Cost-Efficient Passive House Delivery

Learning from the Massachusetts Experience

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PASSIVEhouse MASSACHUSETTS

Finch Cambridge

Executive Summary

Passive House buildings provide superior comfort, health, resilience, durability, and energy efficiency to owners and occupants. These outcomes are the result of careful design, construction, and testing that ensures tight control of air, moisture, and energy flows. But while the benefits and standards for Passive House buildings are high, the cost premium for delivering them in a large **multifamily building is only 2-3% more than in traditional Massachusetts multifamily construction.**

This combination of compelling benefits and low cost premiums has led to a recent boom in demand for Passive House in Massachusetts. Since 2023, more than **50 cities and towns representing 30% of the state's population have voluntarily adopted energy codes that**

encourage (and for large new multifamily buildings, require) Passive House certification. The state's utilities offer robust incentives for Passive House multifamily construction. But the speed of this transition also means that many companies and individuals will be building Passive House certified projects for the first time. As the Passive House community grows dramatically, **how do we ensure that Passive House buildings continue to be delivered successfully and cost-efficiently?**

In early 2025, Passive House Massachusetts launched an in-depth interview program to help answer this question. Supported by a grant from the Massachusetts Clean Energy Center, we interviewed more than 40 Passive House practitioners—developers, architects, engineers, consultants, verifiers, and contractors—to identify the most pressing educational needs facing the industry today. Together, **our interviewees have worked on 136 distinct Passive House projects across the Commonwealth.** In a competitive industry where experience is a hard-earned asset, they generously shared their time and knowledge to help everyone working in this field.

Our interviewees identified the most pressing needs for Passive House education, which we sorted into five broad categories: **values, planning, whole-building airtightness, ventilation, and role-specific training.**

- **Values:** Passive House projects are smoothest when project contributors come together as a team, internalize a shared mission, proactively reach beyond disciplinary boundaries, and build communication practices to keep everyone on the same page.
- **Planning:** Much of Passive House is not about doing new things, but about doing old things with better planning. We found a wealth of specific lessons in our interviews about how projects succeed, like getting pre-certification early, integrating Passive House details and milestones throughout the project, maintaining effective information flows, and safeguarding the quality assurance process.
- **Whole-building airtightness:** One of the defining features of Passive House buildings is their extremely airtight construction. Despite the tight standards, we found this can be achieved practically and cost-efficiently. The first step is educating everyone on the team—especially the trades tasked with implementing it on site—about the central importance of airtightness. This extra attention is then coupled with special care in the design, detailing, sequencing, installation, and testing phases.
- **Ventilation:** Healthy, airtight buildings require a continuous, filtered fresh air system. Getting ventilation systems right is another crucial area where education can help projects run smoothly. Every ventilation system has its own challenges, but anticipation and management of tradeoffs, combined with a rigorous approach to ductwork and commissioning, can overcome them.

- **Role-specific training:** Everyone on a project, from tradespeople with tools in hand to developers wielding financial projections, can do their job better with Passive House-specific training. For some this should be a formal certification course. For others this may simply be a quick video. Either way, it is important to make sure people get tailored, relevant information about their role.

With these needs in mind, Passive House Massachusetts is leading the charge to make sure this information gets to the people who need it. Based on the lessons from our interviews, we have developed an eight-part educational strategy that we will be rolling out over the next two years:

- **Community events**: Enhancing and expanding our existing "Monthly Meeting" event series and our Annual Passive House Symposium.
- **Short courses:** Revamping our Passive House 100/200 level courses, diversifying our offerings to target specific professions and roles.
- **Trades training:** Developing a trades training pilot program, using a distributed model to effectively reach people on site.
- **Team support:** Exploring mentorship, site visit, and peer support models to help accelerate professional development.
- **Connecting to existing training:** Working closely with our partner organizations to help everyone identify, access, and afford the courses they need.
- **Digital presence:** Overhauling our website to serve as a clear, informative, first point of entry for people at every stage of Passive House experience.
- **Public outreach:** Engaging with audiences beyond Passive House delivery to ensure the broader community understands the benefits of passive building.
- **Continuous improvement:** Using ongoing interviews and surveys to seek feedback about all of our offerings and revise accordingly.

A generation ago, the challenge was how to build buildings better. Passive House has met that challenge, providing a clear roadmap to delivering comfortable, healthy, resilient, durable, and efficient buildings. A few years ago, the challenge was whether all these values could be secured at a reasonable price. But Passive House has met that challenge as well: teams across the Commonwealth have shown over and over again that our buildings can be built to the highest standards for a reasonably low cost. The challenge today is whether we can learn from these successes and scale them, so everyone can share in these better buildings tomorrow. We are confident that Massachusetts is up to this challenge.

Credits

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Interviewees

Gabrielle Aitcheson, ICON Architecture
Sean Barfield, New Ecology
Chris Becker, Callahan Construction Mgrs.
Brian Bourgeois, BLW Engineers
Mike Browne, Advanced Building Analysis
Nicole Burger, Innova Building Advisors
Karla Butterfield, Steven Winter Associates
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We interviewed a further eight Passive House experts who preferred to remain anonymous.

About PHMass

Passive House Massachusetts is a non-profit, member-based organization that promotes healthy, comfortable, resilient, durable, and energy-efficient buildings through education, outreach, and advocacy. Visit us at phmass.org to learn more.

Support

This report was made possible by a grant from the Massachusetts Clean Energy Center, along with continuing support from our members.

Thanks to our Passive House Massachusetts Members

Diamond

Gold

Silver

Bronze

Sustainer

Sole Proprietor

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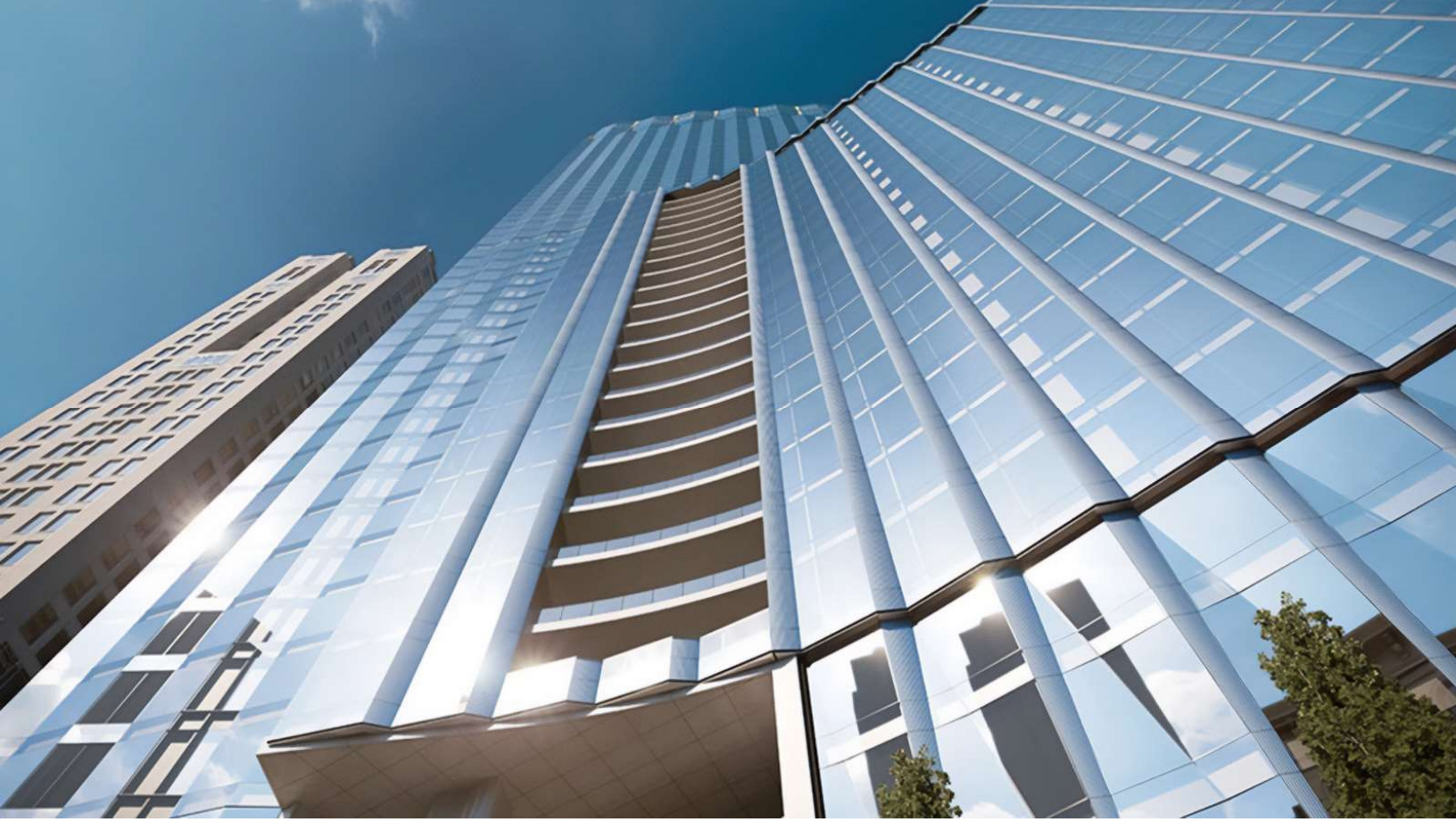


Winthrop Center

Introduction

Massachusetts is the unquestioned leader in Passive House construction in the United States. Massachusetts represents 2% of the U.S. population but has more than 20% of the Passive House projects completed in the United States.

Part of this is because Massachusetts has offered nation-leading support for Passive House building, through MassCEC's Passive House Design Challenge, Mass Save's robust incentives for Passive House construction, and the incorporation of Passive House into the DOER's Specialized Opt-In Energy Code. **More than 50 Massachusetts cities and towns have voluntarily decided to implement the Specialized Code**, which requires that residential multifamily buildings above 12,000 square feet be certified as Passive House.

None of this support or nation-leading demand would be possible without the pioneering work of project teams across the Commonwealth delivering Passive House projects successfully and cost-efficiently. Contractors and consultants, developers and designers have worked tirelessly

to make these incredible buildings a reality. It is their **careful planning, thorough communication, diligent execution, and rigorous testing that has laid such a strong foundation for Passive House in Massachusetts.**

Their work is the heart of this report, which was based on six months of semi-structured, hour-long interviews with more than 40 Passive House professionals from across the industry. Taken together, **they have worked on over 130 distinct Passive House projects in Massachusetts.** They represent a cross-section of backgrounds and roles, helping us to understand every phase of the project development and delivery process.

The biggest lesson of this exercise has been the generosity of these participants. In a cut-throat industry, where time is closely tracked and valued, where knowledge is a competitive advantage, they made themselves available to us. Each bullet point and recommendation in this document represents a hard-won lesson, and they shared their expertise with the explicit goal of helping the industry as a whole move forward. **They demonstrated the same proactive, communicative, community-minded spirit that we believe is at the heart of the most successful Passive House projects.**

This report is broken down into six sections. The first five cover the major categories of educational needs identified by our interviewees as being the most important for Passive House building. **These are values, planning, whole-building airtightness, ventilation, and role-specific training.** The final section lays out Passive House Massachusetts' new educational strategy, built on the results of the interviews and intended to help meet the educational needs they identified.

