Phius 2024

PASSIVE BUILDING STANDARDS CERTIFICATION GUIDEBOOK

phius

v24.1.1
September, 2024

Phius 2024 Passive Building Standards

Certification Guidebook

Version 24.1.1

September 2024

Table of Contents

0 - About Phius Building Certification

0.1 Introduction

The Phius Standards are high-performance building standards that challenge the building industry to construct and rehabilitate buildings that maintain a comfortable indoor environment with very low operational energy consumption. Phius' climate-specific standards were first developed in 2015 through the U.S. Department of Energy (DOE) Building America Grant. Since then, the standards have evolved to also account for changing market conditions and other variables such as building size, occupant density, cost and climate.

Historically, the operational energy consumed by a building over its lifetime has exceeded the embodied energy required to construct and maintain the building. Low energy buildings, however, shift the balance between operational and embodied energy impacts and make consideration of embodied energy more critical than is the case with traditional building practices. A historic illustration of embodied versus operating energy is shown in Figure 1.19 (a), while Figure 1.19 (b) illustrates how the balance shifts with increased efficiency.

The Phius standard is a pass-fail standard for building energy performance, with additional requirements for quality assurance inspections, and for low-moisture-risk design.

Technologies, market conditions, carbon reduction goals and our climate change over time. Consequently, Phius is committed to regularly revising the standards to reflect such changes. Phius 2024 is the third iteration and marks the next step towards making net zero universal. This updated standard expands in two key areas:

1. Re-evaluation and rubric for retrofit projects and
2. Re-optimization for multifamily projects.

Under Phius 2024, the same level of granularity is used for the climate-dependence of the heating/cooling criteria. For more information on the development of the Phius Standards, visit Appendix A and Standard-Setting Documentation.

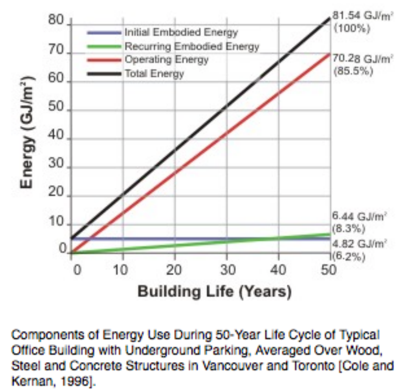


Figure 1.19(a). Example comparing operating energy and embodied energy of a building.

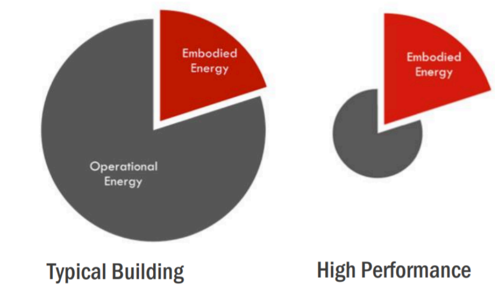


Figure 1.19(b). Example comparing embodied energy in typical vs high performance buildings. Source: West Coast Climate Forum

0.2 Reasons to Certify

The Phius certification process is the best way to design and construct any building, from single-family homes to multi-unit apartments and commercial buildings. As part of the process, Phius' seasoned reviewers are brought onto your team to provide guidance and support for all project submitters.

The Phius Certification process:

Includes third-party verification

This ensures the building is constructed as designed to meet the high-performance standards for energy use and critical systems are commissioned into proper operation. Additionally, third-party verification is a typical requirement by the incentive programs of utilities and governments.

Introduces risk management

Passive building requires special attention to moisture control and ventilation. Phius Certification staff and third-party QA/QC professionals can identify potential problem areas at the design stage before they become real-world problems.

Builds and shares knowledge

As more scenarios, project types and solutions pass through the certification process, Phius pays it forward to project teams through direct feedback. Project teams in turn help build the public Certified Project Database. All of which feeds future updates to this Guidebook.

Designed with policies to grow passive building

With the addition of the QA/QC process and Phius' partnerships with DOE's Zero Energy Ready Home program and ENERGY STAR for Homes, Phius projects are now able to gain more performance-based incentives. Visit the Phius Policy Database for more information on local and national policies.

0.3 About the Guide

The main goal is to help your project team design and execute high-performance, high-quality buildings and avoid as many pitfalls as possible.

This Guidebook contains the following kinds of information, roughly in the order for which they are relevant in the building delivery process:

- The certification process, pricing, and roles of the parties involved
- Design-phase requirements, for all certification paths, including Performance, Prescriptive, and REVIVE
- Energy modeling protocol
- Construction-phase requirements

0.4 Project Team Roles & Responsibilities

Delivering a high-performance building requires exceptional cooperation between the design professionals and the building professionals. "Design-build" or "integrated-project-delivery" organization is more common in passive building and often mentioned as a success factor.

It is highly recommended that a CPHC® (Phius Certified Consultant), Phius Certified Builder, and Phius Certified Rater or Verifier are all involved. However, the only professional that is required to have Phius training and certification is the Phius Certified Rater or Verifier. Regardless of how large or small the project team, all individual team members should remain in communication with each other at all phases of the project to the best of their ability. Typical project team roles and responsibilities are outlined below.

0.4.1 Client or Project Owner

Responsible for signing the project contract, paying the certification invoice and all related project fees, contracting all professionals (including the CPHC, CPHB and Phius Certified Rater and/or Verifier), and enjoying the many benefits of their new Phius Certified building. 'Client' and 'Project Owner' are referred to interchangeably in this guidebook.

0.4.2 Project Submitter

Each project will have a project Submitter. The role of the Submitter is to register the project, upload documentation, and submit the project to the review queue. This individual may also be the CPHC, but could also be a separate team member, such as the owner, the owner's representative, project architect etc.

Process Tip: The Submitter will receive the contract when initial paperwork is being completed for project registration. The Submitter is responsible for distribution of the project contract to the Client / Project Owner.

0.4.3 Phius Certified Consultant: CPHC®

Recommended for all project types. Works with the project team throughout the design process to ensure the project will meet all certification requirements. This includes completing the WUFI® Passive energy modeling for performance path certification, completing the Prescriptive Checklist for prescriptive path certification, or completing the REVIVEcalc energy modeling and associated workbooks for retrofit projects.

Process Tip: Coordination from the CPHC with Rater or Verifier, Builder, and Owner is essential to ensure the compliance tool reflects the most current state of the project at all times. This includes updating the model to align with any as-built changes reported by the Builder, Rater or Verifier during on-site inspection and testing.

0.4.4 Phius Certified Builder: CPHB

Recommended for all project types. The entity entrusted with comprehensively understanding the construction documents (plans and specifications) and executing them on site. The builder is charged with sourcing the intended materials for the project and must then either install or manage the installation of all critical elements of the building envelope, mechanical, electrical, and plumbing systems.

Process Tip: Coordination from the Builder with the Rater or Verifier, CPHC, and Owner is essential to ensure inspections as required by Phius and the accompanying EPA and DOE Programs are completed, all certification deliverables are met and properly implemented.

0.4.5 Phius Certified Rater / Verifier

Responsible for site visits, testing, and verification during construction. It is encouraged that the Phius Certified Rater or Verifier be present at design review meetings with the project team when possible.

A letter of intent (LOI) must be secured from the Rater or Verifier before Design Certification is issued. Coordination from the Rater or Verifier with the Builder, CPHC, and Owner is essential to ensure all tests and inspections are complete and compliant with all certification requirements.

Process Tip: It is not the responsibility of the Rater or Verifier to train builders, building subcontractors, designers, or any other project team member on specific scopes of work to construct Phius compliant projects, other than to make them aware of the requirements listed in the Phius Workbook or allied documents. The Rater or Verifier may choose to provide such guidance at their own discretion.

Phius Certified Rater

Required for single-family detached and may be used for single-family attached and townhouses.

Phius Certified Verifier

Required for non-residential and multifamily projects and may be used for single-family attached and townhouses. To become qualified to verify multifamily buildings, townhouses and single-family attached projects, additional prerequisites must be met. There will be an identifier for professionals with the Multifamily Designation in the Professionals Database.

0.5 Building Types

<table>
<tr><th colspan="4">Table 0.5.0 Certification Programs Matrix</th></tr>
<tr><td>Single-Family, Duplexes & Townhouses</td><td rowspan="4">1 - New Construction - Performance Path</td><td>2 - New Construction - Prescriptive Path</td><td rowspan="4">3 - Retrofit - REVIVE 2024</td></tr>
<tr><td>Multifamily</td><td rowspan="3">n/a</td></tr>
<tr><td>Mixed-Use</td></tr>
<tr><td>Non-Residential</td></tr>
</table>

0.5.1 Single-Family, Duplexes & Townhouse Projects

Single-family, duplexes, and townhouse projects are all eligible for any one of the available Program Versions.

Single-family / Duplexes

"Single-family" refers to single-family detached homes. "Duplex" refers to a 2-unit project whose dwelling units are completely independent of each other (i.e. no shared interior space or mechanical systems). Both single-family and duplex projects should follow the Phius Single-Family Quality Assurance Workbook.

Townhouses

"Townhouse" refers to single-family dwelling units within a group of three or more units that are attached from foundation to roof.[1] Townhouse projects may fall under the single-family or multifamily programs.

0.5.2 Multifamily Residential Projects

Multifamily projects are defined as anything residential other than "single-family" or "duplex". They should follow the Phius Multifamily Quality Assurance Workbook. All certification criteria for the performance path remain the same as for single-family.

Modeling protocol for multifamily projects differs slightly from single-family projects because of the addition of common space lighting loads, elevators, shared spaces, etc. The modeling protocol is described in depth later in Section 1.4.4.

0.5.3 Mixed-Use Projects

0.5.3.1 Submitting a Mixed-Use Project for Certification

New-construction mixed-use projects come in two basic variants:

1. Usage types of <u>all</u> spaces are known at the time of design
2. Part of the building is designed and finished for known usage types, and part of it is designed for an unknown future tenant who is responsible for completing construction in terms of plumbing, HVAC systems, interior finishes, insulation, etc. (aka "shell-lease")

---

[1]Aligns with the IRC 2021 definition for "*Townhouse Unit*"

Finished ("F"):
Refers to spaces whose occupancy / tenant is known at the time of design.

Unfinished ("UF"):
Refers to spaces intended for an unknown non-residential shell-lease.

This document addresses certification and energy modeling protocol for both these cases

0.5.3.2 Phius Mixed-Use Approach
It is encouraged to certify the whole building, but this is not required. Certification may be sought for part of the building only, even if all usage types are known at design time, as long as most of the building by floor area (50% or more) is within the scope of the planned certification.

Residential and non-residential parts of the building may be certified separately or together as a whole building. Due to software limitations, separate energy models are required if part of the building is residential and other parts non-residential, even if it is being certified as a whole building. Multifamily common spaces that primarily serve the residents should be included in a residential energy model.

Process tips:

- Thermally isolate residential spaces from a nonresidential portion for soundproofing among other considerations.
- Air seal to separate the two usages to prevent odor transference.

If there are a mix of "F" and "UF" spaces planned and being certified, each must be separately metered and have its own mechanical systems. The predicted energy use can then be compared to actual usage.

Separate systems also allow for flexibility in accommodating the differing schedules and capacities for the different usage types within the project. If all the usage types are known, the mechanical engineer may find it possible / advantageous to design a system with a shared thermal storage for low-temperature space conditioning.

If, between design certification and final certification, prospective tenants are found to occupy the UF space who are able and willing to meet the constraints of whole-building certification in their build-out plans, the tenant fit-out must be certified under its planned function rather than as unfinished space.

The source energy allowance for nonresidential spaces is on a per square foot basis as noted in Table 1.3.4.

In general, there are 4 unique paths:

A) Whole Building Certification - One combined certification for Residential and Non-Residential
Separate energy models must be created for residential and nonresidential areas. An overall source energy limit for the building applies, consisting of a per person portion for residential space, per-square-foot portion for nonresidential space, and additional custom process load allowance for some usage types. Refer to Appendix-N-1 for protocol on determining which devices may be considered process loads, and related calculations to account for them.

Process Tip: Process loads can be accounted for directly in WUFI passive. The protocol for this is described later in Section 1.4.4.9.

B) Whole Building Certification - Separate Residential and Non-Residential Certifications

Residential and nonresidential parts of the building are both modeled separately and certified separately. They must meet their certification criteria individually. This separated approach is recommended for projects where the nonresidential spaces include “UF” spaces. This way, the energy design for the main residential portion of the project can be settled earlier.

C) Partial Building Certification - One combined certification for Residential and Non-Residential

Same as A) above, except that only part of the building (≥ 50% by floor area) is certified.

D) Partial Building Certification - Separate Residential and Non-Residential Certifications

Same as B) above, except that only part of the building (≥ 50% by floor area) is certified.

Table 0.5.3.2.0 Mixed-Use Certification Matrix

Mixed-Use Certification Paths		Whole Building Certification		Partial Building Certification	
		A	B	C	D
Modeling & Certification	Separate energy models for residential & non-residential.	☑	☑	☑	☑
	100% of the building floor area is modeled / certified.	☑	☑		
	≥ 50% of the building floor area must be modeled / certified.			☑	☑
	Unknown non-residential spaces may not be certified alone.		☑		☑
	Follows UF Protocol outlined in Phius Mixed-Use Approach.	☑	☑	☑	☑
Source Energy Allowance	Determined for building by applying a mix of residential and non-residential allowances to certified spaces.	☑		☑	
	Determined for building by applying a mix of residential and non-residential allowances to certified spaces.		☑		☑
Space Conditioning Targets	Apply to the whole / certified portion of the building.	☑		☑	
	Apply to partial building and must be met in each energy model.		☑		☑

0.5.4 Non-Residential Projects

The criteria for non-residential projects are the same as for residential projects, apart from the Source Energy requirement. The Source Energy limit for commercial buildings is proportional to floor area, rather than occupancy. There may be more differences that require additional documentation for Phius Certification as requested by the certification staff.

Compared to residential projects, the energy models for non-residential projects need more detailed information on lighting systems, usage patterns, plug loads, and custom internal heat gains. For commercial buildings with process loads, Phius will determine the Source Energy allowance on a case-by-case basis. See Appendix N-1 for in-depth information.

Non-Residential QA/QC Commissioning is required using the Phius Non-Residential Quality Assurance Workbook. Certification protocol will continue to be updated as more information becomes available on these types of projects.

0.5.4.1 Dorms & Hotels/Motels

This guidebook references the IBC/IECC definitions to draw the line between residential and commercial usage based on the number of stories and whether the occupancy is assumed to be “Transient” or “Long-Term”.

Dorms: Commercial or Residential

On-site requirements: Complete the Phius Multifamily Quality Assurance Workbook Refer to Section 1.5 for more information.

Transient occupancy:

Occupant stays < 30 days) → Commercial

Long term occupancy:

Occupant stays ≥ 30 days → Residential

Hotel/Motel: Commercial

On-site requirements: Complete the Phius Non-Residential Quality Assurance Workbook. Refer to Section 1.5 On-Site Review for more information.

0.5.5 Campus/Community Certification

For campus/community certification, where there are multiple residential buildings being certified that share a common site, building or space, a source energy limit applies for the campus/community as a whole.

Example: Laundry rooms and kitchens may be in a common shared space.

0.6 Program Versions & Eligibility

The date that the Phius Certification Contract is executed determines the program versions required for that project. Projects may voluntarily choose to comply with a newer version than required by contract date.

Review the Phius Certification Program Version Eligibility Dates page for the matrix of program version effective dates.

0.6.1 Program Version Descriptions

0.6.1.1 Phius CORE

Phius’ longest standing certification sets the industry standard baseline for net-zero building design. It places emphasis on quality, durability, health, safety and cost-optimized conservation. This standard sets a target that is challenging, but achievable with conservation measures only. The new construction program has both a performance path and a limited-scope prescriptive path available.

CORE Performance

Available for new construction projects including residential, mixed use, and commercial buildings. It targets the “sweet spot” where aggressive energy and carbon reduction overlap with cost effectiveness, taking into account a full range of variables including climate zone, building size, building density, source energy and costs utilizing modeling protocol.

CORE Prescriptive

Available for single-family/townhouses and takes a hybrid approach with prescriptive requirements for both envelope and mechanical elements of the building. Allows for some performance tradeoffs within those categories and consists of three types of requirements: universal, climate-specific, and building-specific.

CORE REVIVE 2024

A brand new certification path available for all retrofit projects including residential, mixed use, and commercial buildings. It is based on the Phius REVIVE 2024 Standard, which is a trailblazing new standard that puts mass-scale retrofitting within reach. It prioritizes decarbonization, optimizes solutions based on the specific existing-conditions of each project, and includes quality assurance to ensure results.

0.6.1.2 Phius ZERO

Phius ZERO is Phius' zero energy standard. It is built upon CORE, utilizing the same focus on passive conservation measures first, but sets the net source energy target at ZERO. This path does not allow for fossil-fueled combustion on site, and provides both on-site and off-site renewable energy options to get to ZERO.

ZERO Performance

Goes beyond the Phius CORE Performance path by achieving all of the same requirements while also “netting-out” energy use on an annual basis with renewables.

ZERO REVIVE

Sets the industry standard for net zero energy design for existing buildings and goes beyond the Phius CORE REVIVE 2024 path by achieving all of the same requirements while also “netting-out” energy use on an annual basis with renewables.

1 - New Construction - Performance Path

1.1 Process

Table 1.1.0 New Construction Process Matrix

AIA Project Phase	Phius Benchmarks	Phase Summary
Pre-Design (PD) / Schematic Design (SD)	**Phase 0** Feasibility Study / Red-Flag Review	**1.1.1 Feasibility Study / Red-Flag Review** -Determine if your project is on the right track before committing to certification.
	Phase 1 Paperwork	**1.1.2 Inquiry** -Project team requests a contract.
	Milestone 1 Project Registered	**1.1.3 Registration** -Invoice paid, contract signed, project number created. -The Project is now publicly visible on Phius' Certified Project Database. -A project Dropbox folder is shared with the project team.
Design Development (DD) / Construction Drawings (CD)	**Phase 2** Design Review	**1.1.4 Design Review** -CPHC document upload. -Phius Review & Feedback. -CPHC Revisions & Response. -Repeat until all comments resolved
Bidding & Procurement	**Milestone 2** Design Certification	**1.1.5 Design Certification** -The design is certified by Phius. An official letter of Design Certification will be sent to the project team.

Table 1.1.0 New Construction Process Matrix (continued)		
AIA Project Phase	**Phius Benchmarks**	**Phase Summary**
Construction Administration (CA) / Commissioning (Cx)	**Phase 3.1** Construction, Observation & Testing	**1.1.6.1 Construction, Observation & Testing** -Rater/Verifier performs site visits and communicates all changes to the Submitter/CPHC. -All changes should be recorded in the Phius Certification Feedback Form.
	Phase 3.2 Final Review	**1.1.6.2 Final Review** -Rater or Verifier documentation upload -Phius Review & Feedback -Rater or Verifier Response -Repeat until all comments resolved
Post-Construction (PC)	**Milestone 3** Final Certification	**1.1.7 Final Certification** -The as-built project is certified by Phius -A Phius plaque will be sent to the project owner -A digital certificate will be sent to the project team

1.1.1 Phase 0: Feasibility Study and/or Red-Flag Review (Optional)

Decide if Phius Certification aligns with project goals by requesting Phius to conduct either a **Feasibility Study**, or a **Red-Flag Review:**

1.1.1.1 Feasibility Study

Visit this page: Feasibility Study and review Section 1.2.4.2 for fees.

1.1.1.2 Red-Flag Review

Visit this page: Phius Red Flag Review

There are two options for review:

Virtual Screen-Share Review:

Schedule two 1-hour virtual meetings with a Phius Building Certification staff member to ask questions and receive answers one-on-one in real time.

Written Review:

Receive feedback via the typical Phius Certification Feedback Form. This review method allows the project team to respond to preliminary comments and transition more seamlessly into a first round of design review. Phius comments are tracked more formally and may reduce the number of rounds of design review a project must undergo.

