to get to the CAR to make adjustments.
- Installation into duct work (tight fit)
- Orientation of the damper
- Don’t install until after Aeroseal
Airflows and Fan Power – Central System

• Readout from the manufacturer’s controller is very helpful to verify the overall air flow rates and the fan power
Airflows and Fan Power – Individual System

- For individual systems, measurements for PHIUS by the Verifier
  - Kele FXP to measure air flow at the unit, in addition to all registers
  - Wattage with either Kill-A-Watt or actual power meter
<table>
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<th>AREA SERVED</th>
<th>OUTLET NO.</th>
<th>TYPE</th>
<th>SIZE</th>
<th>AK*</th>
<th>DESIGN CFM FLOW</th>
<th>ACTUAL CFM FLOW</th>
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</tbody>
</table>
• “Perfect” balancing report, but it was found on site that speed controller was still on factory settings and that no adjustments had been made at all.
• SWA hired to do all the balancing = time / $$$ / certification risk
TAB - Timing

• On larger projects, it may take several rounds of back and forth to get it right.

• TAB is usually the last major item needed to complete right before tenant move-ins. Therefore, the process tends to get rushed.

• Just because a project passes the blower door test, remind them they still need to get through TAB which is critical for certification.
TAB - Resources

• ASHRAE Guideline 11-2018, Field Testing of HVAC Controls Components
• https://www.smacna.org/store/product/tab-procedural-guide
• https://www.tabbcertified.org/
• https://nebb.org/
• https://www.aabc.com/
Recommendations – for Project Success
Construction

• Specify and require ductwork shop drawings and As-Built drawings for review
• Mechanical engineer should be engaged during construction and conducting inspections
• Early engagement of TAB contractor and Aeroseal installer
• Hold contractor trainings to ensure all parties are aware of the project’s goals
• Borescope ductwork prior to Aeroseal installation to find any major disconnects, and/or smoke testing.
• Be on site same day as the TAB contractor to ensure all required readings and set points are being understood and covered.
Questions?
What are your final thoughts and takeaways from the presentation today (hint: link works with an underscore)
Questions & Final Discussion
Join Us for More Trainings!

- **Workshop 1**: Continuous Insulation
- **Workshop 2**: Air Sealing and Insulation for Homes
- **Workshop 3**: High Performance Ventilation Systems for Homes
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Thank You

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