"We came to understand energy efficiency as the tail of the dog. We have a practice that's focused on getting the building right. Getting it comfortable, operable, durable, affordable, getting all of those things [...] if we get the building right, it will be energy efficient."

Ken Neuhauser, President, Building Evolution Corp.

Dellbrook|JKS

Values

Most of this report is concrete, covering particular procedures teams can learn and implement or specific technical areas that require extra attention and planning. But one of the major recurring themes of the interviews PHMass conducted was that the smoothest Passive House projects are those where teams not only bring the right knowledge, but the right mindset.

This section is both the shortest and yet the hardest to teach. There is no way to guarantee everyone on the team shares a certain set of values (though if you manage to build such a team, keep it together). There is no lesson plan that can automatically instill the right mindset. More than anything else in this report, values need to be learned and cultivated gradually over time. All the more reason to start early.

Successful Passive House delivery hinges on a profound industry shift towards true collaboration, moving beyond traditional siloed roles and fragmented workflows. Collective expertise and a unified effort of the entire project team enables problem solving across disciplines, and ensures that critical details are planned for and executed. This means fostering a team mindset where everyone takes shared ownership of project goals and understands their contribution to overall project success.

- **Understanding the motivation:** Passive House construction demands that all project team members go above and beyond their traditional roles to execute at a higher level. Sometimes this means re-learning or re-assessing habits and skills that people have learned over decades. The best way to help people rise to this challenge is to make sure they understand why this change is happening in the first place: how their work will deliver excellent buildings that stand the test of time.
- **Thinking beyond your role:** Passive House buildings are interdependent systems where critical details depend on multiple overlapping roles, where knowledge from different disciplines needs to be combined. Thinking about how your work impacts other roles, and about what you can learn from other roles, helps anticipate and resolve these interdependencies. Architects, consultants, verifiers, engineers, GCs, the trades: everyone has something to teach everyone else, if they're willing to go outside their discipline and listen.
- **Speaking up proactively:** Passive House projects rely on getting myriad details correct. This works best if everyone touching the project feels empowered to speak up when they see something that is unclear, that needs to be fixed, that can be improved. This is true during design and on site and underscores the need for the GC and trades to be included in design review. If people speak up early and often, problems can be solved cost-efficiently before the project moves on.
- **Committing to the mission:** Even if people understand the motivation for Passive House, it does not necessarily mean they buy into it. There is no way to guarantee commitment. But if people understand the impact of their work, feel empowered to speak up, and see their contributions respected and valued, it increases the chance that they will feel a personal sense of pride in good work and ownership over the project.

"It's really contractor buy-in that gets these projects to succeed quickly without a lot of pain points."

Shari Rauls, Sustainability Consultant, SWA

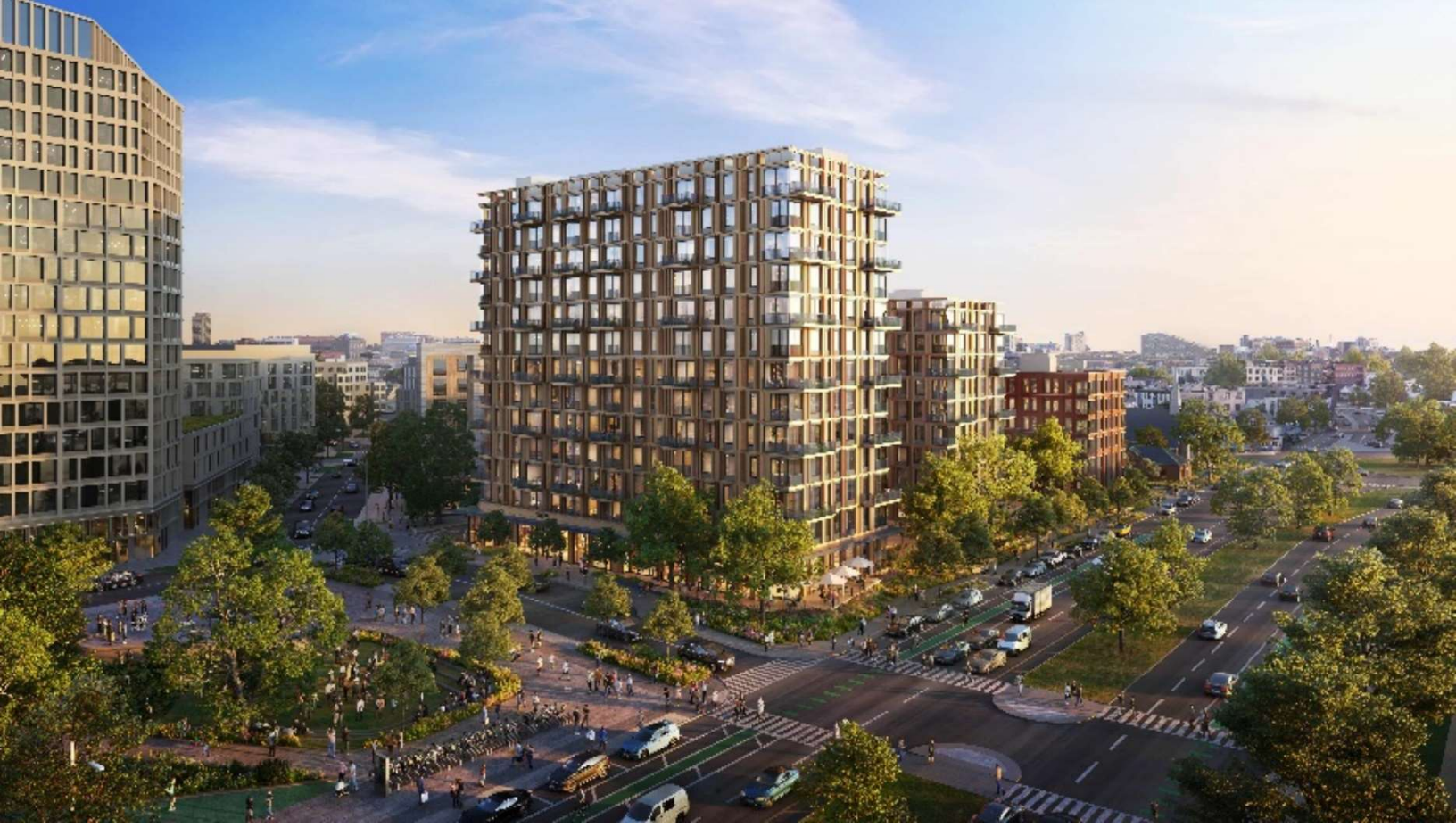
The managers of projects can also take concrete steps to help build these values:

- **Experience:** Try to fill at least some roles with people with Passive House experience, and lean on skilled consultants (see "Hand-Holding" in the Planning Section below).
- **Openness:** When hiring firms or individuals new to Passive House, prioritize openness to learning and receptiveness to new and unfamiliar methods.
- **Visible roadmaps:** Implement clear roadmaps for certification and project goals that are visible to the entire team.
- **Training opportunities:** Seek opportunities for training, both formal (e.g., certified builder certification) and informal (e.g., walk-throughs with verifiers or in-house mentorship programs). For GCs, consider implementing trade education programs.
- **Continuous education:** Prepare for team turnover (including site crews) with a continuous training strategy.
- **Personal investment:** Encourage a sense of personal investment in achieving Passive House goals through friendly competitions, financial bonuses, and company culture of pride in work.
- **Communication support:** Establish communication avenues for all team members, from trade laborers to consultants, to openly contribute ideas, voice concerns, and share field observations.

The smoothest Passive House projects are those where the entire project team cultivates a can-do, problem-solving attitude. This shared commitment, extending from developers and architects to general contractors and trades, directly influences quality, efficiency, and ultimate certification success. If GCs, site superintendents, project managers and others are genuinely on board, their buy-in can transform even a struggling project into one that successfully and cost-efficiently secures Passive House certification.

The Verifier Role

All Passive House projects require formal verification of compliance. For Phius projects, either a Phius Certified Rater (on single family projects) or Verifier (on multifamily and commercial ones) is required. PHI also has a formal Construction Verifier Certification, but this role is not required, and on many PHI projects the verification tasks are fulfilled by a mix of other roles (project certifier, CPHD, GCs, architect, etc.). For simplicity, this document will refer to the third-party compliance role as the verifier, while acknowledging that the person conducting this work may have a different title.



Mary Ellen McCormack Redevelopment

Planning

The most successful Passive House projects adhere to the saying, “Plan your work, and work your plan.” Passive building is relatively new for many practitioners, but careful planning can effectively counterbalance lack of experience. Though any construction project requires forethought and organization, special attention paid to the planning of Passive House projects yields significant savings and better results.

“The kernel of where all the problems come from is a lack of team coordination. I think it all stems from that.”
Jon Erickson, Senior Project Manager, CLEAResult

Communication

Establishing an underlying culture of information flow and collaborative team processes is fundamental for cost-efficient and successful Passive House delivery. A communication-focused approach integrates diverse expertise, breaks down traditional silos between disciplines, and ensures critical data reaches key players. Projects simply can't succeed without effective communication.

- **Foster direct communication channels** and quick feedback loops, avoiding gatekeepers of information and "games of telephone" (e.g., GCs need to speak with verifiers directly vs. through the developer; verifiers need direct communication with TAB teams vs. through the GC).
- **Keep all team members in CC to** ensure comprehensive awareness and facilitate tracking of project information.
- **Use construction management software** such as Procore to centralize tracking of thousands of project documents (e.g., RFIs, submittals, punchlists) and avoid email bottlenecks.
- **Establish communication avenues for all team members**, from trade laborers to consultants, to openly contribute ideas, voice concerns, and share field observations.

Reaching Non-English Speakers

On construction sites, many workers speak languages other than English, creating communication challenges. Effectively conveying Passive House requirements through clear, multi-language education and site signage is important to project budget and success.

- **Develop multi-language site orientations** for the trades, leveraging translation or site orientation software.
- **Utilize site signage** that visually communicates Passive House requirements in multiple languages.
- **In subcontracts, require that trade foremen speak English** to facilitate delivery of Passive House information and quality expectations to diverse crews.

Preconstruction & Design Review

Preconstruction services are an important part of the planning process for any project. On Passive House projects, this is where the heightened requirements, detailed planning, and interdisciplinary coordination converge. Passive buildings require more coordination than many teams are used to. A proactive approach is required to ensure plans are thoroughly vetted and understood before construction begins, avoiding costly rework and certification delays.

- **Budget for GC, verifier, and project certifier to review drawings during SDs**, with a focus on optimization. This may require hiring these roles earlier than in traditional project timeframes or establishing consulting contracts with them. Teams should also apply for project pre-certification early (Design Assurance for PHI and Design Certification for Phius).
- **Include the most critical Passive House requirements directly in drawings**, not just in specifications (e.g., Energy Star checklist items, important product call-outs).
- **Don't punt on figuring out challenging sections of the building:** address these areas head-on.
- **Issue testing and inspection plans to all relevant parties well ahead of time,** detailing what needs to be tested, target measurements, and applicable standards, protocols, and methods.
- **Establish a regular cadence of Passive House-specific meetings** (e.g., weekly check-in calls after OAC meetings).
- **Conduct kick-off meetings at the start of each construction phase,** allowing for early flagging of potential problems.
- **Bring trades together to review overlaps and scopes,** using visual tools like color-coded drawings and schedules to hash out sequencing.
- **Require site foremen to be present at trade preconstruction meetings** so that crucial information reaches the "boots on the ground".