1.1.2 Phase 1: Paperwork

Start with reviewing this Guidebook, which summarizes all certification requirements, energy modeling protocol and additional technical guidance and follow the outlined steps:

1. Inquiry
    a. A representative from the project team, referred to from here on as the 'Submitter' should request a Phius Contract via the Submit a Project page on behalf of the individual, company, entity or team that is financing the project, referred to from here on as the 'Client'
        i. The Submitter may be the CPHC and/or the Client.
    b. Certification fees are outlined in Section 1.2.
2. Contract Issued
    a. Phius will create and issue a contract that includes the quoted fee.
3. Receive and Review
    a. Submitter will receive a link to the contract that can be forwarded to the Client for review.
4. Invoice Issued
    a. An invoice will be issued only after the contract has been signed. The Submitter or Client will receive a link via email to the invoice as requested by the Submitter.

1.1.3 Milestone 1: Project Registered

A project becomes registered after the contract has been signed and the invoice has been paid.

- Contracts can be digitally or physically signed, but should always be digitally uploaded.
- Once the contract is signed and payment is received, Phius will assign a project number, create a Dropbox folder and the project will appear on the Phius Certified Project Database.

Process tips:
The Submitter will receive access to the Dropbox folder via email as well as a link to request access for additional team members.
Review Appendix I-1.1 for instructions on the use of Dropbox for Phius Certification.

1.1.4 Phase 2: Design Review

Design Review can only begin once the project reaches Milestone 1: Project Registered. Section 1.1.9 shows the expected timeline for Design Review.

1.1.4.1 Design Review Steps

1. The Submitter and/or CPHC must upload project documentation into the Phius Project Dropbox folder.
2. The Submitter and/or CPHC must submit the project into the Phius Certification Review Queue. The queue indicates when the project team can expect Phius to complete the current round of review.

Process tip: Submissions can be made in one of two ways:
1. The Submitter and/or CPHC can log into the Phius Portal.
2. Any team member may navigate to the Phius Certification Review Queue and submit via the link at the top.

3. A Phius Building Certification staff member will review and provide comments using the Phius Certification Feedback Document on the documentation uploaded by the Submitter and/or CPHC. Comments focus on items that should be addressed for Design Certification compliance.
4. The Submitter and/or CPHC will be notified via email when Phius' review has been completed. The project will be removed from the Phius Project Certification Review Queue.
5. The Submitter and/or CPHC must reply to comments in the Phius Certification Feedback Document and provide updated documents and WUFI model for review.
6. The Submitter and/or CPHC must then repeat the process by re-submitting to the Project Certification Review Queue as described in Step 2.
7. When no remaining items need to be addressed for Design Certification compliance, the project becomes Design Certified.

Process tip: Most projects undergo 3 rounds of design review but there is no limit to the number of reviews that may be necessary for certification.

1.1.5 Milestone 2: Design Certification

Design Certification is awarded after the design feedback process is complete and the project is meeting all certification requirements.

- Phius will send a Design Certification Letter to the Submitter and/or CPHC via email with a link to request Dropbox access for either the Rater or Verifier and additional team members.
- The Submitter or CPHC should use the Phius Portal to update the public project listing. See Appendix I-1.3 for more information.

1.1.6 Phase 3: Construction & Final Review

1.1.6.1 Construction, Observation & Testing

To improve the efficiency of the final review process, the Phius Rater or Verifier should work closely with the Submitter and/or CPHC.

- During construction, across various site visits, the Phius Rater or Verifier must complete all of the on-site inspections and tests. Refer to Section 1.5 for more information.
- Once the on-site inspections and tests are complete, the Phius Rater or Verifier must communicate all as-built envelope changes to the Submitter and/or CPHC.
- The Submitter and/or CPHC must update the WUFI Passive energy model to match any known as-built changes per the

Phius Rater or Verifier from Design Certification before submitting for final review.

Process tips:

- A copy of the Design Certified WUFI-Passive file should be created to make as-built changes. The as-built WUFI model should be uploaded to the Dropbox for final review with the naming convention: ####_As-Built-Updates_YYYY.MM.DD
- It is imperative that the CPHC record all as-built changes post-Design Certification. This should be done using the Phius Certification Feedback Document that was used during design review.
- In the event of on-site test failure, review Appendix C-2.4.

1.1.6.2 Final Review

Final Review can only begin once the project reaches Milestone 2: Design Certification and all on-site testing has been completed. Section 1.1.9 shows the expected timeline for final review.

1. The Phius Rater or Verifier must upload all documentation to the project DropBox after all on-site inspection and testing is complete.
2. The Phius Rater or Verifier must submit the project into the Phius Certification Review Queue. The queue indicates when the project team can expect Phius to complete the current round of review.

Process tip: Submissions can be made in one of two ways:

3. The Phius Rater or Verifier can log into the Phius Portal.
4. Any team member may navigate to the Phius Certification Review Queue and submit via the link at the top.

3. A Phius Building Certification staff member will review the documentation and provide comments using the Phius Certification Feedback Document on the documentation uploaded by the Rater or Verifier.
4. The Rater or Verifier will be notified via email when Phius' review has been completed. The project will be removed from the Phius Project Certification Review Queue.
5. The Phius Rater or Verifier must reply to comments in the Phius Certification Feedback Document, provide necessary additional documentation and clarify any questions or comments where requested.
6. The Phius Rater or Verifier must then repeat the process by re-submitting to the Phius Certification Review Queue as described in Step 2.
7. When all comments from Phius have been addressed by the Rater or Verifier, Phius will begin the Finalization process. An email notification will be sent to the Rater or Verifier. During Finalization, a Phius Building Certification staff member will adjust the final WUFI Passive energy model to match the verified test results.
8. Once all changes are made and if all requirements continue to be met, the project becomes Final Certified.

Process tip: Most projects undergo 2 rounds of final certification review but there is no limit to the number of reviews that may be necessary for certification.

1.1.7 Milestone 3: Final Certification

Final Certification is awarded after the final review process is complete and the project meets all certification requirements.

- Phius will send a notification to the Submitter and/or CPHC and either Rater or Verifier via email.
- The Submitter and/or CPHC and either Rater or Verifier must review and confirm the following information in order for a digital project certificate to be issued:
    - Architecture Planning
    - Building Owner

    - Construction Company
    - Mechanical Systems Designer
- One plaque is included per project and will be shipped to the project address
    - Pricing information for additional plaques can be found in Section 1.2.6.
- The Submitter, CPHC, Rater or Verifier should use the Phius Portal to update the public project listing. See Appendix I-1.2 for more information.

1.1.8 Phius Certification Feedback Document

The Phius Certification Feedback Document is the main channel of communication between Phius and the project Submitter/CPHC and either the Rater or Verifier during design and final review. The document is used to track project information and any changes that occur during the certification process.

During design review, the Phius reviewer will comment in the Phius Certification Feedback Document on the energy model, drawings, and specifications submitted to the project Dropbox. This document must be uploaded to your project's designated Dropbox Folder for each round of review. The Submitter/CPHC should be diligent about aligning feedback responses with updates made to the WUFI model or project documentation between rounds of review.

During final review, the Phius reviewer will comment in the Phius Certification Feedback Document on the Quality Assurance Workbook (QA Workbook), Phius Quality Control Field Checklist (QC Field Checklist), and on-site documentation submitted to the project Dropbox. This document must be uploaded to your project's designated Dropbox Folder for each round of review. The Rater or Verifier should be diligent about aligning feedback responses with updates made to the QA Workbook, the QC Field Checklist, or on-site documentation between rounds of review.

Process tip: Any external communication via email, phone call, etc. should be noted into the feedback form so the project reviewer is aware. Email threads should be uploaded to the Dropbox in PDF format in the related subfolder.

1.1.9 Review Timeline

Generally, projects pursuing the performance path can expect the review timeframes outlined in Tables 1.1.9.0 & 1.1.9.1. Automated emails will be sent from Phius regularly to remind project teams of important upcoming review deadlines.

The overall certification process timeline is highly variable and depends on the response time from the Submitter and/or CPHC. It also depends on the completeness and accuracy of the first submission. If insufficient documentation is provided, Phius will reach out to the Submitter and/or CPHC and the project will be pushed back two weeks in the Review Queue.

Table 1.1.9.0 Design Review Timeline		
Round of Design Review	**Document Upload Required**	**Feedback Returned**
1	5 weeks after submission	8 weeks after submission
2	4 weeks after submission	6 weeks after submission
3	2 weeks after submission	4 weeks after submission
4 or more	At time of submission	2 weeks after submission
Expedite Review		

Table 1.1.9.1 Final Review Timeline		
Round of Final Review	**Document Upload Required**	**Feedback Returned**
Document	At time of submission	1 week after submission
1 or more		2 weeks after submission

1.1.9.2 Important Design Review Dates

Document Upload Required:

Indicates the latest date that documentation may be uploaded to Dropbox and still allow Phius to meet the feedback return dates. Documentation uploaded after the 'Document Upload Required' date may not be reviewed.

Feedback Return Date:

Indicates the latest date that Phius will return project feedback, issue Design Certification or Final Certification.

1.1.9.3 Expedited Review:

An expedited review path for Design Certification may be available for an additional fee (See Section 1.2.3). Whether or not this option is available is up to the discretion of Phius and the volume of expedited reviews in the certification queue at the time of submission. Because of the shorter timeframe to return feedback during the final review process, an expedited review path is not available during the final review process.

1.2 Fee Schedule

Table 1.2.0 Performance Path Certification Fees							
iCFA (sf)	**<4,500**	**10,000**	**25,000**	**50,000**	**100,000**	**250,000**	**500,000**
Single-Family	$2,200		n/a				
Multifamily*	$2,800	$5,650	$12,250	$19,250	$27,750	$43,250	$58,250
Non-Residential*	$2,500	$5,200	$11,350	$17,950	$25,900	$40,450	$54,500
Expedite Review	An expedited review may be available for an additional 50% up-front cost in addition to the base fee						
Estimated Rates* - Varies based on iCFA							

1.2.1 Performance Path Certification Fees

Certification fees are based upon the building's iCFA (interior conditioned floor area). If a building consists of residential and non-residential spaces, two energy models may be necessary and pricing may be based on each model individually.

All single-family projects have a fixed fee of $2,200 regardless of project size. Other projects up to 4,500 square feet of interior conditioned floor area (iCFA) also have a fixed price as shown above. All projects require a contract which can be requested on the Submit a Project page.

Phius quotes a single fee for the full certification review process, rather than a separate fee for design certification and final certification. Phius' fee does not include the fees associated with the CPHC, Rater or Verifier.

1.2.2 Discounts

- Phius Alliance Members receive a 15% discount, up to $600.
- Non-Profit Organizations are eligible for a 25% discount, up to $1,000.
- Duplicate or repeated buildings may receive a discount for each duplicate building submitted after the first.

1.2.3 Expedite Fee

An expedited review may be available for an additional 50% up-front cost on the base fee.

Example: A single-family home with a base fee of $2,200 would have an expedite fee of $1,100, totaling $3,300 for the full fee. See description of what this service entails in Section 1.1.9.

1.2.4 Additional Consulting

Phius can provide additional services, such as hygrothermal analysis, thermal bridge and moisture risk analysis, red-flag reviews, and feasibility studies. Performing this type of analysis is not included in the project certification fee and is available for an additional fee as needed. Typical consulting rates are noted in Table 1.2.4.1.0, but specific services may have different pricing.

1.2.4.1 Red-Flag Review

Review Section 1.1.1 for more information on the scope. Request a Red Flag Review here.

Table 1.2.4.1.0 Phius Hourly Consulting Rate	
Base Fee	$200/hr
Phius Alliance Member Fee	$175/hr

1.2.4.2 Feasibility Study Fee

Feasibility study fees are based upon the project type and iCFA (interior conditioned floor area). If a project consists of residential and non-residential spaces, two energy models may be necessary, and pricing may be based on each model individually.

Table 1.2.4.2.0 Feasibility Study Fees

iCFA (sf)	Single-Family	Multifamily	Non-Residential
<10,000	$1,500	$2,000	$2,500
10,001 - 50,000	n/a	$3,000	$3,500
50,001 - 100,000	n/a	$3,500	$4,000
Each additional 50,000	n/a	+ $500	+ $500

1.2.5 Certification Plaque

One complimentary certification plaque is included per certified building. Additional plaques can be purchased at a cost of $75/each.

1.2.6 Payment Options

An invoice will be issued to the Submitter or Client via email from www.Bill.com following the signing of the contract. Payments can be made via:

- Check - Mail a check that includes the invoice number to the address below:
  Phius
  53 W. Jackson Blvd. Suite 1432
  Chicago, IL 60604
- Credit Card - Pay via credit card online using the Bill.com link provided

1.3 Performance Path Requirements

This section outlines the requirements for projects pursuing the performance path. The tables below are split requirements by building type and by program version. Specific guidance on designing, implementing and verifying these requirements are outlined in Section 1.4 and Section 1.5.

Table 1.3.0 Performance Path: Building Certification Requirements by Project Type			
Project Type	**Single-Family, Duplexes & Townhouses**	**Multifamily**	**Non-Residential**
Program Version	**CORE & ZERO (for differences refer to Table 1.3.1)**		
Co-requisite Requirements			
Personnel	Phius Certified Rater or Verifier with Multifamily Designation	Phius Certified Verifier with Multifamily Designation	Phius Certified Verifier
EPA Indoor airPLUS	Construction Specifications Version 1 (Rev. 04)		
	Refer to Section 1.4.1.1	Refer to Section 1.4.1.2	
EPA ENERGY STAR	Single-Family New Homes Version 3.2 Refer to Section 1.4.1.1 & Section 1.5.3.1	Multifamily New Construction (MFNC) Version 1.2 Refer to Section 1.4.1.2 & Section 1.5.3.1	
DOE Zero Energy Ready Homes	Single-Family Version 2 Refer to Section 1.4.1.1 & Section 1.5.3.1	Multifamily Version 2 Refer to Section 1.4.1.2 & Section 1.5.3.1	
Phius Passive Conservation Requirements			
Space Conditioning Limits	Refer to the Phius 2024 Criteria Calculator and Section 1.3.3.1		
Airtightness	Whole building blower door test is required to show compliance with limits outlines in Section 1.3.3.2		
Moisture Risk Mitigation & Comfort	Opaque assembly, detailing and fenestration requirements are outlined in Section 1.3.3.3		
Phius Active Conservation Requirements			
Source Energy Limits	Refer to the Phius 2024 Criteria Calculator and Section 1.3.4.1		
Mechanical Ventilation	Balancing, defrost, minimum airflow and distribution requirements are outlined in Section 1.3.4.2		
Electric Vehicles	Full alignment with the DOE Zero Energy Ready Homes Programs		Refer to Section 1.3.4.3

Table 1.3.1 Performance Path: Building Certification Requirements by Program Version		
Project Type	**Single-Family, Duplexes, Townhouses, Multifamily and Non-Residential**	
Program Version	**CORE**	**ZERO**
Renewable Energy		
On-Site Renewables	**Credited with utilization factors applied as outlined in Appendix N-4.**	**Credited**
Off-Site Renewables	**Not credited.**	**Credited with utilization factors applied as outlined in Appendix N-4.**
Combustion Equipment, Appliances & Fireplaces		
Space Heating (natural gas furnace, boiler etc...)	**Allowed with electrification readiness criteria per Appendix E**	**Not Allowed.**
Domestic Hot Water (natural gas water heaters)		
Other Fossil-Fuel based Equipment		
Appliances (natural gas cooking, natural gas dryer etc...)		
Fireplace (Natural Gas)	**Allowed if vented to the outside, with an airtight stove or fireplace box and electrification readiness criteria per Appendix E**	
Fireplace Insert or Wood Stove (Biomass-burning)	Allowed if vented to the outside, with an airtight stove or fireplace box.	
Fireplace (Open / Unvented / Ethanol)	Not Allowed.	

1.3.2 Co-requisite Requirements

1.3.2.1 Personnel Required

Before Design Certification is awarded to a project, Phius requires a Letter of Intent (LOI) from the Phius Certified Rater or Phius Certified Verifier on the project, stating they have been hired to complete the on-site verification and quality assurance process. Review Section 0.4 for more information on the role of the Rater and Verifier. Non–Phius certified Raters or Verifiers may be used based on constraints of the project location. Review Appendix C for more information.

1.3.3 Passive Conservation Requirements

1.3.3.1 Space Conditioning Limits

Specific heating and cooling energy limits are set to guide investment in passive conservation strategies. These limits are considered 'ideal air loads', regardless of the efficiency of the space conditioning system chosen. "Specific" in this sense means per Interior Conditioned Floor Area (iCFA). Review Appendix A for details on the development of the Phius 2024 standards. These limits are applicable only when modeled using Phius' protocol and approved software. Limits for individual buildings are determined by the envelope area, floor area, occupant density, unit density (residential only) and location of the project using the Phius 2024 Criteria Calculator. Table 1.3.3.1.0 outlines the limits set.

Table 1.3.3.1.0 Space Conditioning Limits

Annual Heating Demand	≤ A (kBTU/ft^2.yr)
Annual Cooling Demand[2]	≤ B (kBTU/ft^2.yr)
Peak Heating Load	≤ C (BTU/ft^2.hr)
Peak Cooling Load[2]	≤ D (BTU/ft^2.hr)

1.3.3.2 Airtightness Limits

The pass/fail certification requirement is per square foot of gross enclosure surface area[3] and has varying limits based on test pressure. The airtightness limit(s) are outlined in Table 1.3.3.2.0. A whole-building test for airtightness must be performed. For further details, review Appendix C and Appendix C-2.

Process tip: If testing at 75 Pa, report the flow coefficient and exponent from the blower door tests so that the test result can be converted to 50 Pa for the as-built energy model and final records. The Airtightness Pressure Conversion Calculator found in the Phius Resource Library can be used to convert tested pressures between 50Pa and 75Pa.

Table 1.3.3.2.0 Performance Path Airtightness Limits

Building Type	50 Pa	75 Pa
≥5 Stories & Non-combustible*	≤ 0.08 CFM_{50}/ft^2	≤ 0.11 CFM_{75}/ft^2
All other buildings	≤ 0.06 CFM_{50}/ft^2	≤ 0.08 CFM_{75}/ft^2

*Non-combustible in this sense is construction that is not subject to mold and rot. This would mean no plant-based framing members, sheet goods or insulation.

[2]Cooling criteria apply regardless of whether or not a cooling system is planned. Annual Cooling Demand is the total of latent plus sensible cooling. Peak Cooling Load is the sensible load only.
[3]Gross enclosure area is measured at the exterior of the thermal boundary and includes surfaces in contact with the ground.

1.3.3.3 Moisture Risk Mitigation & Comfort Requirements

Opaque Assemblies

It is important to avoid risks related to mold and moisture. Review Appendix B for guidance and requirements.

Interior Moisture Management at Construction Details

When calculated according to ISO 13788, the interior surface temperature of thermally bridged construction details must avoid mold growth. This requires that the lowest temperature on the inside surface results in less than 80% relative humidity at the surface, when the interior air is chilled down to that temperature. Refer to Appendix N-2.

Fenestration Requirements

Fenestration (windows and doors) have two sets of requirements. Interior condensation risk should be mitigated for both the glass and the frame and interior comfort should be maintained by placing a maximum limit on the whole window U-value.

Condensation Risk:

When calculated according to ISO 13788, the temperature factor at the internal surface (fR_{si}) must stay above the design temperature factor at the internal surface ($fR_{si,min}$). In other words, the interior surface temperature of both the glass and the frame must remain above the interior dew point temperature.

Refer to Section 1.4.2.5 for calculation tools and methods to demonstrate compliance.

Exceptions:
Pet doors are exempt from the condensation risk criteria.

The whole door U-value may be used for the condensation risk assessment for exterior doors that are required to be ADA compliant, egress rated, fire rated, etc., instead of requiring that each of the individual elements pass (glazing and frame).

Comfort:

The maximum whole-window U-value that may be used in a building pursuing Phius certification is set based on the window height and ASHRAE 99% design temperature for that location.

The window comfort criterion applies to all projects, regardless of size. The U-value required scales by window height – the taller the window, the lower the required U-value. Refer to Section 1.4.2.5 for calculation tools to demonstrate compliance. Review Appendix N-3 for calculation explanation.

1.3.4 Active Conservation Requirements

In addition to using passive conservation strategies to limit the needs for heating and cooling, the overall performance must be addressed in the design. This includes all other energy end-uses for the building. Each path guides the designer to investments in active conservation strategies to limit the building's overall energy use. There are two certification "tiers" available, CORE and ZERO.