"We try to really identify what are going to be the two or three most difficult conditions on the job and from day one, embrace those. Because it's really easy to focus on the 99% of the building that you understand and not focus on the 1% where you can't quite picture it."

Nat Coughlin, President, L.D. Russo

Timing of "Kickoff" Meetings

Strategically timed preconstruction ("kickoff") meetings with the trades, held immediately before they begin work, addresses the challenge of worker turnover and ensures critical Passive House details and expectations remain top of mind for the trades.

- **Schedule kickoff meetings close to trade's specific start date** to increase information retention and avoid training individuals who may get moved to other projects.
- **Hold regular trade foreman "look-ahead" meetings**, e.g. weekly, to review details relevant to that week's work.

Phius Corequisite Programs

Phius integrates requirements from federal programs like the Department of Energy Zero Energy Ready Homes, and EPA's Energy Star, WaterSense, and Indoor Air Plus into its certification process. Intended to enhance building performance, navigating these corequisite programs requires additional attention and planning for project teams.

- **Integrate corequisite program requirements and checklists** into project documents like drawings, specifications, schedules, and contracts.
- **Highlight requirements** at preconstruction and kickoff meetings to bring awareness to corequisites.
- **Provide clear guidance on standards** (e.g., such as the Energy Star Field Rater checklist) to prevent confusion and simplify field work.

"We've started to slow down at kickoff meetings and actually say why and what we're looking for. And it helps the installers realize why we're asking them to do certain things."

Karla Butterfield, Sustainability Director, Steven Winters Associates

Whole Team Early and Continuous Involvement

Achieving Passive House levels of performance demands a highly integrated and optimized approach from project inception. Though “Integrated Project Delivery” is gaining traction in conventional practices as well, it is a paramount strategy in Passive House building to ensure successful project delivery. Decisions made in early design, if lacking input from key specialists, can lead to cascading issues affecting cost, constructability, and performance.

- **Conduct constructability reviews** with the GC and verifier during early stages of design.
- **Leverage early team involvement to optimize the design** for cost savings, including input from key subcontractors, the GC, verifier, etc.
- **Ensure continuous involvement of the Passive House consultant through the end of construction** to ensure ongoing guidance on certification requirements and updates to the energy model. For Phius projects this is the Certified Passive House Consultant (CPHC) and for PHI projects this is the Certified Passive House Designer (CPHD).
- **Encourage energy modelers to share performance parameters** with the rest of the team to facilitate understanding of how much "wiggle room” they have during testing and commissioning.
- **Include engineers, particularly MEP and structural, in early design charrettes** to integrate mechanical system needs and thermal bridge mitigation into architectural planning from the outset.

Some project teams find success by integrating key Passive House roles like the CPHC/D & verifier or the architect & CPHC/D within the same company. This unified approach, while not required, may streamline communication and decision-making. It may also lead to more efficient project coordination and quicker turnaround times, ultimately supporting a smoother path to certification. Additional benefits could include providing a consistent voice when guiding the project team, streamlined management of extensive Passive House documentation, and efficiently coordinating field changes with energy model updates. Ultimately, every project will have to find the combination of firms and roles that suits its unique needs.

Hand-Holding

The current state of the industry, with its steep learning curve for many professionals, necessitates a higher level of project support than is traditionally expected. This "hand-holding" is a crucial investment, with roles like the verifier, CPHC/D, GC, and certifier often providing services beyond their typical scope to guide project teams, ensure compliance, and ultimately avoid much more costly errors.

- **Consistency:** Especially for teams that are new to Passive House, it can be very valuable to make sure that there are dedicated professionals who are experienced with Passive House delivery and will stay with the project from beginning to end.
- **Consultant budgeting:** Project owners are advised to integrate on-call construction consulting directly into contracts, empowering project teams to seek guidance without fear of additional charges.
- **Getting ahead of pitfalls:** This higher level of service can prevent the much larger expense of reactive troubleshooting, certification delays, and rework that often arise in inexperienced teams.
- **Contingency budgeting:** Carry contingency budgets for retesting, extra site visits, and rectification work.
- **Trades education:** This can also include project-specific, direct on-the-job training for trades, focusing on practical "show and tell" examples and field demonstrations to effectively communicate the importance of airtightness and correct installation.

Value Engineering

Value engineering (VE) is a standard practice during the preconstruction phase to manage and evaluate predicted project costs. In order to preserve critical Passive House components in the budget during project planning, it's important for the team to understand how those components play a key role in successfully meeting project goals and budgets.

- **Educate owners and GCs on *why*** specific Passive House details and components are fundamentally important for performance.
- **Closely review critical line items during value engineering** to avoid inadvertent substitutions or omissions (e.g., substituting one window for a lower-performing one).
- **Emphasize the importance of Passive House consulting and testing services** and safeguard scopes of work that ultimately save the project money (e.g., midpoint airtightness tests).

- **Weigh the mid-to-long-term payback of Passive House elements** against upfront costs (e.g. high performance cladding clip systems that reduce thermal bridging).
- **Avoid changes that could jeopardize certification,** and carefully consider changes if the design has already been pre-certified through Phius or PHI.

"VE is part of every project and that's a great thing: stuff changes in the marketplace. […] But what happens there if you're not really careful, is that critical components can get signed away."

Maciej Konieczny, Director of Green Building Services, New Ecology

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Project Schedules

Establishing a clear roadmap for Passive House delivery is vital to project success. Missed or overlooked milestones can cause significant cost, delays, and rework. Experienced teams utilize the project schedule as a key tool for ensuring Passive House budgets and success.

- **Integrate Passive House milestones** into the general project schedule, so they are visible to everyone.
- **Tie Passive House inspections into the critical path,** preventing trades from proceeding (e.g., drywalling) before necessary verifications are complete.
- **Include time for inspections and testing,** as well as buffers for troubleshooting and QA/QC.
- **Require key team members to be present at inspections,** for example the GC, airsealing, and insulation trades at all open wall inspections and blower door tests to inform remediation work and reduce the need to relay information second-hand.
- **Schedule code official and verifier-led inspections simultaneously** to increase information and knowledge sharing, such as interpretation of blower door results.
- **Use color-coded project schedules** to help trades more clearly understand their role's impact on the project timeline.

"We have all of the Passive House milestones within our schedule. So we have more of a buffer between expected times, and that does give us a little extra time to be more thorough on the really critical elements before they get covered."

Greg Downing, Sustainability Manager, Bald Hill Builders

Contract Documents

Integrating Passive House requirements directly into contract language supports lower production costs and successful project delivery. Beyond merely outlining scope, project contracts could include performance metrics, quality expectations, specification callouts, and information related to testing protocols. Including this type of information in contracts—at both the GC and subcontract level—helps prevent disputes, reduces value engineering risks, and increases adherence to Passive House standards and requirements.

- **Embed relevant Passive House specifics into contract agreements** (e.g., whole-building airtightness metrics) to clarify responsibilities and requirements.
- **For Phius projects, include corequisite program information (**e.g., Energy Star airtightness criteria for ductwork or program checklists as contract exhibits) to highlight these additional requirements.
- **Require written or specific approval for material substitutions**, underlining the vetting process required for changes and potential impacts to the energy model. Keep the CPHC/D abreast of any changes.
- **Review contracts for boilerplate exclusion clauses** (e.g., excluding triple-pane windows) to rectify inadvertent contradictions with Passive House specifications.
- **Define clear expectations and project conditions** within verification scope contracts to reduce the likelihood of projects being unprepared for inspections or testing.

Submittals and Products

Passive House certification relies on specifying materials, products, methods, and performance requirements that go beyond typical construction. The submittal review process on Passive House Projects is essential for confirming that what is ordered, contracted, and installed meets the architectural specification guidelines. To avoid breakdowns in information flow, like unapproved substitutions or delays in review, project teams must implement robust systems for tracking and approving submittals to keep construction on time and on budget.

- **Include the entire project team on submittal communication chains** to ensure everyone can reference approved submittals.
- **Leverage construction management software** to facilitate efficient, simultaneous submittal review, avoid bottlenecks, and keep them organized.
- **Verify products arriving on site against approved submittals**, using digital platforms (like Procore) to check materials in.

- **Vet proposed material substitutions thoroughly via the CPHC/D,** ensuring they meet Passive House performance standards without compromising the energy model.
- **Support trade adherence to specifications** by including spec details in their contractual scope of work.
- **Underline the importance of sticking with approved submittals** rather than "equal" substitutions to reduce CPHC/D review workload.

Materials Compatibility and Transitions

Ensuring continuity of control layers, especially the air barrier, hinges on well planned and executed transitions between different materials and building components. Confirming material compatibility in the architectural specifications and adhering to manufacturer installation instructions are essential for installing products right the first time, especially at transition points.

- **Coordinate drawings** across architectural, structural, MEP sets to resolve discrepancies in materials or transitions.
- **Follow manufacturer-specific installation instructions,** such as the use of adhesive tapes that require rollers for proper adhesion.
- **Leverage product representatives** for specialized trainings and on-site QA/QC checks.
- **Ensure meticulous attention to transitions** between different materials and building components (e.g., slab to wall or parapet connections).
- **Watch out for materials that aren't compatible,** such as the wrong mix of sealant and tape that can cause deterioration or lack of adhesion.

Procurement

Passive House construction does not intrinsically necessitate specialty materials or equipment. However, project documents may specify uncommon products or require "out of sequence" installation. Therefore, to keep costs and schedules in check, teams are advised to examine procurement schedules, lead times, and sourcing early in the project planning process.

- **Highlight unusual and long lead time products** in contracts, designs, and meetings so everyone is aware they can't "just run to the store" or "order them for next week".
- **Research foreign-sourced or unfamiliar products early** to ensure they meet U.S. standards (e.g., "UL Listed") and can be realistically obtained.
- **Obtain window and door data critical to the energy model** from manufacturers before contracting fenestration, to be certain selected brands and models comply with Passive House requirements.

- **Plan for out-of-sequence materials to be delivered on time,** such as mockup supplies or storefront windows integral to midpoint airtightness testing.
- **Stay ahead of typical construction procurement schedules** to avoid unforeseen substitutions that may affect the energy model.

Mockups

Physical mockups serve as indispensable tools for Passive House projects, providing a platform for project teams and trades to practice, test, and refine complex details and sequences before full-scale installation. Though they add cost to a project budget, they can often pay for themselves by streamlining installation and avoiding costly rework.

- **Focus mockups on complex, out-of-sequence, or atypical details**, such as window installations, plane transitions, and exterior penetrations.
- **Utilize mockups as a training tool for trades** to reference proper installation techniques and work through details in 3D.
- **Write mockup reports** and disseminate to the team as part of training materials.
- **Implement functional testing on mockups**, such as smoke or fog testing, to identify air barrier or other deficiencies and resolve them before full installation.
- **Expedite submittal review for mockup components**, enabling their early construction and testing.
- **Discourage value engineering that aims to eliminate mockups**, as they provide crucial constructability insights, promote efficiency, and help to avoid costly rework.
- **Be creative if the budget doesn't allow for a full, stand-alone mockup;** utilize a corner of the building or apartment units to achieve similar results.

Certification Strategy

Achieving Passive House certification means that a building has undergone rigorous, third-party verification and approval to ensure that it meets tough industry standards. While certification involves navigating a sophisticated (and sometimes lengthy) process with evolving requirements, teams are finding ways to streamline the certification process and manage associated costs.

- **Submit project for feasibility study and pre-certification** (Design Assurance for PHI and Design Certification for Phius) to ensure the design meets Passive house requirements before undertaking construction, when it is most cost-efficient to make compliance changes.

- **Leverage pre- and post-construction incentives** from state and federal sources.
- **Make sure the team aligns on the specific certification standard and version for each project** (e.g., PHI Classic vs. PHI Low Energy Building or Phius 2021 vs. Phius 2018), as different projects may be built under different standards or versions.
- **Implement robust documentation processes** that span the entire project lifecycle, employing construction software platforms to support organized information retrieval.
- **Strengthen on-site quality control**, mitigating the risk of certification delays.
- **Keep the as-built energy model up to date with any site changes,** ensuring project still meets certification targets throughout construction.
- **Inform certifiers of any large-scale issues** that could hinder certification, and leverage their resources for problem-solving.
- **Make a plan with your code jurisdiction to address expectations around certification results** if the project is required to achieve Passive House certification to gain Certificate of Occupancy (COO). Clearly lay out the process and contingencies, as this forethought can support delivery of temporary COO if certification is delayed for any reason.

Commodore Builders

Whole-Building Airtightness

Whole-building airtightness is a cornerstone of Passive House performance, delivering operational cost savings and energy efficiency. Additionally, by eliminating uncontrolled airflow, an airtight enclosure enhances durability by minimizing condensation and mold risk, improves indoor air quality, and creates a healthier, more comfortable living environment. Airtightness is achieved through the careful design and installation of materials and assemblies—such as tapes, caulks, membranes, and windows—that work in concert to form a continuous, unbroken airtight system around the whole building. In the rare cases where buildings have failed to achieve certification, the cause is generally a failure to meet whole-building airtightness tests.

- **Promote in-depth understanding** of air barrier importance, means & methods, and testing across all project roles, especially with trades and beginners.
- **Thoroughly vet designs for comprehensive air barrier detailing,** focusing on complex areas where multiple planes intersect, material transition points, and any areas excluded from the Passive House boundary.
- **Review air barrier sequencing** during preconstruction meetings.
- **Provide airtightness details that trades can accurately follow,** including sequencing and material callouts where necessary.
- **Do not rely on specifications** to communicate air barrier intent; include critical airtightness details throughout drawings.
- **Assign explicit responsibility for managing air barrier penetrations** either to individual trades or an overarching airtightness subcontractor to avoid "finger-pointing" later.
- **Encourage site use of tablets vs. printed drawings,** so installation teams can see color coded drawings and zoom in on complex intersections.
- **Include air barrier mini-trainings at tradesperson touchpoints,** such as first-day site orientations and safety briefings.
- **Hang up visual air barrier signage** throughout jobsites and in lifts, to alert and remind workers about penetrations.
- **Implement QA/QC processes to identify air barrier breaches** before they're concealed, when they can still be economically rectified.

"Have a chain of information: if you put a hole in it, let someone know."
Shari Rauls, Sustainability Consultant, Steven Winter Associates

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Midpoint Airtightness Testing

Though not required for Passive House certification, midpoint airtightness testing is used for early detection of air barrier deficiencies when they are most cost-efficient to fix, significantly reducing the risk of expensive repairs and certification delays/defaults. Effectively executing these tests presents its own set of challenges and must be factored into project planning and budget. However, experienced teams tend to incorporate at least some level of airtightness testing during construction, having learned that spending the time and money to test upfront saves expense and headache in the long run.

- **Encourage GCs to conduct their own in-house airtightness testing** to find and repair air barrier issues in preparation for more comprehensive, verifier-led midpoint testing.

- **Employ mid-construction functional airtightness testing strategies**, like smoke machines and IR cameras as a "leak search" opportunity, rather than focusing on a numerical airtightness target.
- **Integrate midpoint airtightness testing into project schedules**, leaving time for troubleshooting fixes afterward.
- **Plan midpoint airtightness testing very early,** coordinating the procurement and installation of long-lead items like commercial storefront glazing or trash room doors.
- **Leverage the knowledge of Passive House verifiers** to structure and conduct midpoint testing, planning for challenges like temporary sealing of incomplete sections.
- **Establish clear expectations** for shutting down the building during formal midpoint testing (e.g., no one in or out), ensuring more accurate blower door results.
- **Implement zoned, unit, and/or window air infiltration testing** on large or phased projects, which provides actionable data without waiting for the entire air barrier to be complete.
- **Protect midpoint testing from value engineering cuts;** it generally pays for itself.
- **Allocate sufficient time and budget for airtightness testing**, recognizing that projects may require multiple rounds of testing.

"Test the air barrier at the correct time. It's this timing issue: you want to test it when it's early enough that you can spot mistakes, but you also want to test it when it's late enough that there aren't big mistakes to jump over."

Margaret Dean, Energy Rater, Sustainable Comfort

Drawing the Passive House Boundary

Complex areas designated as "outside the Passive House boundary"—such as parking garages, laundry rooms, or retail spaces—can become significant points of air leakage, undermining overall building performance. Some experienced teams include all or most of the building within the Passive House boundary, finding this approach more cost-efficient for meeting stringent airtightness goals and simplifying complex interface detailing. However, other projects may exclude certain areas of the building for cost or constructability reasons.

- **Simplify building geometry and envelope design**, avoiding "complex origami" transitions and plane changes.
- **Closely consider whether or not to include optional spaces** like egress stairwells, shafts, commercial areas, and community laundry rooms within the Passive House boundary.

- **Review project plans for constructability and** sequencing regarding the air barrier.
- **Explicitly define the air control layer in drawings** when areas are carved out of the Passive House boundary.
- **Ensure interior partitions of excluded spaces** are treated as exterior assemblies (e.g., compactor rooms, walls adjoining stairwells).

"There's a lot of black and white thinking: 'I have an air barrier, it's continuous and we're sealing it, therefore we'll have a tight building.' But every time you introduce a penetration, a turn, a transition, those always add air leakage to your total. Every time you add new complexity, it will increase the air leakage of the building."

Mark Newey, Managing Principal, Airtight Energy Consulting

Podium Construction

Podium-style buildings, with unconditioned ground levels (like parking garages) beneath or adjacent to conditioned spaces, present persistent challenges to Passive House airtightness due to complex transitions, trade sequencing, and equipment plenums. These unconditioned areas are convenient for running MEP materials, yet the resulting air barrier penetrations require meticulous attention. Addressing these complexities early with careful detailing avoids costly rework and delays.

- **Address airtightness details where unconditioned podium areas meet conditioned spaces,** ensuring plans specify wall types and include all transition points.
- **Engage GCs and MEP trades** to review and pay close attention to airtight details of drop chasses/plenums, including access hatches and penetrations.
- **Focus on sequencing** to ensure air barrier details are installed ahead of materials that complicate air sealing (such as fire retardant sprays).

"We build a lot of podium style buildings with steel and garages at the ground floor and wood above. And that transition by far has been the most difficult to detail airtight connections and execute in the field."

Gabrielle Aitcheson, Director of Sustainability, ICON Architecture

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Trash Chutes

Trash chutes, commonly found in multifamily buildings, are vertical shafts that allow residents to dispose of waste from each floor. Combined with the associated first floor compactor room, these chutes may either be included or excluded from the air boundary. Either solution presents airtightness challenges due to the large number of required access hatches, garage-style rollup doors, and negatively pressurized roof vents. To avoid costly rework and delays, careful attention must be paid to the lowly trash chute during design and installation.

- **Determine early whether to include or exclude trash chutes** from the air boundary to allow for proper product selection and scheduling.
- **Address roof penetration sequencing**, detailing how chutes are tied into the air barrier and review during kickoff meetings.
- **Ensure MEP contractors account for** airtightness requirements of trash chute shafts, which are often used for electrical and mechanical chaseways.
- **Plan for logistical complexities** of sealing trash chutes, as the small, enclosed space makes internal access impossible.

Windows & Doors

Windows and doors are critical to a Passive House's aesthetics, thermal performance, and function. Achieving stringent installation airtightness, however, requires careful planning and execution, sometimes involving unfamiliar products or processes. Fortunately, cost-efficient fenestration options exist on the market, and prioritizing simple design detailing greatly contributes to efficient installation.

- **Use hinged windows**, specifically avoiding sliding windows (e.g., double-hung) in order to meet airtightness requirements. Simulated double hung windows are an option to meet historic district or aesthetic requirements.
- **Choose hinged doors over traditional sliding doors** for airtightness unless high-performance, gasketed “sliding” doors are specified.
- **Engage window manufacturers early in preconstruction** to confirm their products meet Passive House performance requirements.
- **Only select fenestration brands** that are able to provide the necessary data for Passive House energy modeling, avoiding “like” substitutions that fall short.
- **Consult with window manufacturer representatives** (especially for unusual or European-style windows) for installation troubleshooting and trade education.

- **Provide specialized trades training** on installation details, particularly for less familiar systems like mid-mount windows with clip attachment systems (e.g., mockup training by GC).
- **Perform window QA/QC early** to catch errors or refine instructions before widespread installation is performed and repairs are necessary.
- **Include window installation airtightness testing** as part of mid-construction tests.
- **Plan for exterior door air leakage in the energy model,** due to limited market solutions for entry doors that also meet commercial fire, life safety, and ADA standards.

"Look at the bulk air [leakage] of one window versus another window and put dollar signs on it, and say you're going to be owning and operating this building for years. After 25 years, you're looking at $100,000 worth of heat loss [...] that's a level of analysis that we have started doing for our developers that they haven't had previously."

Kai Fast, Sustainability Specialist, Kaplan Thompson Architects

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Compartmentalization Testing

Compartmentalization (or unit airtightness) testing is a crucial corequisite for Phius projects via Energy Star. Unit-level airtightness ensures individual dwellings are air-sealed from each other and common spaces. While compartmentalization airtightness targets are less stringent than whole-building Passive House requirements, educating trades to consistently achieve specific levels of compartmentalization airtightness saves costs in QA/QC and repair efforts.

- **Perform compartmentalization airtightness testing early** to improve execution of airtight detailing and reduce risk of repeating deficiencies.
- **Provide compartmentalization airsealing training to trades,** such as "airtight drywall" methods for unit compartmentalization, particularly for novice project teams.
- **Focus compartmentalization airsealing efforts on common leakage points**, such as perforated data panels, unsealed medicine cabinet cavities, and MEP penetrations.
- **Clearly assign responsibility for "who owns the hole"** and whether each trade or a specific airsealing contractor will perform final airsealing measures.

Leland House

Ventilation

Continuous, filtered, fresh air systems employing energy recovery ventilators (ERVs) or heat recovery ventilators (HRVs) are essential for airtight buildings, delivering exterior air economically and efficiently. These systems provide exceptional indoor air quality, enhance durability by mitigating moisture, and offer quiet ventilation in urban settings. Smart planning and great installation are needed to ensure proper air flow, effectively meeting precise Passive House ventilation requirements, and avoid inflating project budgets.