1.3.4.1 Source Energy Limits

Phius CORE sets a source energy limit that is challenging but achievable with conservation measures only. Phius ZERO is built upon the same conservative first principles as CORE but sets the net source energy target at 0.

Table 1.3.4.1.0 Performance Path Source Energy Limits

Program Version	CORE	ZERO
Residential Buildings	Net Source Energy Demand ≤ E [kWh/person.yr]	Net Source Energy Demand ≤ 0 [kWh/person.yr]
Mixed-Use Buildings[4]	Residential Building limit(s) apply to dwelling units and common areas that serve the residents.	
	Non-Residential Building limit(s) apply to spaces that mainly serve non-resident clientele.	
Non-Residential Buildings	Net Source Energy Demand ≤ E [kBtu/ft^2.yr]	Net Source Energy Demand ≤ 0 [kBtu/ft^2.yr]
	Process load allowances outlined in Appendix N-1 may increase the source energy limit.	Process load allowances do not increase the source energy limit.
Unfinished Spaces	No source energy limit nor impact associated with internal gains. Refer to Section 0.5.3	
Off-grid Buildings	Review Section 1.3.4 for process load allowances.	
Use the Phius 2024 Criteria Calculator to determine the specific limits		

[4] Phius requires separate modeling of residential and non-residential parts where the non-residential portion serves non-residents.

Net Source Energy Accounting & Renewables

Source energy demand is calculated as the annual usage net of renewable energy that is produced. For Phius CORE projects, renewable energy systems are not required, but some on-site renewable energy is credited. For Phius ZERO projects, a combination of on-site and off-site renewable energy must be installed in order to completely offset the modeled source energy use of the building. See Section 1.4.3 for modeling protocol and Appendix N-4 for details on acceptable system types, contract requirements, calculating the adjusted renewable energy and renewable energy allocation to multiple buildings.

Residential Buildings

Includes single-family detached housing, single-family attached housing, multifamily buildings, excepting hotels and motels. The net source energy limit for all residential buildings varies based on occupant and unit density. For Phius CORE projects, the limit varies per the formula outlined in Appendix A-2.1.

Non-Residential Buildings

For Phius CORE projects, the base net source energy limit for non-residential buildings varies based on ASHRAE climate zone per the Table 1.3.4.1.1. See Appendix A-2.2 for standard-setting logic. Non-residential projects may qualify for a process load allowance to increase the base source energy limit. Phius will determine the source energy allowance granted for process loads on a case-by-case basis.

Table 1.3.4.1.1 Non-Residential Base Source Energy Limits	
ASHRAE 169 Climate Zone	**Source Energy Limit** [kBtu/ft^2.yr]
1A	31.0
1B	28.0
2A	28.0
2B	25.0
3A	27.0
3B	23.0
3C	22.0
4A	28.0
4B	23.0
4C	21.0
5A	30.0
5B	25.0
5C	23.0
6A	34.0
6B	30.0
7	39.0
8	46.0

Off-Grid Buildings

Process load allowances are granted for off-grid systems outlined in Table 1.3.4.1.2

Table 1.3.4.1.2 Off-Grid Building Allowances		
Project Type	**Water Supply**	**Wastewater Treatment**
Residential	400 [kWh/person/yr]	400 [kWh/person/yr]
Non-Residential	7 [kWh/kgal]	7 [kWh/kgal]

1.3.4.2 Mechanical Ventilation

Balanced Ventilation

In the Energy Star framework, the ventilation system type is characterized as either “Supply”, “Exhaust”, or “Balanced”.

Review the recommendations outlined in Appendix I-2.4.

A whole-building mechanical ventilation system is required to be installed. The system shall have a minimum of one supply or exhaust fan with associated ducts and controls.

Process tips:

In the case of ventilation ductwork integrated with heating/cooling ducts:

- The ventilator must remain in balance under all fan speeds of the heating/cooling air handler.

In the case of “Supply” or “Exhaust” systems:

- A ventilation system design with supply fans only or exhaust fans only requires dedicated openings in the envelope (with dampers) for make-up air to meet the balance requirements, because of the airtightness requirement on the building overall.

Regardless of type, the entire mechanical ventilation system must comply with one of the requirements outlined below:

Total measured supply and exhaust airflows are within 10% of each other.

Process tips:
Only continuous ventilation counts towards the airflow balance. (Intermittent exhaust ventilation is not included.)

Use the higher number as the basis of the percentage difference.

If an individual ventilator within the ventilation system is out of balance by more than 10%, the energy penalty must be accounted for per Section 1.4.4.10.

OR

The total net pressurization or depressurization from the un-balanced ventilation system does not exceed 5 Pa.

Process tip: The net pressurization/depressurization that the ventilation system imbalance causes on the building is determined using the multi-point airtightness test results graph.

Minimum Ventilation Rates

Residential Requirements

Dedicated outdoor air supply to bedrooms is required in all dwelling units.

Process tips:
- In the case of ventilation ductwork integrated with heating/cooling ducts, the heating/cooling air handler fan must be designed to run continuously by default.
- The outdoor air supply to the air handling unit must be verified on-site at final commissioning.

Residential building minimum ventilation rates are determined by the larger of either the supply air or exhaust air requirements noted on the following page.

Supply air requirements:
A minimum of 15 cfm per person[5] should be provided. Refer to Section 1.4.4.4 for occupancy calculations of buildings with dwellings.

Exhaust air requirements:[6]
Based on kitchens, baths and other exhaust rooms. Minimum continuous exhaust air flow rates are dependent on project type and the local building code which may override the values below:
- Single-family, Duplexes, & Townhouses
  - Kitchens: 25 cfm
  - Bath/toilet rooms: 20 cfm
- Multifamily (<4 stories)
  - Kitchens: 25 cfm
  - Bath/toilet rooms: 20 cfm
- Multifamily (4+ stories)
  - Kitchens: 50 cfm
  - Bath/toilet rooms: 25 cfm

Example: A 3-story multifamily project is determining their airflow rates for various unit layouts.

Unit type A: 1 bed / 1 bath
- Minimum supply rate: 30 cfm
  - 15 cfm * 2 occupants
- Minimum exhaust rate: 45 cfm
  - Kitchen: 25 cfm

[5] 18 cfm per occupant is recommended.
[6] Future update to align with EPA Indoor airPLUS v2 as required by the ZERH program. Direct, intermittent kitchen exhaust will be required in single-family, duplex, and townhouse buildings.

- Bath: 20 cfm
- Minimum continuous ventilation rate: **45 cfm**
  - 45 (exhaust min) **>** 30 (supply min)

Unit type B: 3 bed / 1.5 bath
- Minimum supply rate: 60 cfm
  - 15 cfm * 4 occupants
- Minimum exhaust rate: 65 cfm
  - Kitchen: 25 cfm
  - Bath + ½ Bath: 40
- Minimum continuous ventilation rate: **65 cfm**
  - 65 (exhaust min) **>** 60 (supply min)

Unit type C: 5 bed / 2 bath
- Minimum supply rate: 75 cfm
  - 15 cfm * 4 occupants
- Minimum exhaust rate: 65 cfm
  - Kitchen: 25 cfm
  - Baths (x2): 40 cfm
- Minimum continuous ventilation rate: **75 cfm**
  - 75 (supply min) **>** 65 (exhaust min)

For intermittent direct exhaust systems, all projects must meet the following minimum exhaust airflow rates:
- Kitchens: 100 cfm
- Bathrooms: 50 cfm
- Bath/toilet rooms: 50 cfm

Non-Residential Requirements
For non-residential buildings, the design[7] occupancy shall be used to size the system and the applicable mechanical code (IMC, ASHRAE 62.2 etc…) for the project's location should be followed.

Ventilator Defrost
A pre-heater defrost (or ground loop pre-heater) is required for Energy Recovery Ventilators (ERVs) where the ASHRAE 99.6% design temperature is below the manufacturer's claimed minimum operating temperature, rather than relying on recirculation defrost.

Ventilators that can maintain the required outdoor air ventilation rates on average with the unit intermittently in recirculation mode are accepted to meet the defrost requirement. The unit needs to have enough boost to maintain the same time-average fresh air ventilation rate as it would at higher temperatures. See Appendix N-5 for calculation method.

Ventilation Distribution System Requirements
Ventilation ducts from the ventilator to the exterior of the thermal envelope shall be insulated to a minimum of R-8. For air-permeable insulation (such as fiberglass duct wrap), an air-sealed, class 1 vapor retarder shall be installed.

If the kitchen exhaust is connected to the ventilator, the register must maintain a minimum distance of 6 feet[8] from the cooktop and provide either a MERV 3 or washable mesh filter for trapping grease along with a recirculation range hood that provides a minimum of 100 cfm of exhaust.

[7] Also referred to as the maximum occupancy and would also be used for cooling load sizing.

[8] Recommended to maintain this distance in plan, but the stretched-string distance is the minimum requirement.

1.3.4.3 Electric Vehicle (EV) Charging Infrastructure

Infrastructure for the current and future charging of electric vehicles (EVs) is required for all buildings where parking spaces are planned and depends on the building's parking requirements.

Single-Family, Duplexes, and Townhouses:

All single-family, duplex, and townhouse Phius projects must comply with DOE ZERH V2 (Rev. 1) - National Rater Checklist.

Multifamily

All multifamily Phius projects must comply with the U.S. DOE Zero Energy Ready Home MultifamilyEV-Ready Checklist Version 2.

Non-Residential

For commercial buildings being constructed, install EV capability in compliance with the International Code Council's "Electric Vehicles and Building Codes: A Strategy for Greenhouse Gas reductions" (2021), Table 1: Sample EV-Integrated Code Provisions following the Commercial column. For projects in municipalities not listed in the above Table:

- Provide 10% EV-Ready Spaces based on total number of parking spaces
- Provide 10% EVSE-Installed based on total number of parking spaces

Example: For a project with a total of 100 parking spaces, provisions for 10 spaces would be made EV-Ready, and an additional 10 would be EVSE-Installed.

1.3.5 Renewable Energy

1.3.5.1 Phius CORE projects

Shall meet the Source Energy requirements outlined above and comply with the DOE Zero Energy Ready Home PV-Ready checklists.

1.3.5.2 Phius ZERO projects

Shall produce enough renewable energy to offset the total source energy of the building (as modeled) to zero using any combination of on-site and off-site renewable energy. Review the utilization factors associated with off-site renewable energy outlined in Appendix N-4.

1.3.6 Combustion Equipment, Appliances & Fireplaces

1.3.6.1 Combustion Equipment

Phius CORE projects

Single-family, Duplexes and Townhouses

Fossil-fueled combustion equipment located within the building's pressure boundary must be sealed, direct-vent and meet the electrification readiness requirements per the ZERH program outlined in Section 1.4.1.1.

Multifamily, Non-residential & Mixed-Use

Fossil-fueled combustion equipment located within the building's pressure boundary must be sealed, direct-vent and meet the electrification readiness requirements per the ZERH program outlined in Section 1.4.1.2.

Phius Amendment: Fossil-fueled combustion equipment outside of dwelling units shall comply with the requirements outlined in Appendix E.

Phius ZERO projects

Fossil-fueled combustion equipment is not allowed.

Exception: Fossil-fueled combustion is allowed for emergency back-up generation of electricity. Ie. back-up propane generator etc...

1.3.6.2 Combustion Appliances

Phius CORE projects

Fossil-fueled combustion appliances may be installed so long as the requirements outlined in Appendix E are implemented.

Phius ZERO projects

Fossil-fueled combustion appliances are not allowed.

Exception: Fossil-fueled combustion is allowed for exterior cooking. (ie. propane grill etc..)

1.3.6.3 Fireplaces

Natural draft (open), unvented and ethanol fireplaces are not permitted.

Biomass fireplaces and woodstoves must have a combustion air inlet connected to an airtight firebox.

Review cautionary notes in Appendix I-2.5 and be aware of the requirements outlined in the disclaimer below:

Fireplace Disclaimer: The use of a fireplace/woodstove in a home can be dangerous due to the risk of carbon monoxide poisoning. The fireplace / woodstove specified for this home must be completely airtight to the room air. Combustion air must be provided by a dedicated pipe connecting to the outside. If smoke is seen to be leaking from the stove into the living area, immediately open all the windows, and discontinue using the stove. DO NOT LEAVE A FIRE BURNING UNATTENDED especially when going to sleep at night. Carbon monoxide detectors should be installed in locations so that they can be heard throughout the house. Phius (the Passive House Institute US) or any of its employees are not responsible for any damage, injury or death caused.

Phius CORE projects

Fossil-fueled fireplaces may be installed so long as a branch circuit sized for an electric appliance, equipment or end use with an equivalent capacity that terminates within 6 feet is installed.

Phius ZERO projects

Fossil-fueled combustion fireplace are not allowed.

1.4 Design Guidance

Table 1.4.0 Performance Path: Design Guidance	
Co-Requisite Programs	Review Section 1.4.1
Required Documentation	Review Section 1.4.2
Modeling Software	Review Section 1.4.3
Modeling Protocol	Review Section 1.4.4

1.4.1 Co-Requisite Program Requirements

The following documents should be reviewed, understood and implemented by the designer. Phius-specific amendments or areas of emphasis for the designer are noted in-line below. Phius considers these programs as 'co-requisites' as opposed to 'pre-requisites' due to Phius' two-step certification process between Design Certification and Final Certification. Though the items listed below will impact the design of a project, the actual checklists and certificates for these programs cannot be obtained until the project is built. And, in most cases, Design Certification is often issued before construction begins. Therefore, Phius works in tandem with the co-requisite programs, as opposed to needing to complete the programs before achieving Phius certification. Co-requisite program websites are hyperlinked so the applicable documents can be downloaded. Please Contact Us for any broken hyperlinks.

1.4.1.1 Single-family, Duplex and Townhouse:

The following programs are required for all single-family, duplex and townhouse projects.

- EPA ENERGY STAR Single-Family New Homes
- EPA Indoor airPLUS (IAP)
- DOE Zero Energy Ready Homes (ZERH) Single-Family

Process tip: The current version and revision number per program is listed to align with the release of this guidebook, but newer revision numbers released after this guide may be used.

EPA ENERGY STAR Single-Family New Homes

Phius requires certification under the National Version 3.2 program regardless of the state-by-state minimum version required per the Zero Energy Ready Home Program.

Exceptions:

Projects located in California shall meet the California Single-Family Version 3.4 program requirements per the Zero Energy Ready Home Program.

Projects located outside of the United States must meet the certification criteria from the National Version 3.2 program, even though actual certification is not required. Review Non-Eligible Buildings for more information.

National Program Requirements, Version 3.2 (Rev. 13)

Exhibit 2 outlines the mandatory documents required for all certified homes. Most Phius projects follow Track B - HVAC Credential. Phius has identified documents that contain requirements that may impact the design to assist the design team in navigating the co-requisite programs. Questions related to the co-requisite programs should first be directed to those programs. The Phius Rater is a valuable resource to offer clarification during the review of these documents.

National Water Management System Builder Requirements, Version 3 / 3.1 / 3.2 (Rev. 13)

While this document is written for builders, it contains important design information that must be planned for before construction begins.

National HVAC Design Report, Version 3 / 3.1 / 3.2 (Rev. 13)

The items and endnotes from this document noted below contain requirements that impact the design.

- Lines 2.1 and 2.6 through 2.13

> **Phius Amendment:** Projects located in ASHRAE climate zones 4 through 8 are required to provide ventilation air inlets and outlets ≥ 4' above grade and/or roof deck.

- Lines 3.1, 4.1 and 5.1

> **Process tip:** WUFI Passive cannot be used for HVAC system capacity sizing.

National Rater Design Review Checklist, Version 3 / 3.1 / 3.2 (Rev. 13)

Track B - HVAC Credential is the most typical track pursued for Phius projects. Within that track the following requirements impact the design.

- Line 3.1 and Section 4a

National Rater Field Checklist Version 3 / 3.1 / 3.2 (Rev. 13)

This document summarizes the information the Rater must confirm on-site, but includes items that impact the design in all sections. Areas of emphasis are included below, but the entire checklist should be reviewed and understood by the design team.

- Sections 2, 3, 4 and 5
- Line 5b.3

> **Phius Amendment:** The National HVAC Commissioning Checklist is required to be collected and submitted to Phius for all projects.

- Line 8.1

> **Exception:** Review endnote 61 which allows a minimum of 25 cfm continuous exhaust rate for kitchens in Phius projects. This may be overridden by the local mechanical code.

- Line 9.1
  - Phius Amendment: MERV 8+ filters are required for ducted ventilation systems.

EPA Indoor airPLUS

Indoor airPLUS Version 1 (Rev. 04) Construction Specifications

Phius will align with Indoor airPLUS Version 2 on the same timeline as the DOE Zero Energy Ready Homes program (permit dates after 1/1/2026). Indoor airPLUS Version 2 | US EPA is now available.

> **Exceptions:**
>
> Projects located outside of the United States must meet certification criteria from the Version 1 (Rev. 04) program, even though actual certification is not required. Visit Non-Eligible Buildings for more information.
>
> Under the Moisture Control section of the current program, the Additional Exceptions outlined under checklist 1.4 do not apply for Phius projects. The language struck through below does not apply:
>
> - ~~In lieu of perimeter wall insulation and conditioned air, crawlspaces that utilize a capillary break on the floor and that are well sealed to prevent outside air infiltration are permitted to utilize active dehumidification with sufficient latent capacity to maintain relative humidity (RH) at or below 60 percent. The dehumidifier shall be drained to the outside or to a sump pump. With this exception, ENERGY STAR Certified Homes Water Management System Builder Requirements Item 1.4.3 staking method for poly sheeting may not be used in crawlspaces with no slab.~~

DOE Zero Energy Ready Homes (ZERH)

Phius requires certification under the National Single-Family Version 2 program.

Exceptions:
For projects located in California, the California Single-Family Version 2 program requirements shall be met.

Projects located outside of the United States must meet certification criteria from the National Single-Family Version 2 program, even though actual certification is not required. Visit Non-Eligible Buildings for more information.

National Program Requirements, Version 2 (Rev. 1)

Exhibit 1 outlines the mandatory requirements for this program. The following sections impact the design.

- Sections 3, 4, 5, 6, 8, 9, 10 & 11

Phius Amendment: Advisory item 12 is required for Phius projects that provide in-dwelling unit HPWHs.

PV-Ready Checklist Version 2 (Rev. 1)

Phius fully aligns with this checklist.

1.4.1.2 Multifamily, Mixed-Use and Non-Residential

The following program requirements apply to all multifamily, mixed-use and non-residential projects.

- EPA ENERGY STAR Multifamily New Construction (MFNC)
- EPA Indoor airPLUS (IAP)
- DOE Zero Energy Ready Homes (ZERH) Multifamily

Process tip: The current version and revision number per program is listed to align with the release of this guidebook, but newer revision numbers released after this guide may be used.

EPA ENERGY STAR Multifamily New Construction (MFNC)

Phius requires certification under the National Version 1.2 program regardless of the state-by-state minimum version required.

Exceptions:
Non-residential buildings (and non-residential spaces within mixed-use buildings) must meet the applicable certification criteria from the National Version 1.2 program, even though actual certification is not required.

For mixed-use buildings where the residential portion of the building (including common areas but excluding parking garages) is < 50% of the iCFA, the project must meet the certification criteria from the National Version 1.2 program, even though actual certification is not required.

For projects located in California, the regional program requirements shall be met per the Zero Energy Ready Home Program.

Projects located outside of the United States must meet certification criteria from the National Version 1.2 program, even though actual certification is not required. Visit Non-Eligible Buildings for more information.

National Program Requirements, Version 1.2 (Rev. 04)

Three paths are available to meet the performance target. It is up to the project team to determine which path will be followed and review the associated documents and requirements. Phius has identified documents that contain requirements that may impact the design to assist the design team in navigating the co-requisite programs. Questions related to the co-requisite programs should first be directed to those programs. The Phius Verifier is a valuable resource to offer clarification during the review of these documents.

National Water Management System Requirements, Version 1 / 1.1 / 1.2 (Rev. 04)

While this document is written for builders, it contains important design information that must be planned for before construction begins.