- **Align all project team members**—including HVAC installers, testing and balancing (TAB) contractors, GCs, verifiers, and MEP engineers—regarding commissioning, testing, and certification requirements.
- **Include verifiers, GCs, and MEP engineers** in early design discussions about ventilation specs and components.

- **Model ventilation system energy performance on realistic, building-specific operation,** recognizing that manufacturer-provided HRV/ERV efficiency data may be insufficient. CPHC/Ds should avoid relying on defaults when modeling, and input project- specific parameters.
- **Integrate access for future commissioning and maintenance** for dampers, equipment, and components (e.g., for changing filters or troubleshooting dampers).
- **Question traditional HVAC design assumptions** and shift toward Passive House-specific and low-load requirements, utilizing right-sized systems and proper layouts.
- **Get on the same page about ventilation testing methodologies, equipment, and targets**, particularly verifiers and TAB teams and those working on Phius projects where corequisite programs are required.
- **Train building managers on ventilation equipment maintenance and operation**: these systems require regular upkeep and malfunctions can go unnoticed.
- **Require airtight ductwork** and ensure GCs and trades understand how to achieve it and the "why" behind it.
- **Perform comprehensive QA/QC of ductwork** installation focused on airtightness and straightforward runs that avoid bends and kinks, and then test it for leaks.
- **Finalize testing and balancing before building occupancy** whenever possible to avoid prolonged commissioning or certification delays.

Ventilation System Strategy

Ventilation systems can be centralized, semi-centralized, or in-unit (unitary). Each method has its own set of benefits and drawbacks, so every project must determine the best strategy for a particular building's goals and constraints. However, there are some universal guidelines that apply to any style of ventilation system.

- **Understand that every approach involves some trade-offs;** there is no perfect ventilation system.
- **Underscore ventilation and airtightness targets** during preconstruction meetings to raise awareness of differing standards from conventional construction.
- **Gather information about buildability** by engaging key stakeholders early, such as verifiers, GCs, HVAC and TAB teams.
- **Stress comprehensive engineering of ventilation system and delivery** to support precise airflow rates at all registers (e.g. clash detection for ductwork layouts to avoid unnecessary bends).
- **Design "wiggle room" into HRV/ERV capacity and energy model** when possible: specify equipment that can run at a higher rate as a backstop if sufficient flow rates are not achieved.

Ventilation Strategy Considerations

- **Holistic cost evaluation:** How do comprehensive costs compare to upfront costs alone, once balancing, certification, maintenance, and operational costs are considered?
- **Interdependencies:** Does a failure in one part of the system affect multiple areas?
- **Number of air barrier penetrations:** How does the system affect whole building airtightness?
- **Air intake and exhaust locations:** What visual or physical constraints are present?
- **Maintenance access:** Do building managers require permission to enter apartments for equipment upkeep? Are systems designed with maintenance in mind, such as filters in easy to access locations?
- **Ventilation flow rates:** How to achieve minimum CFM requirements at all registers? Are additional exhaust-only ventilation or "boost" functions being considered?
- **Floor space requirements:** Does the system necessitate dedicated mechanical space inside the building? Does it take away from the rentable area?
- **Energy budget limitations:** Which strategy(ies) work within the energy model?
- **Balancing:** How to accomplish effective balancing? What happens if required ventilation rates cannot be achieved everywhere necessary?
- **Minimum ventilation requirements:** Will the minimum CFM requirements meet this particular building's needs? Does it work for the type of tenants expected?

"Ventilation, ventilation, ventilation, ventilation.
It's the Achilles' Heel on any project."
Experienced Passive House consultant and verifier

Ductwork Install/QC

Quality ductwork design along with airtight ductwork installation is foundational to delivering precise ventilation airflow rates. While proper ductwork is also important for space conditioning systems, the design, execution, and quality control of ventilation ductwork is especially crucial to successfully meeting stringent Passive House requirements and avoiding unnecessary costs. Ductwork sealing typically relies on careful manual application of mastics and/or tapes, but interior pressurized duct sealing may be used in addition to or in lieu of manual strategies. This type of system closes leakage points from the inside and can be performed after ductwork runs are inaccessible.

- **Design ductwork comprehensively**, avoiding incomplete plans that require trades to improvise suboptimal ductwork runs in the field.
- **Perform clash detection of HVAC ductwork** in 3D modeling software to ensure installers have clear pathways to avoid unnecessary kinks and bends.
- **Include Passive House (or Phius corequisite) ventilation airtightness requirements in subcontracts**, requiring duct installers to achieve higher quality manual sealing upfront.
- **Consider airtightness ductwork testing before ducts are covered** or become inaccessible to support optimal ventilation delivery and trade education of expectations.
- **Perform thorough QA/QC of ductwork as early as possible,** to reduce remediation costs and ensure systems can be balanced during commissioning.
- **Consider including pressurized duct sealing**, such as Aeroseal, in project contracts or as a contingency item ("belt and suspenders" strategy).
- **Support GCs to develop more thorough knowledge of HVAC** design, installation, and testing to effectively perform QA/QC.

"The devil's in the details. Are you doing nice smooth takeoffs in your ductwork or, is it all these kinks in there? Because that's just going to boost your fan energy and not deliver the needed ventilation or air flow. There's a lot that can be done on the HVAC detail side and on the field inspection side to make sure that the system is functioning as it's designed to."

Experienced Passive House engineer

Commissioning

After ventilation ductwork and equipment is installed, commissioning is a critical final step in Passive House construction, ensuring systems, ductwork, and airflow rates meet stringent performance and energy use limits. While typically performed late to protect installed components from construction debris, efficient execution of this phase relies on seamless collaboration between specialized TAB (testing and balancing) subcontractors and Passive House verifiers to accurately balance systems and align final testing reports for certification.

- **Establish direct communication channels** between TAB, GC, and verifier teams, especially when the TAB team is hired by HVAC subcontractors.

- **Educate TAB team on Passive House ventilation requirements** that differ from typical industry standards.
- **Ensure verifier is present at start of work with TAB contractors** to align understanding of ventilation requirements and testing methods.
- **Calibrate equipment to address measurement discrepancies** from one piece of equipment to another, especially between TAB and verification teams.
- **Require specific testing equipment in project specifications and TAB subcontracts** (e.g., for measuring low airflow rates or specific damper styles).
- **Implement oversight of TAB reports**, recognizing that Passive House verification may uncover inaccuracies.

Damper Design and Accessibility

To control and fine-tune ventilation rates within ductwork, various damper styles are employed, ranging from manually adjustable options like "butterfly registers" to auto-adjusting constant airflow regulators (CARs). Regardless of type, **strategic selection and integration of dampers are crucial for cost-efficiently achieving optimal ventilation system performance during both design and commissioning.**

The use of CARs requires special attention be paid to their design and installation, especially with centralized ventilation strategies. While CARs are often specified in part because they can offer a simple and cost-efficient solution for airflow distribution, they require top-notch ventilation system installation to ensure proper function. CARs are not designed to be manually adjusted and may not be accessible once ductwork is complete—therefore QA/QC becomes a critical component of their use.

- **Determine the overall ventilation and damper strategy upfront,** ensuring early communication and whole-team alignment.
- **Design for accessible dampers** to allow for troubleshooting or addressing malfunctions.
- **Design centralized ventilation systems to address building pressure imbalances,** such as those caused by stack effect.
- **Learn from projects where CARs have been successfully implemented** to understand their practical application.
- **Implement rigorous QA/QC** to mitigate the potential for certification delays related to ventilation systems.
- **Request clear guidance on the measuring and balancing of ventilation systems** that rely on dampers, especially those involving CARs.
- **Align testing and balancing strategy** with specific damper requirements, as testing equipment itself may affect pressure within the ductwork and thus CAR function.

Dellbrook|JKS

Role-Specific Needs

While many of the lessons learned from our interviewees were relevant across many roles on the project team, there were also a wealth of lessons that were specific to individual roles. Many of the topics discussed here are covered in formal courses offered by organizations like Phius, the Passive House Network, Emu Passive, Built Environment Plus, the Studio for High Performance Design and Construction, and Passive House Massachusetts itself. The discussion here is not driven by dissatisfaction with these offerings, but acknowledgement that education is always a challenge:

- **Not everyone has taken or will take these courses.** PHMass actively works to encourage more members of the industry to obtain formal certifications, but even in an

optimistic scenario most people working on a Passive House project will not have a formal Passive House qualification. All tradespeople would likely benefit from the full PHI Certified Passive House Tradesperson or the Phius Certified Trades Professional courses, but at most only the forepersons and supervisors will likely be able to take them.

- **Even once people have taken a course, some lessons will be forgotten.** Construction involves an immense volume of information and not everything can remain top of mind.
- **In some cases there is no clear certification course.** There is no "Passive House for Developers" certification, though developers are encouraged to take the Phius Foundations Training or PHI Fundamentals Training and would benefit from the Phius Certified Builder (CPHB) or PHI Certified Passive House Tradesperson (CPHT) courses as well.
- **Every course has a finite amount of time to convey information.** Instructors are always making tough choices about what to emphasize. There are plenty of critical Passive House concepts that are not discussed in this report because they have successfully been drilled into everyone taking these courses.

Hopefully the lessons here will help inform the next generation of courses and new ways of offering Passive House education to everyone who needs it.

Trades

The biggest single gap in Passive House education today is providing consistent, targeted training to the construction trades. The trades are crucial to delivering PH projects successfully and cost-efficiently. Every choice made by developers and designers ultimately needs to be implemented by trades on site. All too often, tradespeople receive insufficient information about how working on a Passive House project differs from traditional projects. Trades often rise to the challenge in spite of this, but the smoothest projects are those where everyone on site is given the information they need to succeed.

> **"The trades are the key to making this thing successful."**
> *Experienced manager at a general contractor*

Passive House Essentials

There are basic pieces of information that everyone on a Passive House job site ought to know:

- **Explain the why:** If a tradesperson with 30 years of experience is suddenly being asked to change how they do their job, they will work better if they know why. They deserve to understand how the higher levels of precision and care required by Passive House projects deliver health, comfort, resilience, durability, and energy efficiency to occupants. And they should understand that someone is going to be checking their work throughout the project against rigorous standards.
- **Protect the air barrier:** Almost every tradesperson carries a cutting tool or transports materials that can penetrate the air barrier. Everyone on site needs to understand the importance of avoiding unnecessary penetrations and fixing or reporting them when they occur.
- **Open communication and clear points of contact:** Even the most skilled, trained workers will run into problems. Someone will accidentally penetrate the air barrier. Some details will be unclear in the plans. Problems communicated early can usually be dealt with simply and cost-efficiently. Problems that are not communicated risk being covered up, only to be detected later when the cost of fixing them is much higher. Everyone on site needs to feel empowered to raise issues or questions, and know which person they should bring them to.
- **Follow architectural designs and specifications:** Following specifications is always a good idea, but it is particularly important on Passive House projects where design performance can depend heavily on particular products and installation methods. Teams should implement processes to ensure that specifications are followed, (e.g. including relevant specs within subcontracts as callouts or exhibits, then checking product deliveries against approved submittals).
- **Follow manufacturer instructions:** Strictly follow manufacturer instructions for material compatibility, sequencing, and installation. Details matter, like using a roller for air-sealing tapes to ensure proper adhesion.

"The trades really rise to the challenge,
as long as they're educated on what the goal is."
Nat Coughlin, President, L.D. Russo

Trade-Specific Topics

There are also many pieces of trade-specific information that need to be communicated. Given the importance of ventilation and whole-building airtightness, some of the highest-priority occupations include:

- **HVAC installers:** Need to understand how crucial tight ductwork and reducing bends is for Passive House projects. Extra education on the complexities of centralized, low-flow ventilation and how to install specific products (like CAR dampers) correctly is also important.
- **HVAC testing and balancing (TAB) contractors:** Need to understand there is much higher level of scrutiny for their work, especially in a low-flow environment where margins for error are much tighter. In traditional projects a 1 CFM shortfall would not be cause for concern, but in a low-flow environment it may mean the difference between compliance and noncompliance. TAB contractors also need to make sure their equipment and testing protocols are suitable for the strict standards involved with Passive House. It may also be worth exploring a new certification specifically focused on testing and balancing.
- **Trades involved in air sealing:** Need to understand basic fundamentals of airtightness and the much higher level of airtightness required on Passive House projects. Techniques and methods used for airtightness on traditional projects can fall short on Passive House projects. The myriad contractors that interface with the air barrier need to understand the central importance of keeping airtightness continuous and following manufacturer instructions to ensure products are compatible and installed correctly.

This is far from an exhaustive list: HVAC, electrical, plumbing, drywall, fire protection, framing, window, and concrete contractors (among others) would all benefit from trade-specific information on Passive House delivery. For some of these groups, the trade-specific information might be brief but vital.

Delivery

There is a wealth of Passive House information and training available today, but most of it is offered on a "if you build it, they will come" model of events and classes people choose to attend on their own. This model can suit early adopters, jobs requiring particular certifications, and white collar professionals seeking continuing education credits. But this model works less well for tradespeople, especially those who may not even know they will be working on a Passive House project.

There are multiple ways to deliver this information: on-site training sessions, pre-construction and "kickoff" meetings, on-site mockups, short videos at job start, signage on the job site, and integration into existing training programs for new tradespeople all have a role to play. However it's delivered, training needs to be efficient and to the point. Training needs to happen as close as possible in time to the job being done. Training ought to be delivered in the audience's native language whenever possible. And supervisors and foremen are not the only audience that needs this training: everyone working on site needs to be prepared for success.

General Contractors

General contractors are the key interface between the design and construction sides of project delivery. While Passive House definitely adds new items to GCs' long list of tasks, over the whole project lifecycle it can actually make some things easier, as the rigorous review process throughout the project can identify issues early.

As with the trades, it is crucial to provide GCs with the motivation behind Passive House, not just the technical standards. This motivation needs to be shared not only with management, but with other staff like site superintendents, assistant superintendents, assistant project managers, estimators, and the like. Passive House depends on those roles—especially field staff—understanding how correct execution of every detail is tied to overall project success.

In general, GCs leading successful Passive House projects have often learned the value of taking a more proactive approach to their role:

- **Reevaluate traditional techniques and materials** which may no longer be appropriate, especially for airtightness.
- **Take more responsibility for subcontractor preparedness,** working with verifiers and educational organizations to make sure all the trades coming on site are properly prepared for Passive House work.
- **Increase coordination** between subcontractors, verifiers, engineers, and architects, making sure nothing falls through the cracks.
- **Identify overlaps and gaps in trade scopes,** especially around air sealing and unit compartmentalization. It may be worth exploring whether multiple scopes related to air sealing can be consolidated to create clarity of responsibility.
- **Take more responsibility for quality control.** "Spot the Problem" training is particularly useful for GC staff, to identify things like unsealed ducts or poorly detailed air barriers by eye.

- **Schedule airtightness testing at the right time,** as problems that are easy to resolve when exposed become much harder to identify and correct after they are covered by later work.
- **Review sequencing of procurement and installation closely,** as Passive House may require out-of-sequence materials delivery and techniques to meet project goals (e.g., installing commercial storefronts before midpoint testing or airsealing before fireblocking).

Part of this can and should be delivered through formal training. All GCs should have staff that have completed a builder course like PHI's Certified Passive House Tradesperson (CPHT) or Phius' Certified Builder (CPHB) course. Project managers and site superintendents are particularly crucial targets for additional PH training.

"I think most subs and GCs really want to learn how to do Passive House. They know it's the wave of the future."

Mark Norton, Energy Rater, New Ecology

In-House QA/QC

In traditional construction, many subcontractors provide their own quality control, meeting well-understood code and installation requirements with minimal oversight. Due to the rigor of third-party verification, Passive House projects benefit from GCs implementing heightened levels of QA/QC to ensure a project will pass inspections and meet certification requirements, avoiding costly rework:

- **Assign dedicated Passive House QA/QC roles** within the GC's team, such as a "Passive House Specialist" or "Air Boss." These dedicated individuals, often assistant superintendents, conduct daily monitoring of subcontractor work, act as the project specialist for Passive House details, and serve as the primary point of contact for verifiers and Passive House-related roles. This role requires a keen eye for details, and is best served by someone with some Passive House field experience.
- **Implementing robust internal inspection processes** with detailed checklists and immediate feedback to trades serve as effective on-the-job learning tools and improve installer accountability. Thoroughly inspecting each scope at each stage (e.g., confirming all penetrations are sealed before drywall) also drastically reduces the need for expensive rework later in the project. GCs can also leverage technologies like hardhat-mounted cameras for automatic recording during walk-throughs or drones for comprehensive QA/QC of inaccessible exterior areas.

- **Set clear procedures and expectations,** emphasizing adherence to specs and material installation procedures (e.g., cross-checking deliveries against approved submittals, following proper air barrier sequencing at parapets) and establishing protocols for penetrations to the continuous air barrier.

The rigorous QA/QC required for Passive House projects also has the benefit of catching errors that are currently made in the course of traditional construction, but that go uncaught. This is a core added value of Passive House that should be factored into cost considerations.

Verifiers

The first educational need related to verifiers is simply to train more of them. As this role does not exist on traditional construction projects, having enough verifiers to meet the rising demand for Passive House projects means increasing supply. But as we do so, it is crucial to make sure people are trained for what a verifier actually does.

There is real variation in verifier scopes in the industry. Some focus narrowly on the verification (and sometimes testing) work implied by the name, with a focused skillset comparable (for example) to a HERS rater. But on many projects, especially complex multifamily projects, the verifier is acting not only as the person confirming the project meets certification targets, but also as a testing agent, crucial coordinator, educator, field problem-solver, and hand-holder. This "all-purpose" version of the verifier's role is often a critical contributor to the success of large and small projects alike, especially when other members of the project team are new to Passive House. It depends on having a sufficient background in construction, as well as a thorough knowledge of building science. But this can go far beyond what an entry-level verifier, even one coming from another certification program like HERS or Energy Star, is necessarily equipped or trained to do.

Here are some key training priorities for verifiers, especially those who will be providing more holistic services on projects:

- **Early and proactive involvement** on projects is crucial. Verifiers should be brought in during Design Development along with enclosure and MEP trades to offer cost optimization ideas, advise on midpoint testing strategies, and identify design omissions and issues. Verifiers need to be empowered (and qualified) to speak up to other experts on the project team and raise issues early.
- **Substantive construction and building science knowledge** are both crucial for verifiers. Verification is not an entry level position. They also need to be able to

translate between plans and reality, moving constantly between details as designed in 2D and details as implemented on site.
- **Clear scopes of work** are especially important given the range of norms in the industry today. If the verifier is going to work "above and beyond" it should be reflected in their contract so they can plan and charge accordingly. Verifiers need to learn how to be explicit about the distinctions between their minimum scope of work and additional services (like early testing, consulting, on-call questions, and trades training) they can offer.

Growing the pipeline of verifiers while also making sure that they have sufficient knowledge of construction and building science is a non-trivial task. Verifiers are good candidates for more rigorous, hands-on training-and apprenticeship programs. It is also worth exploring more continuing education and knowledge-sharing opportunities for verifiers given the complexity and centrality of their role in delivering Passive House projects successfully.

Passive House Consultants (CPHC/CPHDs)

The Certified Passive House Consultant (Phius) or Certified Passive House Designer (PHI) has a crucial role to play in connecting all design decisions with modeling inputs, building the energy model, and consulting on certification requirements that underpin the entire Passive House project. While having a certified consultant is not formally required by either certifying body, many professionals (especially on multifamily and commercial projects) seek certification training to fulfil this role. Despite the rigor of this training, there are still lessons for people serving in this critical role:

- **Continuity:** While in theory it is possible for the CPHC/D to complete the energy model and fulfil their design consultation role then hand the project off to other team members, inevitably there are field changes that require as-built updates to the energy model to assure continued compliance. Having a CPHC/D who can stick with the project and provide consistency and consulting during construction is very valuable. This ongoing support should be written into their scope. If the CPHC/D is not remaining with the project until completion, someone else needs to be clearly vested with the relevant responsibilities.
- **Modeling limitations:** Energy modeling programs like the PHPP, WUFI Passive, and THERM are powerful but they have limitations. CPHC/Ds should be aware of challenges related to changing climates, overheating, and water/energy use patterns of building

inhabitants that may differ from generic assumptions. Project-specific inputs are recommended.

- **Modeling buffers:** CPHC/Ds should also be aware that generic energy data from equipment manufacturers may not accurately predict a project's mechanical energy consumption. Instead, energy models should be based on the specific building's design and local climate, and it may be wise to buffer equipment energy assumptions to ensure installed equipment will meet certification requirements.
- **Further education:** While CPHC/Ds may already have thorough modeling training, they should also be able to provide more holistic knowledge of Passive House and building science principles (similar to that of a verifier, see above). Having CPHC/Ds obtain experience in project execution could help them fulfill this role more effectively.

Architects

Architects make myriad choices that shape passive buildings, with crucial impacts on cost and deliverability. Design is the least expensive time to set projects on an effective, efficient course. Certification, budget, and overall project success all depend on thoroughly applying Passive House principles at the early design stages. There are three main areas for improving architectural education related to Passive House.

The first is better training on Passive House fundamentals:

- **Construction management and cost optimization:** This should include not only Passive House fundamentals, building science, and energy modeling training, but also training on Passive House project management and cost optimization. More architects should consider taking the builder certification courses offered by PHI and Phius, for example, which cover applicable topics to architects involved in Construction Administration.
- **Low-load mechanical systems:** Architects could also benefit from specific training related to mechanical systems for low-load buildings. While they are not responsible for designing these systems, understanding how traditional assumptions are altered in a Passive House context is crucial for effectively coordinating architectural and MEP drawing sets.

The second is better training on Passive House detailing:

- **Ownership:** Architects should own Passive House design details from the outset, rather than relying on consultants to suggest drawing revisions to incorporate these critical elements. Taking existing plans meant for traditional buildings and simply sticking Passive House details on top is not an effective way to work.