National HVAC Design Report, Version 1 / 1.1 / 1.2 (Rev. 04)

The items and endnotes from this document contain requirements that impact the design.

- Lines 2.1, 2.2 and 2.3
- Lines 2.17 through 2.25
  - Line 2.24

Phius Amendment: Projects located in ASHRAE climate zones 4 through 8 are required to provide ventilation air inlets and outlets ≥ 4' above grade and/or roof deck.

- Section 2b

Exception: Review endnote 23 which allows a minimum of 25 cfm continuous exhaust rate for kitchens in Phius projects. This may be overridden by the local mechanical code.

- Section 2c
- Line 3.1 and 4.1
- Lines 4.34 through 4.45
- Line 5.1
- Lines 6.2-6.8

Phius Amendment: MERV 8+ filters are required for ducted ventilation systems.

National Rater Design Review Checklist, Version 1 / 1.1 / 1.2 (Rev. 04)

Two tracks are available. It is up to the project team to review which track will be used and provide the appropriate documentation. The following sections impact the design.

- Track A - HVAC Grading by Rater
  - Sections 2 through 4a
- Track B - HVAC Testing by FT Agent
  - Sections 2 through 4b
  - Section 5

Phius Amendment: The Additional Construction Document Review is required for all Phius projects following Track B.

National Rater Field Checklist, Version 1 / 1.1 / 1.2 (Rev. 04)

This document summarizes the information the Verifier must confirm on-site, but includes items that impact the design in all sections. Areas of emphasis are included below, but the entire checklist should be reviewed and understood by the design team.

- Lines 1.5 and 1.6
- Sections 2 through 4
- Line 5.7

Phius Amendment: The National HVAC Functional Testing Checklist(s) are required for all Phius projects.

- Sections 11, 12 and 13

EPA Indoor airPLUS

Indoor airPLUS Version 1 (Rev. 04) Construction Specifications

Phius will align with Indoor airPLUS Version 2 on the same timeline as the DOE Zero Energy Ready Homes program (permit dates after 1/1/2026). Indoor airPLUS Version 2 | US EPA is now available.

> **Exception:** Projects located outside of the United States must meet certification criteria from the National Version 2 program, even though actual certification is not required.

DOE Zero Energy Ready Homes (ZERH)

Phius requires certification under the National Multifamily Version 2 program.

> **Exceptions:**
> Non-residential buildings (and non-residential spaces within mixed-use buildings) must meet the applicable certification criteria from the National Multifamily Version 2 program, even though actual certification is not required.
>
> For mixed-use buildings where the residential portion of the building (including common areas but excluding parking garages) is < 50% of the iCFA, the project must meet the certification criteria from the National Multifamily Version 2 program, even though actual certification is not required.
>
> For projects located in California, the California Multifamily Version 2 program requirements shall be met.
>
> Projects located outside of the United States must meet certification criteria from the National Multifamily Version 2 program, even though actual certification is not required. Review Non-Eligible Buildings for more information.

National Program Requirements, Version 2 (Rev. 1)

Exhibit 1 outlines the mandatory requirements for this program. The following sections impact the design.

- Sections 3, 4, 5

> **Exception:** Phius projects of 5 stories and less must provide on-demand controls for both unitary and centralized domestic hot water systems.

- Sections 6, 8, 9, 10, 11 & 12

> **Phius Amendment:** Advisory item 12 is required for Phius projects that provide in-dwelling unit HPWHs.

PV-Ready Checklist Version 2

Phius fully aligns with this checklist for all project types.

EV-Ready Checklist Version 2

Multifamily and residential portions of mixed-use buildings are required to fulfill the items outlined in this checklist.

> **Exception:** Non-residential buildings and non-residential portions of mixed-use buildings are not required to fill out this checklist and instead should refer to the requirements outlined in Section 1.5.2

1.4.2 Required Documentation

Table 1.4.2.0 Required Design Documentation	
Compliance Tool	WUFI® Passive Energy Model
Drawings	Architectural, Mechanical, Electrical and Plumbing Sets
	Civil or Landscape Set (refer to Site Plan)
	Structural Set (refer to Detail Drawings)
Technical Datasheets	Fenestration
	Mechanical Ventilation, Heating, Cooling and Domestic Hot Water (DHW) Equipment
	Insulation (refer to Insulation)
	Appliances (refer to Appliances)
	Light fixtures (refer to Light Fixtures)
	Miscellaneous equipment, pumps, fans and appliances (refer to Section 1.4.2)
Calculations & Analyses	Phius 2024 Criteria Calculator
	Take-off Documents
	Comfort & Condensation Risk Calculator (refer to Fenestration Condensation Assessment)
	Thermal Bridge and Moisture Risk Calculations (as noted in Section 1.4.2)
	Additional Calculators
Letter of Intent	From a Rater or Verifier as outlined in Section 0.4.5 and Section 0.4.6
Co-Requisites	HVAC Design Report & Rater Design Review Checklist

1.4.2.1 Required Documentation for Submission

Please review the Phius Single-Family Sample Project for examples of documentation noted below.

For Phius to begin a Project Review, the following documents must be uploaded to the Phius DropBox folder shared during Milestone 1: Project Registered:

1. Compliance Tool (See Section 1.4.3)
2. Drawings
3. Calculations & Analyses
    a. Phius 2024 Criteria Calculator
    b. Take-off Documents

1.4.2.2 Required Documentation for Design Certification

For Phius to award Design Certification to a project, the following documents must be uploaded to the Phius DropBox folder and approved by the Phius Building Certification team:

1. Compliance Tool (See Section 1.4.3)
2. Drawings
3. Technical Datasheets (or basis of design documents)
    a. Fenestration
    b. Systems (Ventilation, Heating/Cooling, Water Heating)
4. Calculations & Analyses
5. Letter of Intent from a Rater or Verifier
6. The National HVAC Design Report & National Rater Design Review Checklists noted in Section 1.4.1.1 or 1.4.2.1

1.4.2.3 Compliance Tool

A WUFI® Passive Energy Model is required for all new construction performance path projects. Review Section 1.4.3 for modeling protocol. The model must be fully complete with all applicable branches filled out and results populated. Design review is meant to begin before the building design is finalized and well-before construction begins.

When submitting the energy model for review, provide only a single case for review or be sure to specify which case should be reviewed by adding ‘REVIEW’ in the case name. If unspecified, Phius will review Case 1.

1.4.2.4 Drawings

Phius does not dictate drawing scales though they should be large enough to be comprehensive and readable. Drawings should be submitted in .PDF format, show dimensions, and cover the following:

Architectural Set

Site Plan

May be supplemented or replaced by a Civil or Landscape set, but must include:

- Project address
- Building orientation
- Changes in topography (if applicable)
- The location and height of neighboring buildings, structures and trees that would reasonably shade the building.

Floor Plans

Must include:

- Over-all and room-by-room dimensions
- Clearly labeled spaces and room tags
- Detail drawing call-out tags. See Detail Drawings for minimum requirements
- Exterior wall tags in combination with an exterior wall schedule or assembly description, unless provided on the sections
- Fenestration tags in combination with an exterior window and door schedule, unless provided on the elevations

Reflected Ceiling Plans

Required for all non-residential buildings and multifamily buildings using custom lighting power densities (rather than the defaults outlined in Section 1.4.4.8) for common areas.

Sections

Must include:

- Over-all building and floor-by-floor dimensions
- Detail drawing call-out tags. See Detail Drawings for minimum requirements
- Floor tags in combination with a floor schedule or assembly description
- Exterior wall tags in combination with an exterior wall schedule or assembly description, unless provided on the plans
- Roof tags in combination with a roof schedule or assembly description

Elevations

Must include:

- Fenestration tags in combination with an exterior window and door schedule, unless provided on the floor plans
- Clearly labeled exterior shading elements attached to the building such as overhangs, exterior shutters or blinds and vertical fins
- Exterior wall or finish tags in combination with an exterior wall or finish schedule for finishes that require a fastener correction calculation. See Section 1.4.2.6 for more details.

Detail Drawings

Show fully annotated and dimensioned drawings of all unique junctions of the thermal envelope. If the dimensions of structural members are not included in the Architectural Set, be sure to provide the associated Structural Set. Material type should be included in the annotations, but specific products are not required to be noted unless specialty products are used.

> **Example:** Rather than noting a continuous exterior insulation type as 'rigid', indicate the high-level family of insulation used such as EPS, XPS, GPS, PolyIso etc…

If a proprietary vapor or air control material is used, be sure to annotate the specific product being used.

The list of details that should be provided for review includes, but is not limited to:

- Exterior and interior wall junctions to the basement floor or slab on grade (section)
- Junctions between exterior walls and intermediate floors (section)
- Junctions between exterior walls (plan)
- Window and door installation (section and plan)
- Exterior anchoring systems for balconies or awnings (section)
- Penetrations such as roof drains, hose bibs, duct intake and exhaust, water connections etc…
- Exterior junctions to roof or ceiling (section)
- Airtight details (section and plan)
    - Must be comprehensible and show a continuous uninterrupted barrier that forms from the different materials and components at all junctions.

Schedules (recommended)

Schedules are most typical on larger and more complicated projects, but can be very useful from an organizational perspective for all project types.

Phius does not dictate strict naming conventions. However, naming conventions should be included for all windows and assemblies. These should be clearly labeled and easily understood by a reviewer unfamiliar with the project. The best way to do this is to label the drawing or schedule and have the labels in the drawing or schedule match the labels used in the energy model.

Exterior Walls, Roofs and Floors

If using a schedule to describe the different assemblies used in a project, ensure the assembly tags used in the plans and sections align with the schedule provided. Each layer of the assembly should be included and all material type annotations and dimensions needed to confirm the assembly modeled in WUFI passive should be provided.

Exterior Window & Door

If using a schedule to describe the different window and door types used in a project, ensure the window and door tags used in the plans and elevations align with the schedule provided. Fenestration type (fixed, casement, tilt and turn windows, glazed and opaque doors) should be clearly delineated along with the opening and height dimensions.

Mechanical Set

The make and model of all mechanical equipment noted below should be provided through either an equipment schedule or annotations within the plans and must include:

Mechanical Ventilation Systems

- Review recommendations outlined in Appendix I-2.4.
- Duct layout and sizes
- Supply and exhaust airflow rates at each diffuser and the diffuser location
- Soundproofing, filters, pressure overflows
- Outdoor penetration location for exhaust and supply ducts (plan and elevation)
- Duct insulation thickness and type
- Supply and exhaust duct length from the inside of the exterior wall to the ventilation unit

Heating and Cooling Systems

- Location of exterior and interior equipment, registers associated with supply and return air
- Size/capacity of equipment and distribution ductwork (if applicable)

Domestic Hot Water Systems

- Type of tank(s) and system

Additional systems

Pumps, fans, solar thermal, defroster, ground loop, earth tube, etc...

1.4.2.5 Technical Datasheets

Basis of design documentation is required in the form of data sheets or performance specifications. The following list summarizes the most common products and equipment that documentation is required for. This list is non-exhaustive and documentation may be required for specialty products and equipment not explicitly noted.

Fenestration

Performance data is needed for all windows, storefront, curtain wall, glazed doors, opaque doors, skylights and roof-hatches that make up the thermal and airtight boundary of the building.

Phius has verified data for a number of windows and manufacturers. If the project is using windows included on the Phius Find & Compare Windows, Phius' data must be used.

Data provided should include the following:

- Center-of-glass (Cog) U-value
- Center of Glass Solar Heat Gain Coefficient (g-value)
- Frame Thickness (in elevation)
- Frame U-value
- Psi-Spacer: Linear heat loss coefficient at the edge of the glass

Phius' window program calculates all these. But the project certification program is flexible as to the source of the data used. If the fenestration used in the project does not have Phius verification data, other 3rd party rating systems such as CEN, NFRC, NFRC CMAST or PHI may be used and barring other ratings manufacturer data is accepted. If whole-window data is available, but no U-frame data, the Phius Frame U-value Estimator may be used.

Mechanical Ventilation Equipment

Phius accepts ventilator efficiency data from six sources[9]. The sources are listed below in priority order of acceptable data. If data is available for a product from two sources on the list, the data from the source listed first is given priority.

1. Phius Certified Ventilator Program
2. Home Ventilation Institute (HVI)
    a. Section 3 Directory ventilators up to 300 cfm.
    b. Adjusted Sensible Recovery Efficiency (ASRE) or Adjusted Total Recovery Efficiency (ATRE).
        i. Climate zones 3C and colder: ASRE HEATING rating at 32°F (0°C)
        ii. Climate zones 3B and warmer: ATRE COOLING rating at 95°F (35°C).
    c. Net Moisture Transfer (NMT) or Latent Recovery/Moisture Transfer (LRMT).
3. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)
    a. AHRI Standard 1060 based simulation data required.

Process Tip: Ratings for commercial units do not include electrical efficiency data. For design certification calculations, estimate electrical consumption from manufacturer's specifications. This can be done by dividing the fan power by the design flow rate.

4. Eurovent Certified Products Database
    a. EN 308:2022 based simulation data required
5. Passivhaus Institut (PHI) Certified Component Data (PHI)
    a. May be used as long as the planned airflow for the project is within the range listed on the certificate.

Process Tip: Ensure the data available aligns with the ventilator chosen for the project. If the humidity recovery is 0% on the data provided, it is for the HRV core of that device. If the ERV core of the device is specified for the project, the PHI data cannot be used.

6. Individual Manufacturers
    a. If no 3rd party verification data is available, the stated manufacturer efficiency minus 12 percentage points shall be used.

Heating & Cooling Equipment

Phius accepts performance and capacity data from 3rd party rating systems such as ENERGY STAR, NEEP, AHRI or Eurovent and manufacturer provided data. Typical performance data available based on product type are outlined below. Review Section 1.4.4.13 for modeling protocol for certification.

Heating Systems

- Heat Pumps
    - Coefficient of Performance (COP)
        - Rated at 17F
        - Rated at 47F
    - Heating Seasonal Performance Factor (HSPF)
- Boiler or Furnace
    - Annual Fuel Utilization Efficiency (AFUE)
    - Energy Factor (EF)
    - % Efficiency

Cooling Systems

- Seasonal Energy Efficiency Ratio (SEER or SEER2)
- Energy Efficiency Ratio (EER or EER2)
- Integrated Energy Efficiency Ratio (IEER)

Domestic Hot Water (DHW) Equipment

Phius accepts performance data from 3rd party rating systems such as ENERGY STAR or AHRI and manufacturer provided data.

[9] Round up the planned airflow to the closest test airflow if data is available at multiple airflows. eg. Data at 80cfm and 100 cfm is available, but planned airflow is 90 cfm, use the 100 cfm data.

Typical performance data available based on product type are outlined below. Review Section 1.4.4.13 for modeling protocol for certification.

- Uniform Energy Factor (UEF)
- Energy Factor (EF)
- Coefficient of Performance (COP)

Insulation

Some insulation is temperature-dependent; use the R-value at 75 F for the energy model. Some insulation is thickness-dependent; use the R-value at the appropriate thickness for the assembly. If the insulation type is not yet specified, refer to Appendix I- for modeling defaults that may be used through Design Certification for typical insulation types.

Appliances

Phius accepts performance data from 3rd party rating systems such as ENERGY STAR as well as manufacturer provided data. Review Section 1.4.4.8 for Median ENERGY STAR (ES) values as of 2024 that may be used for projects through Design Certification or until project specific appliances are selected.

Light Fixtures

Phius requires fixture schedules or light fixture cut-sheets to confirm the energy use in watts for all non-residential buildings and multifamily buildings using custom lighting power densities (rather than the defaults outlined in Table 1.4.4.8.7) for common areas.

Miscellaneous equipment, pump, fans and appliances

Generally, these should be provided by the product manufacturer. For some components and equipment, third party ratings are provided. More details on each component/system found under Section 1.4.4.7.

1.4.2.6 Calculations & Analyses

Phius 2024 Criteria Calculator

This calculator is required all performance path projects[10]. A screenshot of the calculator should accompany the WUFI Passive file uploaded for Phius' review.

General Inputs

Envelope Area: Building exterior envelope area, including partitions to adjacent non-certified spaces or buildings.

- The total envelope area can be found in the WUFI Passive model within the PH Verification Report[11] or the 'Visualized Components' branch in the modeling tree.

Interior Conditioned Floor Area (iCFA): The total iCFA of the building. Review Take-off Documents below.

Residential Mode

Required for all residential type buildings: single-family detached, single-family attached and multifamily buildings, excepting hotels and motels.

- Dwelling Units: The total number of dwelling units in the building.
- Total Bedrooms: The total number of bedrooms in the building.

Process Tip: Studio apartments are counted as '0' bedrooms.

[10] Projects that use custom climate data will be issued a project-specific criteria calculator.

[11] If there are components assigned to an attached zone or 'Space with same inner conditions' as their outer side attachment, the envelope area for use in the criteria calculator should be taken ONLY from the 'Visualized Components' branch. The envelope area calculated for the PH Verification report does NOT include these components.

Non-Residential Mode

Should be used for certification of all non-residential building types.

- Average Occupancy: The average occupancy over the course of a typical 24-hour period.
- Design (Max) Occupancy: Maximum occupancy of the building.

Mixed-Use Buildings

Currently requires the criteria calculator to be run twice under the two separate modes to represent the different use types.

Custom Optimization

For unique non-residential buildings with very high internal loads, ventilation loads, or highly variable occupancy, custom optimization may be needed to determine the appropriate targets. Contact Us on a case-by-case basis. An additional certification fee will apply.

Project teams requiring Custom Climate Data will also receive a link to a custom Google Sheets-based version of the Phius 2024 Criteria Calculator that will require the same inputs described above. This custom calculator may not be used for any other projects except the one for which it was purchased, unless they share a site.

Take-off Documents

Take-offs should be provided in drawn form and supplemented with calculations required to best summarize the data outlined in the drawings or diagrams provided.

Thermal Envelope

Must be clearly identified. This is best accomplished using section and elevation drawings with exterior dimensions.

Interior Conditioned Floor Area (iCFA)

iCFA is the interior-dimension (drywall-to-drywall) projected floor area of the conditioned space that meets the following parameters:

- Interior spaces at least 7' in height, measured from the interior finished surfaces that comprise the thermal boundary of the building.
- Spaces that are visually open-to-below such as elevator shafts and true double-height spaces shall not be counted.
- Other than open-to-below, the projected floor area of all spaces within the building shall count toward the iCFA measurement, including stairs, interior walls, columns, built-in furniture, etc...

Site Shading Study

Phius requires a shading study of the project site. Refer to Section 1.4.3 for modeling protocol. Along with the Site Plan, the following documentation may better represent the shading situation and lead to a more accurate model. Any images provided should indicate the direction the image is facing and the site plan should indicate the location from where the images were taken.

- Sky-dome or sky-panorama images for each facade with overlaid measurement grids.
- Solar pathfinder images for each facade.
- Solmetric images for each facade.

DHW Pipes

Comprehensive lengths of the DHW distribution system should be shown in plan, elevation or riser diagram and may be supplemented or summarized in a matrix in order to clearly represent the planned piping layout as outlined in Section 1.4.4.13.

Mechanical Ducts

Mechanical plans should be annotated with information on the duct sizes and lengths for supply and exhaust ducts as measured from the inside of the exterior wall or roof to the ventilator.

Fenestration Condensation Assessment

Refer to Section 1.3.3 and use Phius' Window Comfort & Condensation Risk Assessment Tool to look up the required temperature factor (fRsi) for a given project and test compliance with any of the methods outlined below.