- **Constructability and sequencing:** These are always important concerns for architects, but become even more crucial in a Passive House context with multiple important vapor, air, thermal, and bulk water control layers interacting in complex ways. Leveraging GCs and key trades to advise on constructability during Schematic Design is valuable.
- **Energy modeling proficiency:** Enables architects to communicate more effectively with the CPHC/D. More importantly, being able to work in the energy model provides the architect with a quick feedback loop on how design decisions impact Passive House outcomes.
- **High level of detail:** A high level of detail is vital. Anything not detailed in the plans will be detailed in the field. Architects can also make more use of growing Passive House detail libraries and build their own to leverage great examples and avoid duplicate work. The CPHC/D is a crucial resource, but cannot be responsible for all Passive House details. Passive House architects will likely need to provide more visual guidance (e.g. elevation drawings) on varying conditions and assemblies than they have been accustomed to do on traditional projects.
- **Visualization:** Clear graphic representations are very useful for getting things built correctly. Explicitly visualizing air and thermal control layers in plan and section views, particularly at complex transitions or where the building edge shifts, can help avoid misunderstandings. Colored drawings can be especially helpful for critical elements such as the air barrier, and separate drawing sheets devoted to Passive House detailing are also worthwhile.
- **Determine the Passive House scope early:** Architects should push to define the Passive House boundary as early as possible to avoid costly design changes later in the process. Examples include detailing podium construction transitions, commercial spaces, elevator shafts, egress stairwells, and trash chutes (especially when areas of the building are excluded from the Passive House boundary).

The third priority is learning to seek early review and input from certifiers and consultants. Architects on successful Passive House projects often do this already, seeking early review by the verifier and a buildability assessment by a general contractor. Massachusetts also offers incentives to help cover costs of review by certification bodies (PHI Design Assurance or Phius Design Certification services). While this can add some cost, it is also the least expensive time to make changes and can save large amounts during project construction.

"When you can find a design team that's thinking about how to actually put the framing together, sequence things so the subcontractors are flowing, that makes it go smoothly."

Karla Butterfield, Sustainability Director, Steven Winters Associates

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Structural and MEP Engineers

Engineers are in many ways well-equipped to work on Passive House projects: Physics and building science do not change regardless of certification standard. But there are areas where Passive House projects require engineers to change how they work, and where education can help.

- **Adapting to low loads:** For MEP engineers coming to Passive House for the first time, it is crucial to understand how very different load requirements impact their decision choices. Rules of thumb and assumptions that are deeply embedded in traditional practices need to be thrown out. Given the dangers of oversizing HVAC equipment, and the potential cost reductions from right-sizing, engineers can benefit from training on Passive House-specific load calculations and certifications like CPHC/D.
- **Ventilation:** MEP engineers can also benefit from targeted education around ventilation, and the importance of making sure everyone on the project team understands the requirements and how they will be met. This is especially important when there are multiple competing requirements from different standards at play. Engineers also need to understand that Passive House buildings utilize expressly balanced ventilation systems and do not employ pressurized building strategies.
- **Thermal bridging:** Structural engineers must work closely with the architectural and CPHC/D teams to design structural elements that align with Passive House goals. Thermal bridging is of utmost concern for these projects and mitigating even small thermal bridges (e.g. cladding standoffs and fasteners) may be required to meet energy requirements for certification. A deep understanding of Passive House metrics is advised for structural engineers, and specialized training like CPHC/D courses allow engineers to “speak the same language” as others on the design team.
- **Downstream impacts:** Like architects, engineers can benefit from education and feedback around constructability. Getting feedback from and engaging with GCs and trades responsible for carrying out instructions can be valuable for refining designs. For example, it is worth paying particular attention to ductwork clash detection or sequencing difficulties in thermal break installation. Similarly, their decisions impact project verification, equipment commissioning, and building maintenance, and engineers should take into account these downstream impacts.
- **Energy modeling proficiency** enables engineers to learn more about how their equipment choices and layout impact Passive House outcomes.

Developers

As the financial authority over projects, developers hold the ultimate "carrot and stick" for managing costs. While not responsible for the details of project implementation, they make many crucial decisions that shape the successful delivery of Passive House projects, and are a key audience for education:

- **Investment:** Passive House is different from traditional building. It is not simply another box-ticking exercise that adds another label; it requires serious and dedicated attention and investment. This requires that developers spend money on consultants and allot extra time and budget for design, verification, and certification.
- **Acting early:** Making financial investments early in the project pays itself back many times over, helping to keep costs down throughout the rest of the project and avoiding unnecessary delays and change orders. Bringing the team together as early as possible helps identify issues when they are less expensive to solve. Even if the GC or verifier has not been contracted yet, these roles can be brought in on a consulting basis at the earliest phases. Developers need to understand how hiring a verifier with a higher quote but a more extensive scope may ultimately save them money, especially if other members of the project team are inexperienced.
- **Long-term benefits:** Added attention to planning and design produces real benefits once the building is complete, both for owners and occupants. Developers need to understand how the enhanced health, comfort, durability, resilience, and energy efficiency of Passive House buildings positively affect the pro forma and the value proposition of their project. Passive House building provides much higher levels of quality assurance, ensuring developers are getting what they pay for in their investment.
- **Keeping the team together:** Once a project has been completed successfully, developers should consider "keeping the team together" where possible to preserve the multidisciplinary networks and trust that a Passive House project can build.

"There are two pieces to building these things cost-effectively: optimization and then not making mistakes where you have to go back and fix 'em."

Jon Erickson, Senior Project Manager, CLEAResult

Passive House Massachusetts Annual Symposium

Educational Strategy

Passive House Massachusetts has long been leading high-performance building education in the Commonwealth, providing regular events and courses taught and attended by many of the people who have made Passive House such a success here. But as the scale of Passive House building is changing, our approach to education is changing as well. Our model is shifting from one targeting primarily early adopter professionals to serving a broader range of audiences in a broader range of venues. We are simultaneously overhauling our existing offerings and developing, piloting, and refining new ones. At the same time, we are carefully shepherding our resources as a small non-profit and collaborating with other organizations as much as possible. As we go forward, we are also continuously seeking feedback to improve and refine how we support the Passive House community.

Community Events

Passive House Massachusetts will continue to offer and improve our robust series of open community events that allow the community to learn together while advancing Passive House adoption.

- **Monthly speaker series:** We are continuing our monthly evening learning and networking event series that regularly draws 50-100 attendees in downtown Boston and online. These usually offer PHI, Phius, and AIA continuing education credits and cover a range of topics relevant to the Passive House community.
- **Annual symposium:** The theme of this year's 2025 Annual Passive House Symposium is "Raising Standards, Lowering Costs." This showpiece full-day event will examine cost control strategies from across the design and construction lifecycle. In a change from previous years, we have launched a public call for proposals to solicit the best ideas from across the industry. This theme will also carry through to next year's Monthly Speaker series.
- **Expanded geographical reach:** We are exploring opportunities to connect with audiences outside of the greater Boston area by holding events in other parts of the state as well, especially where the Specialized Opt-In Energy Code has been adopted.

Passive House Short Courses

Passive House Massachusetts has traditionally offered a PH101 Introduction to Passive House course and a PH201 Advanced Passive House course. Looking ahead, we will be refining and expanding these offerings to meet the needs identified in this report.

- **Revamped introductory course:** We are overhauling our Passive House 101 course, redesigning it from the ground up to be a more useful and comprehensive introduction.
- **Role-specific advanced training:** We are shifting away from a single "advanced" 201 to distinct 200-level sessions specifically tailored for architects, engineers, general contractors, developers, and others, informed by our interviews and feedback from past course attendees.
- **Expanded audience reach:** Traditionally we taught our courses to employees at 1-3 large companies at the same time. We are developing new collaborations with partners like the Boston Society for Architecture (BSA) to efficiently deliver courses to other audiences, particularly professionals from smaller firms and code officials.

Trades Training Pilot

Despite their critical role in on-site execution, many tradespeople working on Passive House projects do not receive any dedicated training in Passive House methodologies. Both Phius (Certified Trades Professional) and PHI (Certified Passive House Tradesperson) offer their own trades-focused courses, but these are significant time commitments that are unlikely to reach everyone who needs training. Outside of these courses, trades training in Passive House has been inconsistent and has relied on proactive GCs and verifiers designing and implementing trades instruction themselves. In addition to encouraging people to take the formal courses where possible, PHMass will also launch a pilot program to reach the rest of the workforce.

- **Targeted, concise content:** We will develop short training modules that target each trade's specific work as it relates to Passive House requirements.
- **Emphasizing the "why":** Understanding the big picture of Passive House (e.g., why the air barrier is critical) can make the difference between a smooth, cost-efficient project and one with delays.
- **Scalable delivery methods:** We will pilot low-cost, scalable approaches such as training others to become trainers and creating multi-lingual videos and signage, rather than relying on on-site direct instruction for every project.

Team Support

Moving beyond initial training, PHMass will focus on accelerating the learning curve for new Passive House professionals and teams, recognizing that sustained, hands-on support is essential for transitioning from novice to experienced practice.

- **Early project intervention:** Trial outreach to new Passive House project teams to make sure they have the resources they need as they start their projects.
- **Mentorship program:** Investigate the development of a mentorship program for Passive House professionals, with a potential focus on supporting new verifiers given their crucial role in project success.
- **"Pay It Forward" project visit program:** Explore a program where experienced teams invite newer teams to observe critical project milestones firsthand, such as mockup demonstrations or midpoint blower door tests, fostering direct knowledge transfer and Q&A sessions.
- **"Best practice" share-out sessions:** Encouraging teams to share tips & tricks, lessons learned, and optimization techniques.

Training Navigation

There is already a wealth of Passive House training available beyond PHMass, including formal certification courses as well as articles, short videos, webinars, and conferences. But navigating all these rich resources can be a challenge for someone just getting started in the industry (and even experienced professionals can sometimes struggle to know where to go). PHMass is committed to helping members of our community navigate this complex training landscape.

- **Targeted guidance:** We will help individuals and organizations navigate the two Passive House certifications and connect them to specific information, courses, and certifications relevant to their roles. We will help make sure that options are accessible and affordable.
- **Role recruitment:** We will be exploring opportunities to collaborate with workforce development organizations to address specific shortages in the industry, like the supply of Passive House verifiers.

Digital Resource Hub

Building on our commitment to streamline access to Passive House resources, PHMass plans to undertake a comprehensive overhaul of our digital presence. This initiative aims to transform the site into an intuitive, centralized digital hub for Passive House professionals and stakeholders.

- **Entry portal for newcomers:** Our website will serve as a primary entry point for individuals and companies new to Passive House, guiding them through foundational concepts.
- **Comprehensive navigator:** Our website will provide a robust resource navigator, directing users to relevant training, certification pathways, and other essential resources, both from PHMass and external organizations.
- **Resource hub:** Our website will offer clear explainers, curated links to educational content, and highlight successful Passive House projects and case studies.

Broader Public Education

While PHMass' primary focus remains on supporting Passive House professionals, the widespread adoption and success of Passive House hinge on understanding and engaging with the broader community and jurisdictions statewide. We actively reach out to and address questions from groups seeking to understand the benefits that Passive House offers their locale.

- **Widespread engagement:** Actively engage with cities and towns considering stretch code adoption, as well as other key players such as real estate agents, building inspectors, building owners and residents, and environmental advocates. We are exploring a "circuit rider" program to reach some of these audiences around the state.
- **Value proposition communication:** Tailor our messaging to ensure these varied groups understand the benefits that Passive House construction brings to their needs.