1. General Frame Type U-value
   a. This is the most straightforward method to confirm compliance using the calculator noted above.
2. U-Frame (Uf) inferred from U-Window (Uw) and U-Center of Glass (Ucog)
   a. If U-frame data is not available, the Phius Frame U-value Estimator may be used to infer the U-frame which can then be input in the calculator noted above.
3. AAMA 1503 Condensation Resistance Factor (CRF)
   a. This tested value may be available from the manufacturer or a 3rd party testing agency. This value will be a whole number between 1 and 100. If the tested CRF (for both frame and glass) is higher than the critical CRF rating from the calculator above, the fenestration unit complies.
4. NFRC 500-2020 Condensation Resistance
   a. This tested value may be available from the National Fenestration Rating Council (NFRC). This value will be a whole number between 1 and 100. If the tested CR value (for both frame and glass) is higher than the critical CRF rating from the calculator above, the fenestration unit complies. Please note the year of the CR value is critical. Only 2020 and newer CR values can use this compliance path.
5. CAN/CSA A440.2 Temperature Index (TI)
   a. This tested value may be available from the manufacturer or a 3rd party testing agency. This value will be a whole number between 1 and 100. If the tested TI value (for both frame and glass) is higher than the critical CRF rating from the calculator above, the fenestration unit complies.
6. fRSI Method[12]

Fenestration Comfort Assessment

Refer to Section 1.3.3.3 and use Phius' Window Comfort & Condensation Risk Assessment Tool to determine the climate-specific comfort requirements per window height. Review Appendix N-3 for exceptions.

Thermal Bridge & Moisture Risk Calculations

Thermal Bridge Psi-Value Calculator

Use this to calculate linear heat loss transmission coefficients (psi-values) in combination with THERM files. The workbook is set up to print 1-page thermal bridging reports that can also be presented to clients.

Fastener Correction Thermal Bridge Calculator

Generates an adjusted assembly R-value. It is required for aluminum fasteners and can be used when a project specific de-rate is required instead of the default de-rates outlined in Appendix I-3.1. Tutorial available here.

Phius Psi-Install Modeling Protocol

May be used for any window install detail in lieu of using Phius' default psi-install values.

[12] Passivhaus Institut (PHI) Certified Component Data

ISO 13788 Critical Interior Surface Temp Calculator
This calculator is used to determine the minimum critical interior surface temperature to avoid mold risk at a thermal bridge or corner.

Additional Calculators

The Phius Resource Library contains a database of calculators covering a wide range of topics related to project certification and the Phius standards. The following list contains additional calculators not previously covered that may be required to determine and/or confirm WUFI inputs.

Fenestration

Blinds Calculator
This calculator accounts for occupant control over blinds in passive buildings. Use this to convert datasheet information to WUFI Passive inputs. For exterior and interior blinds.

Active Systems

Heat Pump Calculator
Use this calculator for all projects that use an air source heat pump with an outdoor condenser or multiple condensers, a ground source heat pump, or a blend of different heat pumps.

> **Process Tip:** If a heat pump has energy efficiency data following AHRI Standard 1230 or has data for a ducted distribution system, the fan power associated with space conditioning distribution is already accounted for in the efficiency from the datasheet and does not need to be accounted for separately.

HRV/ERV Outside Calculator
This calculator should be used to determine the 'Mechanical Room' temperature when a mechanical ventilation device is located outside of the thermal envelope. (eg. the roof)

Multifamily Lighting & Misc Load Calculator
Use for all projects with more than one dwelling unit. This includes townhouses, duplexes, traditional multifamily, dormitories, long stay hotels etc.

Intermittent Kitchen Exhaust Allowance Calculator
Use this calculator to determine if a building is required to provide makeup air when using direct kitchen exhaust hoods.

Sanden CO2 HPWH Climate-Adjusted EF Calculator
Calculates a climate-adjusted Energy Factor for the Sanden CO2 Heat Pump Water Heater. Applies to Gen 1 through Gen 4.

Water Pressure Booster Pump Estimator
This estimator should be used to determine the energy use of water pressure booster pumps for residential buildings over four stories or where a water booster pressure pump is planned in the design to provide adequate water pressure for the upper floors.

Temperature Reduction Factor & Auxiliary Space Heating Estimator
This estimator may be used to determine a lower temperature reduction factor than the default of 0.95 and the associated additional energy use for attached zones outside of the thermal and airtight envelope that are conditioned to a lower setpoint temperature than the certified portion of the building. Be sure to Contact Us to ensure hourly climate data for the specific project location is available.

1.4.3 WUFI® Passive Energy Modeling Software

1.4.3.1 Accepted Modeling Software

For Phius CORE 2024 & Phius ZERO 2024:

- WUFI Passive: Version 3.5
- WUFI Passive Free: Version 3.5

Process Tip: Older project files can always be opened in newer versions of the software, but newer files generally cannot be opened in older versions. A project file may be opened in a previous version of WUFI Passive by saving the file type as 'XML' in the newer version WUFI Passive, then opening the XML file in the older version

Example: A project file created in WUFI Passive v3.3.0.2 can be opened in v3.5.0.1. However, a project file created in WUFI Passive v3.5.0.1 cannot be opened directly in v3.3.0.2.

1.4.3.2 WUFI Passive Online Tutorials

Free online tutorials can be found here.

1.4.3.3 WUFI Passive Settings

Table 1.4.3.3.0 WUFI Passive Settings

Options	Selections	Instructions and Descriptions
Usability	Tool tips	Check all boxes to ensure the proper hover-over hints are visible.
	Data Recovery	Turn this on to auto-save projects.
	Comments	Use this to save notes within each screen of the project file. Helpful for colleagues, personal notes, etc...
	Show edit icons in tables	Select to view cells with built-in calculators. Will appear with [...]
	Show project / case in footnote	Select to include case name in footer of printed results reports.
Passive	Default Certificate Criteria	Set to Phius 2021 (Phius 2024 selection available in future).

1.4.3.4 Dynamic modeling in WUFIplus

Though not required for certification, consider also doing dynamic modeling (WUFI Plus) when:

- Cooling and/or moisture loads are high.
- Heating is discontinuous (during the heating period).
- Occupancy and indoor conditions vary considerably.
- Comfort and overheating should be assessed.

If dynamic modeling seems called for, Phius suggests running a 3-zone dynamic model as a comfort analysis using WUFI Plus (WUFI Passive dynamic side), or another dynamic energy model. The 3 zones would be the coldest room, warmest room, rest-of-building. There are two possible approaches – one is to set the heating and cooling system capacities very high and look for the per-square-foot differences in the heating and cooling loads among the zones. The other is to limit the system capacities and look for failure to maintain the desired interior temperature set-points.

Energy Model Defaults

The accepted software versions agree on default input values for several input parameters. Most pre-filled fields in WUFI should be left unchanged unless otherwise noted in the sections below, or when documentation is provided to verify altered values. These values (and the way they are calculated) may be updated in the future to coincide with research and best practices.

External Calculators & Protocol Documents

Many external calculation methods and protocol documents are developed as new modeling situations arise. Eventually, these calculation methods and protocols are built in or implemented into the WUFI Passive energy modeling tool. External calculators may be used in the interim.

Always download the latest version of the protocol documents on the Calculators & Protocols page.

Using SketchUp with WUFI Passive

For guidance, tips and tricks on using WUFI Passive in tandem with SketchUp and for other general modeling guidance review the Guidelines for using Sketchup with WUFI Passive here.

1.4.4 Phius Energy Modeling Protocol for WUFI Passive

Table 1.4.4.0 Modeling Protocol Table of Contents

Table 1.4.4.1 Modeling Protocol TOC (continued)

1.4.4.1 Cases

WUFI Passive allows for quick creation of multiple 'cases' within a single project file. Cases are generally created by duplicating a previous case. This can be used to compare alternate designs and provides direct result comparison. Cases can contain varying geometry, and a new geometry file can be imported into a duplicate case.

For Mixed-Use projects, it is helpful to import the whole building as two zones (residential and non-residential). Then, one case can cover the residential portion as the 'active' or 'simulated zone', and the second case can cover the non-residential portion as the 'simulated zone'. This keeps the entire building in one WUFI Passive model.

Process tip: Be aware that assemblies, windows, ventilation utilization patterns and non-residential utilization patterns are shared across WUFI Passive cases. A change to a pattern or assembly in one case, will update it in the other cases.

General

See Table 1.4.3.3.0 for recommended settings.

Name:

If multiple cases are provided to Phius for review, be sure to name the case meant for Phius review as 'Round # - For Phius Review'.

Remarks:

This text box is useful for internal tracking of changes made or quick internal notes. Phius does not review this box as part of the certification process and all changes between rounds of review should be tracked in the Phius Feedback Document.

Certificate Criteria:

WUFI Passive does not yet have a 'Phius 2024' dropdown menu option. Until that is available, choose the inputs noted in the following table and keep in mind the source energy target calculated by WUFI Passive is not correct. Use the Phius 2024 Criteria Calculator to determine the Source Energy limit.

Table 1.4.4.1.0 Certificate Criteria Setting for Phius 2024	
Standard Pursued	**WUFI Passive Input**
Phius CORE 2024	Phius CORE 2021
Phius ZERO 2024	Phius ZERO 2021

Use WUFI month mean shading factors:

This box must be checked for all Phius projects.

Process tip: Entry changes that affect the shading calculation will trigger a warning stating "Shading factors are not...". The 'Calculate WUFI shading' button will appear (in the bottom right screen directly above where the results will populate), prompting the shading calculation to be re-run.

Report: Data & Results

Reports are automatically generated upon completion of a WUFI Passive model. If results are present, the reports are available. Reports can be printed to PDF or exported into Microsoft Word. If exported into MS Word, charts can be copied into Excel if needed. Review WUFI Passive Tutorial 3: Report Data and Results.

Passive House Verification:

Comprehensive summary of results and verification of compliance for all performance-based certification requirements, verification of compliance with Phius' add-on badges, breakdown of losses and gains for calculation of annual demands and peak loads, electricity & DHW consumption, etc.

REM-Rate Report:
Summary report for Phius Certified Rater/Verifier to view for coordination with REM/Rate model.

Site Energy Report:
Breakdown of site energy by end use.

Source Energy Report:
Breakdown of source energy by end use.

Site Energy Monthly Report:
Breakdown of monthly site energy by end use. Supports comparison of energy model results to monthly utility bills. Available in PHIUS+ 2018 and Phius 2021 modes. Currently only available in residential mode.

User Defined:
Combines all reports into one, long report.

View Settings

- Normal: Used for viewing within WUFI Passive. Does not have headers or page numbers.
- Print/Export Layout: Includes a header, page numbers, and a footer which includes the case name on each page of the report.

Process tip: Select WUFI Passive Options> >Usability> 'Show project/case in footnote'.

1.4.4.2 Localization / Climate

Localization

Phius has generated >1,000 climate datasets for locations around the United States; they are available as individual Text and Excel files per city and state for the United States and Canada. These datasets are available free to Phius Alliance members and can be downloaded from the Phius Alliance Member Resources page. For individual datasets for non-Alliance members, Contact Us. Keep in mind the following when choosing climate data for a project: Climate data must be approved by Phius for each project.

- The dataset must meet the following criteria:
  - ≤50 linear miles from the project location.
  - ≤400' difference in elevation from the project location
- If no standard climate datasets are available within the limits above, a custom data set is required. Custom climate data may be purchased on the Phius Climate Data page.

If a project falls within the constraints for an existing climate data set to be used, the Phius space conditioning targets associated with the existing data set must be used. Project teams that require custom climate data will receive a custom calculator for establishing the project-specific space conditioning performance targets.

Uploading a Phius Climate File into WUFI Passive
Select "User Defined" from the dropdown list, click the "Browse" button, and search for the saved climate file. The file types available for import are: Text files (.txt) and Excel (*xlsx)
Review WUFI Passive Tutorial 4: Import Climate Data.

Exception: Climate data import is not available in the free version of WUFI Passive; in this version the climate data must be input manually. See Entering Climate Data into WUFI Passive Free below.

Altitude Building:
The altitude of the project site must be input. Use the typical elevation at grade. If there is a large grade change (i.e. projects with walk-out basements, use the average site elevation. Site altitude may be easily determined using Google Earth.

Time Zone:
This entry is required for the dynamic shading calculation. Use standard time, not daylight.

- Eastern Standard Time: UTC -5
- Central Standard Time: UTC -6
- Mountain Standard Time: UTC -7
- Pacific Standard Time: UTC -8
- Alaskan Standard Time: UTC -9

Climate Zone:
Must be set to align with the climate dataset used for certification. The climate zone is used to determine the utilization for Phius CORE projects that employ on-site renewable energy. This is not applicable for Phius ZERO projects, so the dropdown menu for this input will not appear.

Ground Thermal Conductivity:
In heating dominated climates, this value may not be lower than 0.833 (BTU/hr.ft.F), and should typically be left at the default of 1.1558 (BTU/hr.ft^2.F).

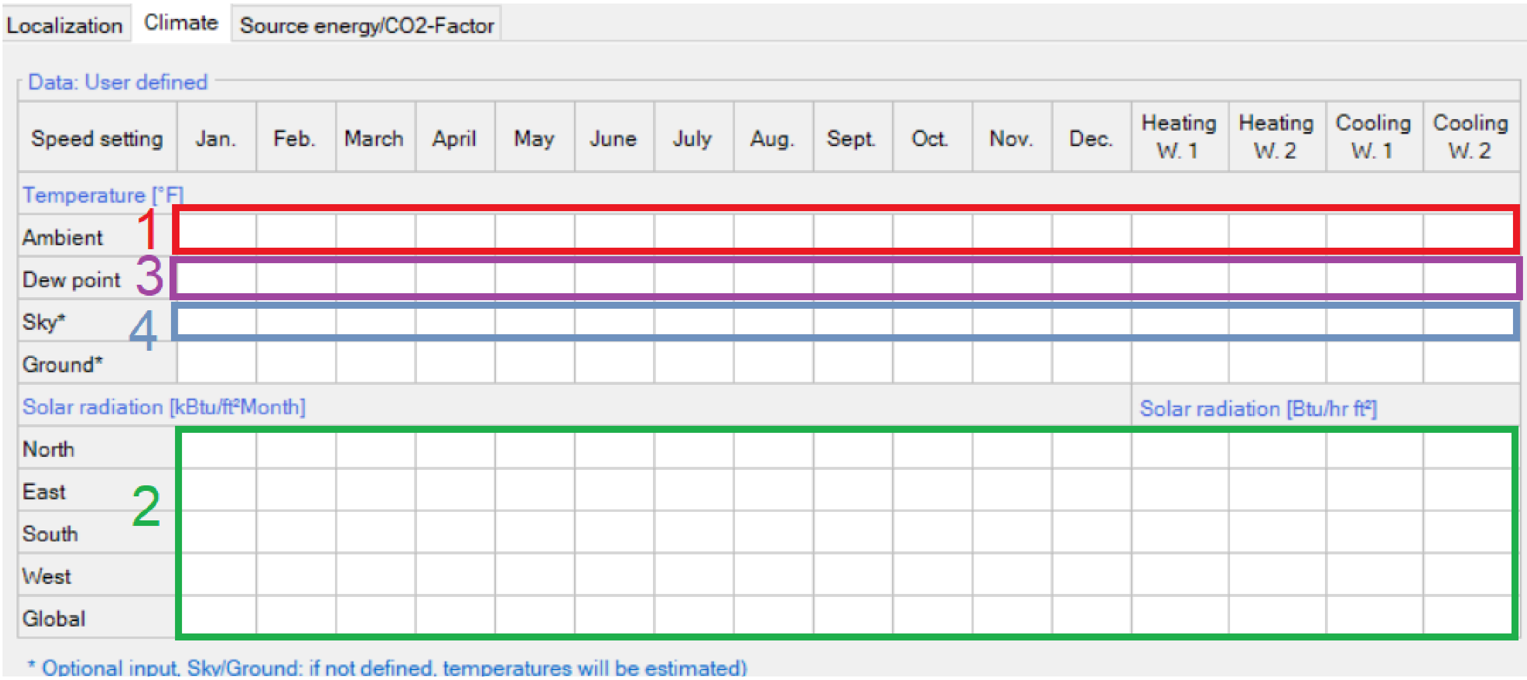
For thermal resistance, this is equivalent to no more than 0.1 R/in (hr.ft^2.F/BTU.in). Additional documentation is required to verify inputs outside of the typical range noted above.

Space Conditioning Target Data
Use the Phius 2024 Performance Criteria Calculator to determine project specific space conditioning criteria. For guidance on populating the calculator, refer to Section 1.4.2.6.

Review WUFI Passive Tutorial 5: Space Conditioning Target Data.

Entering Climate Data into WUFI Passive Free

US CUSTOMARY:															
Month	1	2	3	4	5	6	7	8	9	10	11	12	Heating Load		Cooling Load
Days	31	28	31	30	31	30	31	31	30	31	30	31	Weather 1	Weather 2	Radiation
CHICAGO OHARE INTL AP IL	Latitude:	42.0	Longitude ° East:	-87.9	Altitude (ft):	659.4	0	Daily temperature variation summer (F)		18.7	Radiation Data:	kBTU/(ft².month)	Radiation: BTU/hr.ft²		BTU/hr.ft²
Ambient Temp (°F) 1	23.7	27.5	38.8	50.0	59.5	70.0	75.4	71.2	64.6	51.8	40.5	25.3	7.5	21.2	80.8
North	8.2	10.1	12.0	12.7	18.1	20.0	19.7	15.5	11.1	8.6	6.3	7.0	11.4	11.4	28.2
East 2	17.4	21.9	27.9	31.1	40.3	40.6	39.9	35.5	31.4	24.1	15.2	15.8	35.8	15.5	64.7
South	30.7	31.4	32.3	26.6	28.2	24.7	27.6	28.5	31.4	33.0	24.4	27.9	67.2	23.8	43.1
West	11.7	14.6	17.8	20.6	27.3	27.6	28.5	24.4	19.0	14.3	8.6	9.8	19.7	13.6	42.8
Global	17.1	21.9	33.0	41.2	57.7	59.0	59.9	49.8	39.0	27.9	16.8	14.3	27.6	20.3	95.1
Dewpoint 3	15.1	17.2	29.3	39.2	45.0	55.4	65.7	61.9	55.2	41.0	32.7	18.3			
Sky temperature 4	-16.2	-5.3	7.9	17.8	29.3	37.6	52.0	47.8	38.1	21.4	14.4	-11.4			



Review WUFI Passive Tutorial 6: Entering Climate Data in WUFI Passive Free.

Climate

Phius uses Meteonorm to generate and output monthly climate data for the calculations run in WUFI Passive.

Ambient Temperature:

Monthly average outdoor air temperatures used for the annual heating and cooling demand calculations.

Heating W. 1:

Column of data is used to calculate one of two peak heating load scenarios. This extreme weather condition uses a cold, clear day to calculate the heating load. WUFI Passive calculates the peak heating load based on the higher losses scenario.

Heating W. 2:
This column of data is used to calculate one of two peak heating load scenarios. This extreme weather condition uses a warmer, but overcast day compared to the Heating W. 1 described above to calculate the heating load. WUFI Passive calculates the peak heating load based on the higher losses scenario.

Cooling W. 1:
Extreme weather condition, used for calculating the peak cooling load.

Solar Radiation:
Average monthly solar radiation per facade used for the annual heating and cooling demand calculations.

Source Energy / CO_2-Factors

Electricity Mix

- USA: 2.0[13]
- Canada: 1.96
- Japan: 2.77

Use the national average value for certification, regardless of regional differences[14]. If using v3.5 of the software or older, update the Source Energy Factors within WUFI Passive as outlined in this Phius 2024 Modeling Update for WUFI Passive document. Review WUFI Passive Tutorial 7: Source Energy and CO2 Factor.

[13] This value is reflecting a 2050 outlook, see Appendix I-3.2.
[14] This policy aims to preemptively avoid the "rebound effect," where building designers take advantage of locally "cleaner" grids to use more energy, and instead, as a result, shares that benefit with designers in "dirty grid" regions. This is consistent with the idea that with the current fossil-dominated primary fuel mix, energy impact translates into atmosphere impact.

1.4.4.3 Building

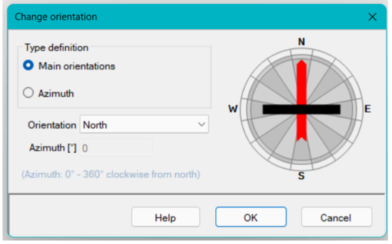
Building Wizard

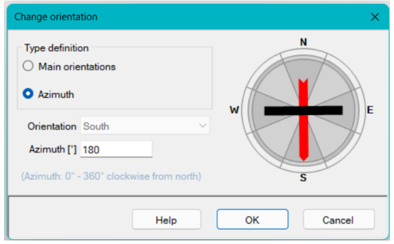
The building wizard can be used to create basic opaque massings by entering numeric values for plan, roof and foundation section dimensions. Review WUFI Passive Tutorial 9: The Building Wizard.

Process tip: Phius does not recommend this modeling method due to software limitations that may not allow the user to create complex geometries or project-specific unique conditions, but may be a beneficial tool for modelers using the free version of the software.

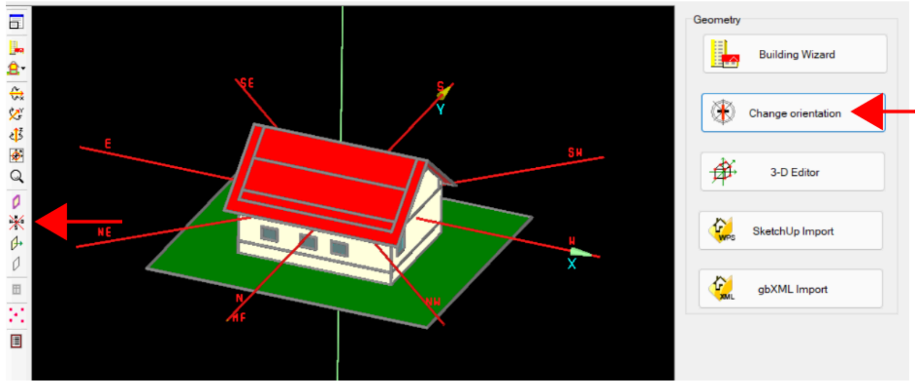
Change Orientation

The orientation can be changed by either selecting the main orientation from the built-in dropdown menu, or by entering a user-defined value for the azimuth (0° - 360° clockwise from N). Review WUFI Passive Tutorial 10: Change Building Orientation.



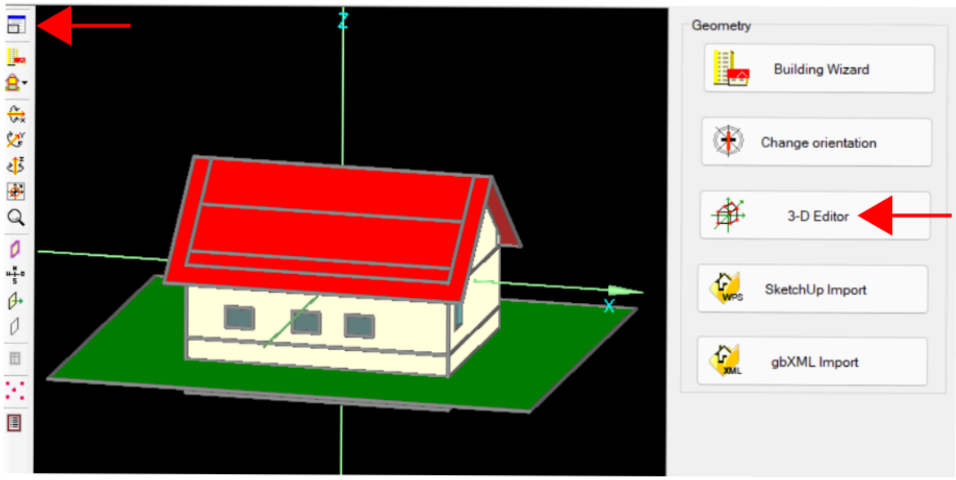


Process tip: The orientation can also be changed using the 'Orientation' toggle within the ribbon of the geometry viewer. This will turn on the compass as well to verify that the orientation is set correctly.



3-D Editor

The 3-D Editor will expand the geometry viewer so that it is full-screen. This can also be done by using the 'Expand/Shrink Window' toggle within the ribbon of the geometry viewer. Review WUFI Passive Tutorial 11: 3D Editor - Revising Window Sizes and WUFI Passive Tutorial 12: 3D - Revising Geometry.



SketchUp Import (Recommended)

Use this button to import the .wps file after creating the geometry in Sketchup. This is the most ideal option for importing 3D geometry. For modeling guidance, please refer to the Guidelines for using SketchUp with WUFI Passive.

gbXML Import (Not Recommended)

This option is not recommended due to the tendency for import errors to occur. As an alternative, the Revit-to-Sketchup-to-WUFI workflow could be used, which comes with its own set of unique challenges due to the level of detail in a Revit file vs what is ideal and sufficient for WUFI modeling purposes. For access to the guideline for this workflow, Contact Us.

1.4.4.4 PH Case

General

Review WUFI Passive Tutorial 15: PH Case General.

Building Category

Input should align with the definitions used in Section 0.5.

Occupancy Type

If Building Category is set to 'Non-residential', the following options may be used based on the descriptions below:

Office/Administrative building: Used for all non-residential projects that have a defined program that do not fall under the category of school.

School: Used for all school or learning facilities.

Other: Never use for Phius certification.

Undefined/unfinished: Used for non-residential projects with undefined programs.

Indoor Temperature

68F is a required input regardless of the planned winter setpoint temperature.[15]

Number of Units

Residential: The total number of residential units should be used. At minimum, a 'unit' includes a kitchen, bedroom/living space, and bathroom.

Non-Residential: Enter 1.

[15] Contact Us for unique facilities such as refrigerated buildings.

Number of Floors

The number of total full-height floors should be entered. This is used to determine:

1. Airtightness allowance adjustment, if applicable.
2. Number of floors to be used for the DHW distribution losses when using 'floor method'.

Additional Data

Review WUFI Passive Tutorial 16: Additional Data.

Preferred minimum indoor temperature for night ventilation:

68F is a required input regardless of the planned summer setpoint temperature.

Overheating temperature threshold:

77F is a required input regardless of the planned summer setpoint temperature.

Fresh Air Per Person:

Residential: 15 cfm minimum required for residential

Process tip: 18 cfm per person is recommended and is the current default in WUFI Passive

Non-Residential: IMC, ASHRAE 62.2, or local mechanical code should be followed.

Hot water tap-openings per person per day:

Defines how many times each DHW tap is opened per person, per day. Used to calculate DHW distribution losses only when using the 'Simplified Individual pipes' method for DHW individual pipes.

Residential: This entry does not apply for Phius 2024 projects. DHW Distribution calculation method cannot be 'Simplified Individual pipes' for design certification.

Non-Residential: A user defined value must be input here based on the total typical occupancy on an average day of building use. The following formula should be used:

- **(**Number of People in an Occupancy Group **/** Total Number of People in the Building**) x (**Estimated number of DHW tap openings per person per day **/** Total DHW taps in the building**)**

Envelope airtightness at 50 Pa:

Per Section 1.3.3, for buildings of five stories and above that are also of noncombustible construction:

q50 <= 0.08 CFM_{50}/ft^2 of gross envelope area

For all other buildings:

q50 <= 0.06 CFM_{50}/ft^2 of gross envelope area

Gross envelope is measured at the exterior of the thermal boundary, the same as for the energy model, and includes surfaces in contact with the ground.

Phius recommends entering the maximum limit for the building here. A lower value may be used to meet space conditioning targets, but the designer must acknowledge that the lower value must be met in the field for the project to pass at final certification.

Process tip: For some large buildings with elements that are considered non-threatening leakage (Review Appendix C-2.3), modeling with a higher airtightness value than the durability requirement noted above may be beneficial to ensure that the project passes the space-conditioning and source energy requirements with the un-taped blower door test value.

☐ Non-Combustible Materials:

Check this box if the building is of non-combustible construction. If this box is checked, and the building is 5 stories or greater (input on PH Case>General), the 'target' airtightness will be adjusted in the model and report. Refer to Appendix I-3.3 for example conversion.

Type of Ventilation System

Balanced PH Ventilation: Default system type for Phius projects. Incorporates continuous ventilation and allows the Sensible and Humidity Recovery of the Mechanical Ventilation system to impact the results.

Exhaust Only: This system selection may be useful for typical or code comparison models. Only exhaust air inputs on the 'Rooms Ventilation' tab affect the model and the Sensible and Humidity Recovery of the Mechanical Ventilation system do not impact the results.

Maximum Humidity Ratio

0.012 lbw/lba is a required input for Phius Certification.
Refer to Appendix I-3.4 for additional information.

Building Wind Exposure

This metric impacts the space conditioning results by calculating additional heat loss due to wind-washing of the facade. Three distinct factors are used:

1. Wind Screening Coefficient (e)
    a. 0.04 - No Screening
    b. 0.07 - Moderate Screening
    c. 0.1 - High Screening
2. Wind Exposure Factor (f)
3. Wind Shield Factor

Process tip: Of the factors listed above, the only one that currently affects the results in WUFI Passive is the Wind Screening Coefficient (e). This means that at this time, the Wind Exposure Factor (f) which is controlled by the number of facades exposed to the screening (either Several Sides Exposed or One Side Exposed) currently has no impact on the results.

No Screening: Low or non-existent neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)

Examples: Building located in an open field with a non-existant or distant (>100') tree line. Highrise or skyscraper that towers above adjacent buildings or structures.

Moderate Screening: Similar height neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)

Examples: Building located in a rural treed area, suburban development or low-rise city center.

High Screening: Tall and dense neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)

Examples: Building located in a dense forest surrounded by trees. Low to average height building in a dense city center.

User Defined: When a building falls between one of the pre-defined screening factors, a user-defined entry may be used.

Process tip: A well-documented site plan and narrative from the project team is required with justification outlined for Phius' review.

Examples: Average height building is located in a dense city center, however it is located on a corner at a wide street intersection with little cover. A user-defined Wind Screening Coefficient (e) value half-way between 0.07 (Moderate) and 0.1 (High) screening of 0.085 is used to more conservatively estimate the screening condition.

Domestic Hot Water Use Per Person

Residential: No input is required for Phius certification and values input here do not affect the results.

Non-residential: 3.2 gal/person/day

- The default above will not fit for all non-residential projects. The entry may vary from the default if supporting documentation/calculation is provided and approved by Phius.

Refer to Appendix I-3.5 for additional information.

Average cold water temperature of the supply:

Leave this input blank.[16] WUFI Passive will calculate it using an average annual ground temperature.

Mechanical Room Temperature

Input here should be based on one of the following scenarios:
Ventilator within the thermal and airtight envelope: 68F is the required input for Phius Certification. **or**

Ventilator in unconditioned space outside of the thermal and airtight envelope: Calculate input using the ERV/HRV Outside Calculator.

OR

Ventilator in conditioned space outside of the thermal and airtight envelope: Input the setpoint temperature of the space.

Foundation Interface

Up to three different foundation interface connections can be defined. These determine reduction factors to be applied to components with 'Ground' assigned on the Outer Side. The 'Setting' for each foundation interface modeled should always be set to 'User defined'. The following list outlines the options available from the 'Type' dropdown menu and gives instructions on when and how to use them.

[16] A user defined entry may be used if supporting documentation is submitted to confirm the new groundwater temperature. The adjusted groundwater temperature generally should not exceed the average ambient air temperature for the project's climate.

Heated Basement, or Underground Floor Slab:

Use this type when the project has a conditioned basement or partially-underground slab (i.e. walkout basement) that is within the thermal envelope. Review WUFI Passive Tutorial 20: Foundation Interface - Heated Basement.

Floor slab area [sf]: The area for this interface should be measured from the interior face of the basement walls.

U-value of basement slab [Btu/hr.sf.°F]: Typically, choose 'Detect automatically' if there are one or more basement slab assemblies. If there is only one, 'User defined' may also be used. Align the U-value with the WUFI-calculated U-value of the corresponding basement slab component. This is most appropriate when there are multiple foundation interfaces.

Floor slab perimeter [ft]: The perimeter should also be measured from the interior face of the basement walls. If there are multiple depths of basement or underground slab, do NOT include lengths of slab that are in contact with conditioned space.

Depth of basement slab below grade [ft]: Enter the depth of the slab below grade. If there are multiple depths of basement or underground slab (i.e. basement with an elevator pit), or a significant grade change (i.e. walkout basement) use the average depth.

U-value of basement wall [Btu/hr.sf.°F]: Typically, choose 'Detect automatically' if there are one or more basement wall assemblies. If there is only one, 'User defined' may also be used. Align the U-value with the WUFI-calculated U-value of the corresponding basement wall assembly.

Additional Parameters: This section should always be left blank.

Unheated Basement:
This option should never be used.

Process tip: See Appendix I-3.6 for additional guidance on acceptable crawlspace foundation conditions per Indoor Air Plus (IAP), as well as their corresponding foundation interface parameters for WUFI passive.

Slab on Grade:
Use this type when a slab on grade is planned (i.e. no basement or crawlspace). Review WUFI Passive Tutorial 17: Foundation Interface - Slab on Grade.

Floor slab area [sf]: The area for this interface should be measured from the exterior face of the thermal envelope.

U-value of slab on grade [Btu/hr.sf.°F]: Typically, choose 'Detect automatically' if there are one or more slab-on-grade assemblies. If there is only one, 'User defined' may also be used. Align the U-value with the WUFI-calculated U-value of the corresponding slab on grade component. This is most appropriate when there are multiple foundation interfaces.

Floor slab perimeter [sf]: The perimeter of this interface should be measured from the exterior face of the thermal envelope. Do NOT include lengths of slab that are in contact with conditioned space.

Suspended Floor:
This option should never be used. Assign suspended or overhanging floors to 'Outer Air' on the outer side.

1.4.4.5 Zone 1

Single-zone modeling is required for Phius Certification. WUFI Passive is a whole-building energy model, meaning multiple zones do not affect the calculations and only serve to complicate modeling. Mixed-use projects that contain residential and non-residential space types should have separate cases or entirely separate WUFI Passive files for the different space types.

Visualized Volume

This value is not used for the "Passive House Verification" calculation; it refers to the volume of the visualized 3D model. This will be equal to the gross volume in most cases (when the model is drawn to the exterior dimensions).

Gross Volume

No calculation is required for certification. 'From visualized geometry and components' should be selected.

Process tip: This volume represents the volume of the building measured from the exterior boundary of the thermal envelope. Generally, this is the same as the visualized volume. However, if objects are included in the 3D geometry that are not part of the thermal boundary, for shading, etc., the visualized volume may not represent the gross volume.

Net Volume

The net volume does not affect the results of the energy model and is not a required calculation for certification. 'Estimated from gross volume' should be selected.

Refer to Appendix I-3.6 for additional information.

Interior Conditioned Floor Area (iCFA)

The reference floor area. The space conditioning criteria (heating and cooling annual demands and peak loads) are per square foot of iCFA. See Section 1.4.2.6 for the definition and guidance on calculating the iCFA.

Specific Heat Capacity / Thermal Mass

Regarding thermal mass, it is not just the total mass that matters but the distribution, so that it can interact with the infrared radiation bouncing around the room. The way of figuring this is based on the number of heavy surfaces (0 to 6) per room, in an average sense. Review WUFI Passive Tutorial 22: Zone 1 - Heat Capacity.

Thermal mass is determined by the equation = [60+n(heavy)*24]*0.176 (BTU/ft^2.F).

Refer to Appendix I-3.8 for guidance.

Example: A two-story building with a first-floor concrete slab would have 1/2 of a heavy surface per room on average.

1.4.4.6 Visualized Components

Process tip: Use the 'Total area of envelope components' value at the bottom of the list of Visualized Components when filling out the Performance Criteria Calculator.

Type / Attachment

This information is automatically populated based on the WUFI parameters assigned in Sketchup. Review the Sketchup to WUFI Passive Guideline for more information. Double check that these inputs are aligned with the type of component being modeled. Review WUFI Passive Tutorial 23: Opaque Components.

Type:
All components in Zone 1 should typically only be defined as either 'Opaque' or 'Transparent'. See guidance below on how to treat 'Openings' in the geometry.

Inner Side:
All components should be assigned to 'Zone 1'.

Outer Side:
Several options are available, and this input will vary depending on the component type. Typical selections are described below:

Outer air: Appropriate for all above-grade components (AG walls, roof, windows, exterior doors, etc.)

Ground: Appropriate for below grade components (BG walls, floor slab, elevator pit, etc.) Cannot be applied to transparent components.

Space with same inner conditions: Appropriate when an assembly is attached to conditioned, non-certified space (i.e. residential and occupied, non-residential and always conditioned)

Attached zone: Appropriate when an assembly is attached to an unconditioned or semi-heated space. See Section 1.4.4.11 below for guidance on setting up an attached zone.

Zone 1: Only appropriate if the adjacent zone is also being certified

Process Tip: 'Openings' should be assigned to 'Outer Air' for both the 'Inner side' and 'Outer side' attachments. This prevents openings from being counted towards the envelope area, which impacts the performance targets.

Opaque Assemblies

General
Naming conventions entered in WUFI Passive should align with the drawings and documentation provided for review. See Section 1.4.2.4 Schedules.

Exception: Opaque spandrel panels should be modeled as a 'Transparent Assembly'. See additional guidance below.

Material Layers

Opaque assemblies in WUFI should be built from outside to inside, and top to bottom in the assembly builder. The exterior layer of the assembly should align with the extents of the thermal envelope. Review WUFI Passive Tutorials 24 - 27. Do not include vented air gaps and cladding systems outboard of the insulation. Refer to Appendix I-3.9 for default materials from the WUFI database that can be used for modeling typical assemblies.

Framing

Framing must be accounted for in all assemblies that contain it. For walls, vertical and horizontal framing must be included. For roofs, truss chords should be included at a minimum.

3D Method (Recommended):

Use this method for typical wood-frame assemblies with exterior continuous insulation.

- Use the 'vertical subdivisions' in the assembly editor to account for top and bottom plates. The overall 'height' of the assembly created should be defined by a typical floor to floor height.
- Use the 'horizontal subdivisions' in the assembly editor to account for typical on-center framing. The overall 'width' of the assembly created should be defined by the typical on-center spacing.

Exceptions:

Wood Framing Factor Method: Use this method for typical wood-frame assemblies with no exterior continuous insulation.

- Model 25% of the cavity as framing for 16" o.c. assemblies
- Model 15% of the cavity as framing for 24" o.c. assemblies

Metal Framing Deration Methods: Choose one method below whenever metal framing is used.

Simple Method:

33% x R-value/in of the cavity insulation for 16" o.c. assemblies
39% x R-value/in of the cavity insulation for 24" o.c. assemblies

ASHRAE Method:

Apply a deration to the insulation layer containing metal framing in accordance with ASHRAE 90.1 Table A.

Insulation Specifications

Assign the insulation R/in in correspondence with the datasheet for the insulation selected for the project.

Process Tips:

Expand the 'R/in' dialogue box by clicking into the cell for the insulation layer in the conductivity (λ [Btu/hr.ft°F]) column.

If a specific insulation has not been selected, review Appendix I-3.9 for default material R-values that may be used for typical insulation types.

Exception: A deration to the R/in of the insulation must be applied if any of the following conditions apply:

- Using either of the 'Metal Framing Deration Methods' to account for steel framing
- Using mechanical fasteners for the installation of exterior continuous insulation. See Appendix I-3.1 Default Fastener Deration Values

Opaque Doors

Panel doors with no glazing components should be modeled as an opaque assembly where the total R or U-value aligns with performance data for that particular door. Material type and thickness does not need to align with the actual construction of the door.

☐ **Process Tip:** In the 'General' tab for opaque door components, check the box for 'Exterior door' at the bottom of the window. This will avoid the opaque doors being categorized as exterior walls in the reports.

Surface / Radiation Balances / Solar Absorption/Emission

Default values are applied for all components according to the component type in WUFI. No user input is needed in this section unless opaque assemblies are heavily shaded or white finish materials are used specifically to reflect radiation heat gains.

Transparent Assemblies

Vertical windows, glazed doors, storefront, curtain wall systems, skylights and spandrel panels are all considered 'Windows' in WUFI Passive and should follow the modeling protocol outlined below.

General

Naming conventions entered in WUFI Passive should align with the drawings and documentation provided for review. See Section 1.4.2.4 Schedules.

Mulled Windows: Two methods are available for accounting for mulled conditions.

1. Uncheck the box for 'From window parameters' in the 'Frame-to-wall psi-value' section at the bottom of the 'General' tab window.
    - Enter '0' for sides of the window that is mulled
    - Enter the typical 'Frame-to-wall psi-value' for the sides that are not mulled
2. Modify the frame 'Frame-to-wall psi' parameter for the assigned window type. See 'Window Parameters' below.