Continuous Improvement

This report represents the culmination of a six-month interview program. But it does not represent the end of our efforts to listen to our community. To make sure we are using our resources wisely, we will continue to gather input and feedback on Passive House educational needs and how our efforts to serve them can be improved. We will continue to use interviews as well as regular surveys of event and course attendees to refine our programming. We will also use pilot programs to test novel content and models before scaling them to broader audiences.

Glossary

- **Air barrier:** A continuous plane designed to control air flow through the building envelope, preventing unwanted air leakage. Used interchangeably with “air control layer” and "airtightness" in this document, and references the Passive House airtightness standards developed independently by PHI and Phius.
- **Architectural Development phases:**
    - **PD:** Preliminary Design is the initial phase, focused on high-level concepts, project goals, and feasibility studies.
    - **SD:** Schematic Design is the second phase where the design is developed to a more concrete level, including major systems and a general layout.
    - **DD:** Design Development is the third phase where the design is refined, major systems are specified, and details are worked out in preparation for construction documents.
    - **CD:** Construction Documents is the final phase where detailed drawings and specifications are created for bidding and construction.
    - **CA:** Construction Administration is the ongoing phase when the design team responds to questions (RFIs) and ensures the project is built according to plans.
- **Architectural document types:**
    - **Assembly:** The combination of building materials and components that create a complete structural or non-structural element, such as a wall or roof.
    - **As-built Plans:** The final set of project drawings that document the changes made during construction, reflecting the actual conditions of the completed building.
    - **Design (or Plans):** The collection of drawings and documents that illustrate the project's layout, dimensions, materials, and construction details. The “Plan Set” includes pages for structural and mechanical engineering designs.
    - **Details:** Specific, enlarged drawings that show the precise construction and assembly of building components, especially at junctions and transitions.
    - **Specifications Documents ("Specs"):** Detailed written instructions that complement drawings by defining the quality, materials, and performance of building elements. Accompanies the Plans to create
- **Blower door:** A diagnostic tool used to measure a building's air tightness by pressurizing or depressurizing the interior to find and quantify air leaks. Made up of a fan or set of fans mounted into a framework that fits into a doorway or window,

multifamily buildings may require simultaneous multiple blower doors to account for the particulars of a given building.

- **CFM:** Cubic Feet per Minute, a unit of measurement for airflow volume in ventilation systems.
- **Energy model:** A software-based simulation (e.g., Phius WUFI or PHI PHPP) that predicts a building's energy consumption and performance, and is used to weigh architectural and design choices based on project targets and goals.
    - **As-built energy model:** An energy model that has been updated to reflect the final, as-built conditions of the project.
- **ERV:** Energy Recovery Ventilator, a mechanical system that provides filtered, fresh air while recovering heat and moisture from exhaust air to improve efficiency. Can large units that serve entire buildings, or smaller units that serve individual or small groups
- **GMP:** Guaranteed Maximum Price, a contract type that sets a maximum price for a construction project, beyond which the contractor absorbs additional costs.
- **IPD:** is a collaborative project delivery method that brings key stakeholders together from the earliest stages of design to optimize costs and project outcomes. It requires certain roles (such as GCs and key trades) to be selected earlier in the process than in more antiquated “Design-Bid-Build” systems of project delivery.
- **Kickoff meeting:** An initial project meeting where the team, typically the GC and key trades, aligns on goals, roles, schedules, and communication protocols. In the case of Passive House, these meetings may also include other roles such as consultants and architects for better collaboration and information flow.
- **"Look Ahead" meeting:** Regular coordination meetings held on-site, typically between the GC and trade foremen to cover upcoming work over a one or two week period
- **MEP:** An acronym for Mechanical, Electrical, and Plumbing, referring to the building systems that provide heating, cooling, power, water, and sometimes fire prevention. These trades are typically grouped together because this work requires specialized licensure and inspections, and their work must adhere to engineering requirements.
- **Mockup:** A full-size or scale model of a building assembly or component used to test design details, materials, and installation methods. It may be a stand-alone unit or occur on a section of a building, and is often used to train trades and as a point of reference for sequencing and proper installation through construction.
- **OAC meeting:** A regular project meeting that includes the owner, architect, and contractor to discuss progress, issues, and decisions.
- **Passive House, passive buildings:** A high-performance building of any typology (single family, commercial, institutional, multifamily, etc.) focused on drastically reducing energy demand while delivering exceptional building durability, resilience in extreme weather events, health, comfort, and energy security.
- **PHPP:** the Passive House Planning Package is a software tool developed by the Passive House Institute (PHI) to help design and verify PHI new construction and EnerPHit

(retrofit) buildings. It is an Excel-based tool that predicts a building's energy performance. For Phius projects, see WUFI Passive.

- **Phius corequisite requirements:**
    - **DOE ZERH:** Department of Energy Zero Energy Ready Home is a program requiring buildings to be “net zero ready” whereby a renewable energy system can offset their annual energy use.
    - **ES:** EPA Energy Star is a program that certifies energy-efficient products and homes that meet strict energy efficiency guidelines set by the U.S. Environmental Protection Agency.
    - **IAP:** EPA Indoor Air Plus is a program that verifies homes meet a set of construction specifications designed to improve indoor air quality and reduce health risks.
    - **WS:** EPA WaterSense is a program that promotes water efficiency by identifying high-performing, water-efficient products and practices. Note that only some requirements of this program are required by Phius.
- **Preconstruction:** The planning phase before physical construction begins, involving design development, budgeting, and scheduling. Preconstruction occurs mainly during the design phase of a project, though may continue into the construction phase.
- **Punchlist (“Punch”):** A list of small, unfinished, or defective items that need to be completed or repaired by the GC or trades before final payment. Often requiring construction management software to effectively manage multiple trades in big buildings, punchlists are also part of contract documents.
- **RFI:** Request for Information, a formal document used by GCs and trades to clarify missing or conflicting information in the project drawings and/or specifications. RFIs are tracked by multiple roles and become part of the record of project documentation.
    - **ASI**: Architect’s Supplemental Instruction, similar to RFI and typically used for minor changes or clarifications.
- **(Project) schedule:** Typically tied to contract documents, the project schedule is an in-depth document with many interlocking scopes of work and sequences.
    - **Critical path:** The sequence of tasks that directly affect the project’s completion date. Any delay in a critical path task will delay the entire project, and therefore carries a lot of importance within the Project Schedule. Specific Passive House requirements, such as testing and inspections, may be on the critical path and therefore incorporated into Project Schedules.
- **SOW:** Scope of Work in this context is typically tied to contract documents, it is a document that defines and enumerates tasks, deliverables, and milestones for a project. The SOW for trades may refer to specific methodologies, products, and metrics and may refer to certain sections of the Architectural Specifications for required details.
- **Standards-setting bodies** (related to Passive House and other high-performance building delivery methods):

    - **PHI:** the Passive House Institute, one of two major international organizations that set a Passive House building standard. Founded in Germany in the 1990s.
    - **Phius:** one of two major international organizations that sets a Passive House building standard. Founded in the US in the early 2000s, it mainly operates in the U.S. and North America.
    - **ASHRAE:** American Society of Heating, Refrigerating and Air-Conditioning Engineers; develops industry standards for building systems, including energy efficiency.
    - **HERS:** Home Energy Rating System Index is a numerical representation of a home's energy efficiency. The lower the HERS score, the more energy-efficient the home or apartment. HERS raters are certified through RESNET-accredited training.
    - **ISO:** International Organization for Standardization; an independent, non-governmental organization that establishes internationally recognized frameworks of guidelines, rules, and best practices, developed through global consensus among experts, including topics like thermal comfort, heating demand calculations, material thermal resistance and transmittance, airtightness measurement, and more.
    - **RESNET:** Residential Energy Services Network is a non-profit organization that establishes standards for home energy ratings and certifications. It develops and maintains the Home Energy Rating System (HERS) Index. RESNET provides the framework and methodology for measuring and verifying home energy performance through the HERS program, whereas ASHRAE provides foundational standards that inform and complement RESNET's work.
- **Submittals:** A formalized review process for pre-approval of materials and techniques that a contractor or trade submits to the architect, engineer, and/or CPHC/D before purchasing or installing materials. Submittals can number in the hundreds or thousands for large buildings, so robust tracking, document organization, and approval systems must be employed.
- **THERM software:** a 2D heat transfer modeling software developed by Lawrence Berkeley National Laboratory. It is primarily used to analyze heat transfer through building components, such as walls and windows, and is widely used in the building science field, helping to identify areas of heat loss and improve energy efficiency.
- **Thermal bridging:** An area of a building envelope with a significantly higher thermal conductivity than the surrounding materials, allowing heat to bypass the insulation layer.
- **Value engineering:** A systematic process to improve a project's value by finding alternative materials or methods to reduce costs without sacrificing performance or quality.

- **WUFI Passive:** a building energy modeling software used for designing and analyzing Phius buildings. Developed by Fraunhofer IBP and Phius, it provides tools for evaluating thermal and moisture behavior within building assemblies in addition to predicting energy use. For PHI buildings, see Passive House Planning Package.

Passive House Project Roles

- **CPHC/D:** Certified Passive House Consultant (Phius) or Certified Passive House Designer, a certified professional who builds and updates the building Energy Model. This role consults with the design team to ensure Passive House principles, metrics, and targets are met by the intended design.
- **GC (general contractor):** The primary party responsible for overseeing and managing the day-to-day operations of a construction project. This role may or may not self-perform some trade scopes.
    - **PM (project manager):** The individual responsible for the overall planning and execution of a building, including managing budget, schedule, and team.
    - **Assistant PM:** Sometimes called "project engineer", this role is responsible for managing much of the required documentation for a project (e.g. change orders, submittals, and RFIs).
    - **Site super (superintendent):** The on-site manager responsible for the day-to-day supervision of construction activities and coordinating trades.
    - **Assistant site super:** An individual who assists the site superintendent with daily on-site management and coordination tasks.
- **HVAC (heating, ventilation, and air conditioning):**
    - **HVAC installers:** The tradespeople responsible for installing the heating, ventilation, and air conditioning equipment and ductwork.
    - **TAB team:** The Testing, Adjusting, and Balancing team, who commission, balance, and verify ventilation system to ensure it performs as designed. May be contracted directly by the GC, or subcontracted by the HVAC trade.
- **MEP engineers:** The engineers who design the mechanical, electrical, plumbing, and sometimes fire suppression systems of a building.
- **Owner/developer:** The individual or entity that owns the property and funds the project.
- **Owner's rep:** A consultant hired by the owner to represent their interests and provide oversight of the design and construction process.
- **Trade roles:**
    - **Foreman:** A lead tradesperson who supervises a crew of workers within a specific trade.
    - **Trade PMs:** Project managers who work for a specific trade subcontractor, overseeing their scope of work, schedule, and budget.

    - **Subcontractor** (interchangeable with **“sub”, “trade”, or “tradesperson”** in this document): an individual or company hired by the GC to perform a specific portion of the work.
- **Verifier:** See breakout section in report. All Passive House projects require formal testing. For Phius projects, either a formally certified rater (on small projects) or verifier (on large ones) is required. PHI also has a formal Construction Verifier Certification, but this role is not required, and on some projects the verification tasks are fulfilled by a mix of other roles (project certifier, CPHD, GCs, architect, etc.). For simplicity, this document refers to the testing/verification role as the verifier, while acknowledging that the person conducting this work may have a different title.