Exception: If the connector is substantially more conductive than the frame, a thermal bridge calculation may be necessary.

Window Geometry

In the energy model, each individual 'lite' or individual 'piece of glazing' should be its own clickable component. This ensures that the proper solar gain and frame to glazing ratio is accounted for.

Window Sizes:

The dimensions of the modeled windows should align with the rough opening of the window. For mulled configurations, model to the centerline of the shared frame.

Simulated Divided Lites

If there are simulated mullions applied to the window that do not actually interrupt the glass, the overall SHGC should be reduced, but no additional thermal bridging need be accounted for.

Window Groups

Windows are most easily grouped in the Sketchup phase when assigning WUFI properties for import, however windows can be grouped/ungrouped in WUFI Passive without having to re-import:

To Ungroup: Right-click component > Ungroup:

- Main component: will separate only the component outlined in RED
- All selected components: will ungroup all grouped components selected

To Group: Click on a component to add to the group, ctrl+click additional components to group, right-click > Group

- The properties of the component selected LAST will be applied to all components being grouped

Process Tip: The more consolidated the window groupings, the easier it is to stay organized throughout the modeling process. As a general rule, group windows according to (in hierarchical order):

Window type

Fixed, operable, storefront, glazed door, etc.

Mulled conditions

Top / bottom mulled; Left / right mulled; Top + right mulled; Bottom + left mulled, etc.

Shading conditions

Cladding condition causing varying reveal depths across windows

Projects that include more than 15 window groups in a model should re-evaluate and consolidate if possible.

Window Parameters

Process Tip: The 'Assign Data' option can be used for transparent assemblies to quickly assign properties to multiple window components at once. Review the Window and Door Refresher.

Uw-mounted
Leave blank, this value will be auto-calculated by WUFI Passive.

Frame Factor
Leave blank, this value will be auto-calculated by WUFI Passive.

Glass U-value
Input the product specific center-of-glass U-value. Review Section 1.4.2.5 Fenestration.

SHGC
Input the product specific center-of-glass U-value. Review Section 1.4.2.5 Fenestration.

Exception: Spandrel panels should have an SHGC=0.

Frame width
Input the product specific frame thickness as viewed in elevation.

Frame U-value
Input the product specific frame U-value.Review Section 1.4.2.5 Fenestration.

Glazing-to-frame psi-value
Input the product specific glazing-to-frame psi-value.

Process Tip: Otherwise known as the psi-spacer. 0.023 [Btu/hr.ft.F] is acceptable as a conservative placeholder.

Psi-Installation / Frame-to-wall psi-value
0.030 [BTU/hr.ft.F] shall be used for installation details.

Process Tip: The frame-to-wall psi-installation value is dependent on how the window is installed within the wall.

Exceptions:
- 0.020 [Btu/hr.ft.F] for a mid-wall mounted window that is not over-insulated.
- 0.015 [Btu/hr.ft.F] for a mid-wall mounted window that is also over-insulated.
- Lower inputs are acceptable with an accompanying thermal bridge calculation using one of the following:
    - Manufacturer value for a project specific installation detail.
    - THERM (or equivalent software) calculation following Phius Psi-Install Modeling Protocol.

Example: A project team is in the early stages of design, and wants to model windows based on the maximum whole-window U-value to comply with the Window Comfort Requirements. They cannot exceed a whole-window U-value of 0.19 based on the tallest window in the project. To model this in WUFI, the team should enter the following:
- Glass U-value: 0.19
- SHGC: 0.15-0.4 (typ. whole-window range)
    - This can be adjusted as an intentional design decision to meet the performance criteria targets
- Frame width: 0.01”
- Frame U-value: 0.19
- Glazing-to-frame psi-value: 0 (included in whole window U-value)
- Psi-Installation: 0.03 (default)

This method “ignores” the frame inputs and calculates a whole-window U-value of 0.19. This is helpful when modeling for a feasibility study or before a final window selection has been made.

Solar Protection

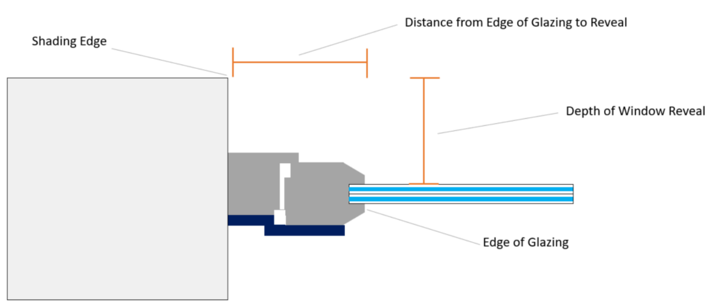
Process Tip: The 'Assign Data' option can be used for transparent assemblies to quickly assign properties to multiple window components at once. Review the Window and Door Refresher.

Reveal Shading

Often windows are not installed flush with the exterior of the building façade which causes shading to the left and right sides of the window from the window in-set in the wall.

Depth of window reveal: Measured from the outside of the leading shading edge to the glazing.

Distance from edge of glazing to reveal: Measured from the edge of glazing to the shading edge.



Reveal shading must be input for all windows.

- This can be done quickly with the [Assign Data] function.

Process Tip: The 3D geometry will visualize the window in-set into the wall when entries are adjusted.

- All reveal entries are calculated as if on both sides of the window.

Process Tip: If the reveal depths are significantly different on the left and right, due to a vertical shading fin or similar, it is recommended that the irregular shading device is drawn into the 3D geometry rather than input numerically.

Shading Fraction of Solar Exposure

Other shading fraction of solar exposure:

This numeric input impacts the solar gains for the heating season. It acts as an additional reduction factor on top of any 3D visualized shading obstructions and numerically input overhangs. This input should be used for year-round blinds, simulated divided lites, window screens or as a seasonal shading factor for south facing windows for which solar pathfinder images and calculations have been provided. An input of 1 gives solar gain access to the window, while an input of 0 calculates no solar gains.

Other shading summer fraction of solar exposure:

This numeric input impacts the solar gains for the cooling season. It acts as an additional reduction factor on top of any 3D visualized shading obstructions, numerically input overhangs and shading devices as noted in the next section. This input should be used for simulated divided lites or as a seasonal shading factor for south facing windows for which solar pathfinder images and calculations have been provided. An input of 1 gives solar gain access to the window, while an input of 0 calculates no solar gains.

Shading Devices

Sunscreen/shading devices in WUFI Passive are assumed to be used only during the cooling season. If year-round blinds are used, please input as an “other shading fraction of solar exposure”.

External blinds offer better thermal protection than internal blinds because the solar radiation is partially absorbed by the fabric before reaching the glazing and reflected outwards.

The effectiveness of window blinds need to be derated if they are manually operated, to account for occupant behavior. Use the Phius Blinds Calculator which follows the deration method noted in Appendix N-6.

Blind Ratings

Should be provided by manufacturers. Solar transmittance is used in the following equation. Solar radiation is always partially transmitted through, absorbed or reflected by the fabric.

Ts + Rs + As = 100% of solar energy

Ts = Solar Transmittance:
Proportion of solar energy transmitted through the fabric. A low percentage means the fabric performs well at reducing solar energy.

Rs = Solar Reflectance:
Proportion of solar radiation reflected by the fabric. A high percentage means the fabric reflects more solar energy.

As = Solar Absorptance:
Proportion of solar radiation absorbed by the fabric. A low percentage means the fabric absorbs little solar energy.

OF = Openness Factor:
Percentage of blind fabric/material that is open between the threads.

Refer to Appendix I-3.10 for additional information on insulated interior blinds.

Overhangs

Overhangs may be included in the 3D geometry or entered numerically into WUFI Passive.[17]

If included in 3D geometry, angled or complex overhangs may be modeled.

[17] If no overhangs are assigned to a window, the reveal depth dimensions are automatically set as the overhang. If this inaccurately represents the shading condition, please assign an overhang to the specific window.

If entering numerically, an overhang parallel to the window head will be simulated. Three parameters must be defined:

Depth of overhang

Measured horizontally out from the glazing to the shading edge.

Vertical distance from top of glazing to bottom of overhang:

Measured vertically from edge of glazing to shading edge.

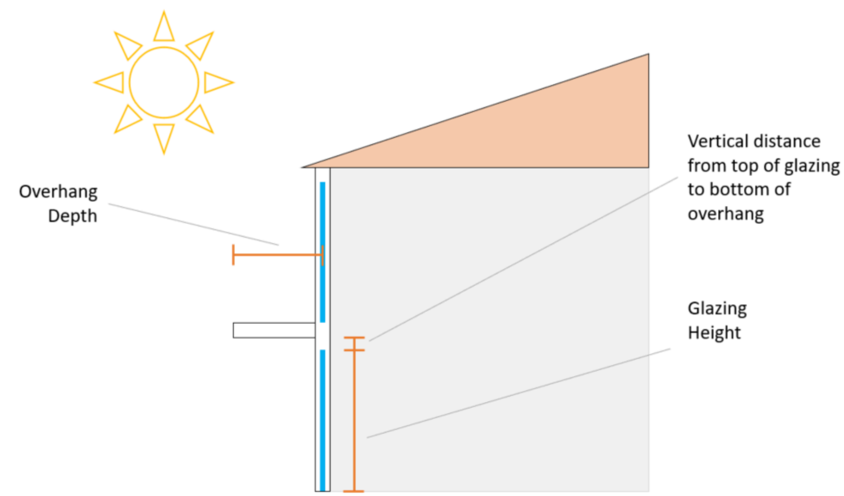
Side spacing:

The default side spacing is '0', which would simulate an overhang that matches the width of the window it is assigned to.

Process Tip: If the overhang extends longer than the width of the window, 'side spacing' may be input to extend the overhang on each side of the window. At this time, the extension must be uniform on each side of the window.

The numerically entered overhangs will appear in the 3D geometry.

Process Tip: If an overhang is both included in the 3D visualization and entered numerically, that is OK, it will not double count the shading if the two overlap in the 3D geometry.



WUFI Mean Month Shading Factors

Shading due to building geometry

Shading from building geometry such as overhangs, bump-outs, complicated geometry, surrounding buildings etc. will be considered. For documentation to confirm site shading elements, refer to Section 1.4.2.6.

- Any elements that should be considered for shading can be included in the 3D geometry imported into WUFI Passive. This includes overhangs, surrounding buildings, etc.

Process Tip: These elements should be assigned as 'opaque' and 'Outer Air' should be assigned on both the Inner Side and Outer Side of the components.

- Monthly shading factors are calculated and shown on the 'WUFI Mean Month Shading Factors' tab.
    - Correction/reduction factor per month can be applied in the row above the results, or
    - Default correction factor input can be used to apply a uniform reduction factor for all months.
- Results are calculated per window, even when windows are grouped.

Exception: Unique shading properties such as reveals, numerically entered overhangs, blinds, etc. will not be retained per window if grouping and ungrouping. When windows are grouped, they are given uniform numerical entries based on the last window selected when grouping.

- More information can be found in this presentation from NAPHC2018.
- To account for deciduous trees or seasonal shading using 3D visualized geometry in WUFI Passive, refer to the Site Shading Modeling in the New WUFI Passive Shading Tool webinar and Contact Us for access to the calculator and SketchUp plugin.

1.4.4.7 Thermal Bridges

To learn how to use THERM software developed by Lawrence Berkeley National Laboratory (LBNL) to calculate thermal bridges, an introductory training course may be purchased from the Intro to THERM Workshop page on the Phius website.

Phius has created a Psi-Value Calculator for consultants to use to document and calculate a project's thermal bridges.

Positive Thermal Bridges

Positive thermal bridges account for additional transmission losses that are not being accounted for in the typical modeled construction assemblies in WUFI. Phius defines a positive thermal bridge as any calculated psi-value > 0.006 Btu/hr.ft.F. The most common thermal bridges occur due to an interruption of continuous insulation. Review the following non-exhaustive list of common details where thermal bridging may occur and should be accounted for:

- Foundation-to-wall conditions, both above and below grade
- Grade beams and thickened slab edges
- Rim-joist or floor-to-exterior wall connections
- Wall-to-roof connections, especially parapet detailing at low-slope roofs
- Overhang and exterior shading devices

Negative Thermal Bridges

If accounting for any negative thermal bridges, all thermal bridges in the project must be calculated, no matter how small. In general, Phius strongly recommends against taking negative thermal bridges in the design phase, and only using these as a "last line of defense".

General

Naming conventions entered in WUFI Passive should include the name and/or number of the detail being modeled, aligned with the documentation provided for review.

Linear Thermal Transmittance

The psi-value of the thermal bridge, calculated using the Psi-Value Calculator noted above. All positive thermal bridges should be input in WUFI.

Length

The linear span [ft] of the detail calculated as a positive thermal bridge.

Example: If a ledger board for a deck attachment interrupts the exterior continuous insulation, the length of the TB for WUFI would be the linear length of the ledger board.

Attachment

Table 1.4.4.7.0 Temperature Zone Assignments

WUFI Passive Attachment	Temperature conditions in psi-value calculation		
	Interior [68F]	Exterior [14F]	Ground [41F]
Ambient	☑	☑	☐
Perimeter	☑	☑	☑
Basement Floor	☑	☐	☑

Ambient:

Use this selection for thermal bridges occurring above grade. Only two temperatures will be used in the THERM/psi value calculation– interior and exterior.

Perimeter:

Use this selection for thermal bridges occurring at grade. In this case, there will be three temperature zones used in the THERM calculation – interior, exterior, and ground.

Basement Floor:

Use this selection for thermal bridges below grade. Only two temperatures will be used in the THERM calculation – interior and ground.

Attached Zones / Zone 1

These attachments should never be used. For thermal bridges in contact with attached zones, the attachment should be assigned to 'Outer Air' and the psi-value of the thermal bridge should be multiplied by the attached zone reduction factor.

Example: A multifamily project discovers positive thermal bridges at the assembly transitions between a grade-level stairwell within the thermal envelope and a stepped-down enclosed parking garage outside of the thermal envelope.

- Garage ceiling connection
  - Attachment: Ambient
- Stepped-slab transition
  - Attachment: Perimeter
- Stepped-slab transition (if stair shaft is below grade)
  - Attachment: Basement floor

1.4.4.8 Residential Internal Loads / Occupancy

Occupant Quantity

Single-family:

Calculate the occupant quantity as the number of bedrooms plus 1. Assume normal occupancy, regardless of planned occupancy-schedule. (i.e. vacation home, second home etc…)

Multifamily, including Duplexes and Townhouses:

Calculate the occupant quantity as the number of bedrooms + 1 per dwelling unit. Studio apartments are assumed to have one occupant per unit. Phius Multifamily Lighting & Misc Load Calculator calculates this value and is required for certification.

Exception: For dormitory buildings, occupancy is determined by the number of beds. Where the number of beds is equivalent to the number of occupants.

Number of Bedrooms

Based on the total number of bedrooms[18] in the building.

Process Tip: Studio apartments are counted as '0' bedrooms.

Humidity Sources

0.00041 [lb/(ft^{2}hr)] is the default that should be used for all projects and accounts for internal sources due to respiration or evaporation.

Exception: If a jetted tub is installed within the thermal envelope that does not have an automated exhaust fan controlled by a humidistat, add 0.12 lb/hr to the moisture generation rate.[19] Calculate the humidity input for WUFI Passive using the following example:

Example: Project iCFA = 4,000 ft^2.
0.12 lb/hr ÷ 4,000 sf = 0.00003 lb/ft^2.hr
0.00041 lb/ft^2.hr + 0.00003 lb/ft^2.hr = 0.00044 lb/ft^2.hr

Device List

Pre-defined appliances are built into the software. Choose 'Set Standard Dataset' to insert one of each typical appliance.

Process Tip: The standard dataset will populate with more devices than are usually needed. For example, it includes 3 devices for refrigeration:

- Refrigerator
- Freezer
- Kitchen fridge/freeze combo

It is typical to delete the 'Refrigerator' and 'Freezer' entries, and keep only the 'Fridge/freeze combo' (unless the project includes additional devices, such as a chest freezer or a dedicated wine fridge).

Device/end use (Typical Appliances)

Tables 1.4.4.8.0 - 1.4.4.8.5 outline a list of Median Energy Star (ES) values as of 2024 for typical residential appliances. These values are accepted as placeholders through Design Certification or until the appliance is selected. Project specific appliances should be confirmed for Final Certification.

Process Tip: Plug-in appliances such as microwaves, water kettles, toaster ovens, air purifiers, box fans etc… are not required to be modeled.

Single-family: If the cooktop or range is not combined with the oven, do not input two separate line items for cooking.

Multifamily: If a common area kitchen is provided for the

[18] A bedroom per RESNET, op. Cit., Appendix B: A room or space 70 square feet or greater, with egress window and closet, used or intended to be used for sleeping. A "den." "library," "home office" with a closet, egress window, and 70 square feet or greater or other similar rooms shall count as a bedroom, but living rooms and foyers shall not.

[19] ASHRAE Standard 160, clause 4.3.2.1.1

residents, model the refrigerator as a separate line item, but do not model additional cooking even if an oven, cooktop or microwave is installed.

If common laundry is provided, do not adjust the quantity of laundry appliances in WUFI Passive since the energy use associated with these devices is occupant-driven.

Table 1.4.4.8.0 Dishwasher

Water Connection	Reference Quantity	Energy Demand	Capacity[20]
DHW	PH case occupants	239 kWh/yr	Standard (12)

Table 1.4.4.8.1 Cooking

Choice	Reference Quantity	When Applicable?	Energy Demand[21]
Electricity	PH case occupants	Coil	0.22 kWh/use
		Induction	0.20 kWh/use
Natural Gas		-	0.25 kWh/use

Table 1.4.4.8.2 Fridge / Freezer Combo

Size (cu ft)	Reference Quantity	Energy Demand Reference	Energy Demand
<10	PH case Units or User Defined	Year	230 kWh/yr
15-20			451 kWh/yr
>20			699 kWh/yr

Table 1.4.4.8.3 Freezer

Reference Quantity	Energy Demand Reference	Energy Demand
PH Case Units or User Defined	Year	394 kWh/yr

[20] Place settings, from manufacturer or ES: Standard (12), Compact (8)
[21] All cooking energy accounted for, not just the cooktop. Assumed that 500 single serving meals are cooked annually, per occupant.

Table 1.4.4.8.4 Clothes Dryers

Type	When Applicable?	Reference Quantity	CEF[22]
Condensation	Ventless	PH case occupants	2.68
	Heat Pump		5.85
Exhaust Air	Electric		3.93[23]
	Natural Gas[24]		3.48

Table 1.4.4.8.5 Clothes Washer

Reference Quantity	Energy Demand	Utilization Factor	Capacity	MEF[25]
PH case occupants	110 kWh/yr	1	4.5 ft^3	3.13

Device/end use (Lighting and Miscellaneous Loads)

Lighting and MELs are modeled differently according to project type.

Single-family: In addition to typical appliances, 3 additional line items will populate when selecting the 'Set Standard Dataset' option. They are only applicable to single family projects:

- PHIUS+ MELS
- PHIUS+ Interior lighting
- PHIUS+ Exterior lighting

[22] Combined Energy Factor calculated per ANSI/RESNET/ICC 301-2019.
[23] Default CEF if no Energy Star rating: 3.14
[24] Match the electrical kWh/yr divided by 392/yr of the washer and assign the rest to gas consumption.
Example: if using the default 11/ CEF = 3.5 kWh/use for the dryer, and the washer is rated at 196 kWh/yr / 392 cycles/yr = 0.5 kWh/use, input for the gas consumption: 3.5-0.5 = 3.0 kWh * 3412 Btu/kWh = 10236 Btu.
[25] Modified Energy Factor: From Energy Star. Considers the amount of dryer energy used to remove the remaining moisture content in washed items, in addition to the unit's energy use and water heating energy. The higher the I/MEF, the more efficient the clothes washer.

- MEF = 0.503 + 0.95*IMEF

All single-family projects must model lighting and miscellaneous electric loads per the table below. The reference quantities noted are the dropdown menu options within WUFI Passive.

If a garage is present, this should be added by choosing ‘New’ and selecting ‘PHIUS+ Garage lighting’. Although the reference quantity is ‘none’, the energy associated with garage lighting is still accounted for.

Table 1.4.4.8.6 Single-family Lighting & Misc. Electric Loads

Device / end use	Reference Quantity	Fraction of high efficiency
PHIUS+ Interior Lighting	PH case floor area	If all LED or high efficacy: 1
PHIUS+ Exterior Lighting		
PHIUS+ Garage Lighting	None	
PHIUS+ MELS	Bedrooms	n/a

Multifamily: All multifamily projects with more than one dwelling unit, including duplexes, townhouses and dormitories must use the Phius Multifamily Lighting & Misc Load Calculator to determine annual energy consumption associated with

- Lighting for:
    - Dwelling units
    - Common areas
    - General building exterior

Exception: Phius does not require projects to include the lighting energy for an open parking lot, parking garage, block heaters or vehicle charging in the energy model for certification. These end-uses are considered to be part of the ‘transportation sector’ as opposed to the ‘building sector’.

- Miscellaneous Electric Loads (MELs) for:
    - Dwelling units
    - Common areas
    - Elevators

Process Tip: Use the table below as a reference for inputting all values in WUFI Passive. **Enter values as whole-numbers with no comma delineations.**

Table 1.4.4.8.7 Multifamily Lighting & Misc. Electric Loads

Device / end use	Comment	Reference Quantity	In Conditioned Space	Energy Demand
User Defined - Lighting	Interior	User defined (1)	☑	Phius Multifamily Lighting & Misc Load Calculator
	Exterior		☐	
	Garage		☐	
User Defined - Misc Electric Loads			☑	

Device/end use (Additional Devices)

Additional fans, pumps or mechanical equipment not otherwise accounted for under the Systems section within WUFI Passive should be modeled as Auxiliary Energy later on.

Uncommon devices or appliances not covered above may be input as ‘User defined’ devices. A calculation or estimate for the annual energy use (kWh/yr) should be provided for certification.

1.4.4.9 Non-Residential Internal Loads / Occupancy

Unfinished (UF) Spaces:

It is necessary to assume a scenario to apply the certification criteria in regards to calculating the heating and cooling loads and demands of Unfinished spaces (UF). For the source energy criterion, there is no additional source energy allowance for unfinished spaces and therefore no assumption about their energy use.

Utilization Pattern

The internal loads and occupancy calculation for non-residential projects begins with the definition of utilization patterns. These patterns are used for two purposes: lighting energy calculation and internal gains due to people and the equipment they use. A set of default patterns for typical space types is shown in the table in Appendix N-8 and can be translated directly into WUFI, and should be referenced for all of the following inputs.

Unfinished (UF) Spaces:

A utilization pattern must be defined for the required 'Toilet utilization pattern' selection, defined later. Instructions for specific inputs for UF spaces are given in the following sections.

General

Simplicity is key when determining how many utilization patterns should be included in the model. The naming convention of each Utilization Pattern in WUFI should align with the Appendix N-8 space types. In general, only one utilization pattern per unique space type should be modeled. In an office building with single-shift operation and occupants typically sitting at desks, a single pattern would suffice. Projects that include multiple space types within them, like schools, may have several utilization patterns. Lighting assumptions will be further broken out later.

Begin/End Utilization

Beginning and end hour of utilization for the space type. Enter values in 24-hour time. Custom values may be used, or use typical values from Appendix N-8 for the corresponding space type. Factors into the lighting calculation and internal gains calculations.

Example: A business planning a Phius-certified office space is going to be open 9am-9pm daily. In WUFI, they should enter:

- Begin utilization: 9
- End utilization: 21

A hospital in development is looking to achieve Phius certification and will operate 24/7. In WUFI, they should enter:

- Begin utilization: 0
- End utilization: 24

Note: Other spaces in the hospital project may not be operational for the full 24 hrs (i.e. cafeteria, gift shop, etc.). A separate utilization pattern should be created for these spaces with alternate patterns.

Unfinished (UF) Spaces:

Set 'Begin utilization' to 0, and 'End utilization' to 24.

Annual Utilization Days

Number of utilization days per year, up to 365. Can be custom, or use typical values from Appendix N-8 for the corresponding space type. Factors into the lighting calculation and internal gains calculations. Typical values are listed below:

- 5 days/wk = 250 days/yr
- 6 days/wk = 300 days/yr
- 7 days/wk = 365 days/yr

Unfinished (UF) Spaces:

Set to 365.

Illumination level

Typical illumination level, in lux, required to perform the activities that occur within the space. Enter values according to Appendix N-8 space types if the specific lighting power densities are not yet known (see Installed Lighting Power below). This input only impacts the lighting calculation.

Unfinished (UF) Spaces:
Set to 300.

Height of Utilization

Height of the work plane in typical space types. This input only impacts the lighting calculation.

- Indoor corridors/circulation: 0ft
- All other space types: 2.62 ft

Unfinished (UF) Spaces:
Set to 2.62 ft.

Relative Absence

The typical fraction of absenteeism, or occupancy reduction factor, based on the space type. Use typical values from Appendix N-8 for the corresponding space type. This input impacts both the lighting and internal gains calculations.

- 1 = Occupants always absent
- 0 = Occupants never absent

Unfinished (UF) Spaces:
Set to 1.

Part Use Factor of Building Period for Lighting

The typical lighting factor relative to building operational time. Use typical values from Appendix N-8 for the corresponding space type. This input only impacts the lighting calculation.

- 1 = No reduction in lighting energy
- 0 = Full reduction in lighting energy

Unfinished (UF) Spaces:
Set to 1.

Optional Data

Do not input anything in this section. It should be left completely blank.

Occupancy

Must be defined for the whole building as well as for unique space types in correspondence with the Utilization Patterns previously defined.

Occupant Quantity - Whole Building

The top-level 'Occupant Quantity' entry should reflect the average number of occupants in all spaces over a 24-hour period. This value influences total DHW consumption, daily tap openings for DHW distribution losses, and the 'Supply air due to persons' ventilation requirement. This entry does not influence the internal heat gains related to occupants.

Unfinished (UF) Spaces:
Assume 30% of the design (maximum) occupancy for the space. Further guidance on the default assumption for design (max) occupancy is given in the sections that follow.

Process Tip: This is the value that should be used in the calculation of the project-specific performance criteria targets.

Humidity Sources

Refer to Humidity Sources under the residential section.

Occupancy Groups

In general, each unique Appendix N-8 space type should correspond with one occupancy group. For consistency, align the name of the occupancy group with the utilization pattern it is associated with. The only time more occupancy groups than utilization patterns should be modeled is if one space type has more than one occupancy group within it.

> **Example:** An elementary school has modeled a unique utilization pattern called 'Classrooms'. Because the typical classrooms consist of teachers and students, it would be appropriate to model two separate occupancy groups:
> - Teachers in Classrooms
> - Students in Classrooms

Not all space types need designated occupants or entries. Transient spaces such as stairwells, restrooms, storage spaces, or auxiliary spaces serving the 'main' occupied areas, such as conference rooms, print/copy rooms, etc. should not have their own occupancy pattern, as these spaces do not have regular full-time occupancy.

> **Example:** If there is an office with 20 desks, the main office should have an occupancy pattern with 20 occupants. If there are also two conference rooms that serve the office occupants, to avoid double counting, do not model an occupancy pattern for the conference rooms. The lighting and loads associated with the conference rooms will be accounted for later.

Utilization Pattern:
From the patterns defined previously, select the appropriate utilization pattern for the occupancy group.

Activity of Persons:
Select from the available options that most closely represents the activity in the space.

- Kid, 0-10 years (i.e. elementary classroom)
- Adult, sitting (i.e. typical office)
- Adult, standing or light work (i.e. kitchen staff)

Occupant Quantity:
The design (maximum) occupancy for major space types. The relative absence defined for the utilization pattern will use this value to calculate internal heat heat gains.

Unfinished (UF) Spaces: Assume the maximum occupancy for the most realistic commercial tenant for the space according to IBC 2021 Table 1004.5 (or local code if more stringent).

> **Example:** A project under development has 3,000 ft^2 of additional commercial space available for lease. The owner hopes to lease it to a small local business for office space.
> - Design (maximum)
>   - IBC 2021: 150 GSF/person
>   - 3,000 / 150 = 20 occupants
> - Average occupancy (for target setting)
>   - 20 * 0.3 = 6 occupants

Additional Data

Heat loss due to evaporation (per person): Default value of 51.2 BTU/hr. Do not change this value.

☐ Heat loss due to flushing toilets (cold water): Box is checked by default. Leave as-is.

Number of flush toilets: Enter the total quantity of flush toilets planned in the project.

Toilet Utilization Pattern: Select the utilization pattern with the most 'Annual utilization days'.

☐ Use default values for school: This box should be checked only for school projects.

Office Equipment

Planned equipment for each unique space type should be input in this section. Consolidate equipment as much as possible. Use the predefined equipment types as a starting point for accounting for typical equipment.

Unfinished (UF) Spaces: Skip this section. No inputs needed here.

Type

Use the predefined equipment type options to account for typical non-residential equipment.

- PC, Monitor
- Copier, Printer
- Server
- Telephone system

User Defined: May be used for any miscellaneous items that do not fit the predefined options. External calculations and/or documentation is needed to determine the annual energy consumption of unique equipment in kWh/yr.

Utilization pattern

Select the utilization pattern that corresponds to the space type in which the equipment is located.

Quantity

Enter the physical quantity of the equipment type.

☐ Within thermal envelope

Check this box if the equipment is within the thermal envelope. Checked equipment will impact internal heat gains.

Power rating / Power rating (saving mode) [W]

Use Appendix I-3.11 to determine the power rating entries for predefined equipment and some unique equipment types. The following predefined equipment types also require and entry for power rating (saving mode):

- PC, Monitor
- Copier, Printer
- Server

User Defined: Enter the annual kWh/yr of the unique equipment as the Power Rating [W].

Additional Data

Some equipment types will prompt the user to enter additional data about the selected equipment. See instructions on how to complete these inputs below:

Duration of utilization time in energy saving mode: The number of hours in energy savings mode is calculated automatically. No input is needed.

User Defined: Enter 1000 hrs/yr for 'Utilization hours per year'. This entry will be multiplied by the previous 'Power Rating [W]' entry to calculate the unique equipment's total annual energy consumption in kWh/yr.

Kitchen Equipment

Planned kitchen equipment for the non-residential building should be input here. Consolidate equipment as much as possible. Use the predefined equipment types as a starting point for accounting for typical equipment.

Marginal performance ratio DHW: This input should always be left blank.

Unfinished (UF) Spaces: Skip this section. No inputs needed here.

Type

Use the predefined equipment type options to account for typical kitchen equipment in non-residential projects.

- Cooktop
    - Includes ranges, microwaves, toasters, etc.
- Dishwasher
- Refrigerator

User Defined: May be used for any miscellaneous items that do not fit the predefined options. External calculations and/or documentation is needed to determine the annual energy consumption of unique equipment in kWh/yr.

Utilization pattern

Select the utilization pattern that corresponds to when the equipment will be used by building occupants. Some overlap may occur, so choose the utilization pattern with the greatest utilization time. No input required for refrigerators.

Quantity

Varies depending on equipment type.

Cooktop, Dishwasher: Enter quantity of 1. The annual usage of these devices will be calculated based on the 'Additional data' inputs, explained later in this section.

Refrigerator: Enter the physical quantity of refrigerators in the project. If several different models exist in the project, model them separately with their respective quantities.

User defined: Enter quantity of 1.

☐ Within thermal envelope

Check this box if the equipment is within the thermal envelope. Checked equipment will impact internal heat gains.

Process tip:
Some projects that include large commercial kitchens choose to exclude them from the certified zone due to air tightness concerns, specifically regarding exhaust hoods that are required to remain continuously open.

In order for this box to be unchecked, all of the following conditions must be met (assuming space type is a kitchen or similar space):

- Kitchen is being excluded from the certified space
- Kitchen primarily serves occupants of the certified space
- Kitchen is an amenity / not a required space for regular operation and function of the buildings intended use

If a kitchen is a required space for regular operation, but being left out of the certified space, kitchen equipment should be accounted for in 'Process loads'

Additional Data

Different equipment types will prompt the user to enter additional data about the selected equipment. See instructions on how to complete these inputs below:

Cooktop: Define the fuel type for cooking. Options are gas or electricity.

'Number of meals per utilization day' refers to the total number of meals cooked in that zone, per day. In most cases, it's conservative to assume 1 meal per day per occupant (average occupancy).

Process tips:
By default, the model will assume 0.25 kWh/meal for cooking energy.

All cooking energy accounted for, not just the cooktop.

Dishwasher: DWH connection is the default assumption for dishwashing. This input should be left unchanged.

‘Number of meals per utilization day’ refers to the total number of meals cooked (place settings washed) in that zone, per day. Align with the entry for the cooktop.

Process tip: By default, the model will assume 0.055 kWh/meal for dishwashing energy.

Refrigerator: Norm demand [kWh/day] must be input. This data is available from Energy Star for residential fridges and some commercial fridges.

User Defined: Enter the kWh/yr of the unique equipment into the ‘kWh/day’ field. Enter 1 day/yr. These entries are multiplied to calculate the unique equipment’s total annual energy consumption in kWh/yr.

Lighting

Grouping of rooms is appropriate if they share a utilization pattern and have a similar required or designed lighting power density [W/ft^2].

Space types should be split out into individual line items here. If multiple Utilization Patterns are used to define the full usage hours for a single space, that space must be entered multiple times on this sheet and assigned to the appropriate Utilization Patterns to cover all hours of usage.

Example: An elementary school model includes the following high-level space types for lighting:

- Typical classrooms
- Specialty classrooms
- Gym/Cafeteria
- Circulation

Utilization Pattern

Select the utilization pattern that corresponds to the space type being lit.

Fraction of conditioned floor area

Account for the percentage of the total iCFA of each space type with active lighting that has a regular usage pattern. (ignore storage spaces, mechanical closets, etc…) Round fractions of conditioned floor area to the nearest hundredth. (ie. 0.20, 0.15 etc..)

Example: An elementary school project team enters the Fraction of Conditioned floor area for each space type using the calculation:

Space type area (ft^2) / iCFA (ft^2)

- Typical classrooms = 0.5
- Specialty classrooms = 0.15
- Gym/Cafeteria = 0.15
- Circulation = 0.2

Daylighting

Phius’ certification protocol has taken the conservative stance not to account for day-lighting using WUFI Passive’s built-in calculator, but instead allows project teams to provide a separate calculation or default reduction factor on the lighting power density.

Although the following inputs are used to run the calculation, they should not be revised from the values noted in the sections below for certification purposes.

- Derivation from North,
- Glazing Visible Transmittance,
- Room Width/Depth/Height,
- Façade has windows (box checked)
- Lintel height
- Window width

Inputs of this granularity generally take longer to determine and are more difficult to gather, document, and review. Because of this, the inputs for the daylighting calculation should remain constant across all non-residential projects and should not differ from the values below for certification purposes:

Derivation from North: Enter 0.

Glazing Visible Transmittance: Default is 'Double low-e glazing: 0.78'. Do not change this input.

Room Depth, Width, Height: Enter 10 ft for all. This input will not have an impact on the model.

Additional data

☐ Facade has windows: Do not check this box.

Lintel height: Enter 1ft.

Window width: Enter 1ft.

Lighting control: Set to 'Manually'

☐ Motion detector: Check only if occupancy sensors are installed.

Installed Lighting Power: Enter the lighting power density of the space type in W/ft^2. Phius requires lighting plans and a fixture schedule or cut-sheets to verify these values.

- Values entered here will override 'illuminance [lux]' entries from the Utilization Pattern.
- Up to a 10% reduction in lighting power density may be used in situations where rooms have windows, and a daylighting control system, whether continuous or stepped control is used.
    - Project teams may take a greater reduction of lighting power where a comparative daylighting simulation is provided showing the percentage reduction of lighting energy over a baseline with no controls.

Lighting full load hours: This entry should be left blank. It is used to override the utilization pattern previously defined for each space type.

Process Loads

Per Section 1.3.4, process load allowances may be defined for non-residential projects. Each unique process load should be input as an individual line item. To determine whether or not unique equipment qualifies as a process load, review the criteria outlined in Appendix N-1.

Process tip: Office and retail spaces do not qualify for an additional source energy allowance for process loads, but restaurants and groceries do. Contact Us about process load allowances for other usage types.

Unfinished (UF) Spaces: Skip this section. No inputs needed here.

Quantity

Enter the quantity of devices / equipment being accounted for.

Total energy use

Enter the total energy consumption of the equipment in kWh/yr.

☐ Include in Source Energy Total

For certification, this box should always be checked.

Process tip: During early design, this checkbox allows the modeler to include and/or remove process loads from the calculated source energy total. This is helpful to verify compliance with the base source energy target before process loads and allowances are included.

☐ **Increase Source Energy Allowance**

For certification, this box should only be checked for Phius-approved process loads. This checkbox will increase the source energy target of the project by the exact annual consumption of the modeled equipment.

1.4.4.10 Ventilation / Rooms

Utilization Pattern

The utilization pattern applies to the schedule of airflow for mechanical ventilation devices (E/HRVs).

Process tip: Avoid modeling 'boost mode' operation unless the device is on a programmed schedule that regularly changes the airflow rate of the device. Any manually operated device settings should be ignored, as it is assumed that different people may occupy the building over its lifetime, and may not require or use the systems in the same way as the previous occupants.

Residential: The utilization pattern should be set up to represent continuous airflow for most spaces. Special cases may be accepted with Phius approval and sufficient documentation to verify alternate patterns.

Non-Residential: It is generally recommended to model the utilization patterns and design ventilation rates as if they were continuous. This approach is helpful during early design, but is also effective in capturing the average design ventilation rate, even if ventilation rates vary due to the anticipated operation schedule of the space.

Multiple utilization patterns may be set up to reflect varying levels of ventilation rates for different days (i.e. weekday vs weekend). Additional guidance is given in the sections that follow.

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays (until 8pm), and every weekend (Saturday & Sunday 10 am - 3pm). Follow along in the 'Example' boxes in the sections that follow for guidance on how this scenario could be modeled.

- Pattern 1: Whole school Continuous

OR

- Pattern 1: Typical school week
- Pattern 2: Typical school - summer week
- Pattern 3: Typical school weekends
- Pattern 4: Gymnasium Typical
- Pattern 5: Gymnasium After-Hours

Unfinished (UF): Inputs should align with the typical modeling protocol for continuous ventilation as indicated in the following sections.

Operating days per week

Enter 7 to indicate that the device will run every day of the week (continuous, typical).

Non-Residential: It is recommended to enter 7 as noted above to represent continuous ventilation.

If airflow rates will regularly differ dramatically day-to-day each week over the course of the whole year, enter the days per week for each pattern. Consolidate days of the week with similar ventilation rates. If taking this approach, the number of days for each general space (or whole-building) should sum to 7. An alternative approach for modeling this scenario is described in the Daily operation schedule section later.

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays (until 8pm, 3pm-8pm during Summer), and every weekend (Saturday & Sunday 10 am - 3pm).

- Pattern 1: 7 days/wk

OR

- Pattern 1: 5 days/wk
- Pattern 2: 5 days/wk
- Pattern 3: 2 days/wk
- Pattern 4: 4 days/wk
- Pattern 5: 3 days/wk

Note that Patterns 4 & 5 apply to the same space (Gymnasium), and the modeled days/week add up to 7 to represent the schedule for the full week. Patterns 1 and 2 are related on the weekly level, but patterns 1 + 3, and patterns 2 + 3 sum to 7 days/week.

Operating weeks per year

Enter 52 to indicate that the device will run every week of the year (continuous, typical).

Non-Residential: It is recommended to enter 52 as noted above to represent continuous ventilation for most non-residential projects.

School projects or other non-residential projects with drastic seasonal occupancy differences may model separate utilization patterns. If taking this approach, the number of weeks for each general space (or whole-building) should sum to 52.

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays (until 8pm, 3pm-8pm during Summer), and every weekend (Saturday & Sunday 10 am - 3pm).

- Pattern 1: 52 weeks/yr

OR

- Pattern 1: 40 weeks/yr
- Pattern 2: 12 weeks/yr
- Pattern 3: 52 weeks/yr
- Pattern 4: 52 weeks/yr
- Pattern 5: 52 weeks/yr

Patterns 1 + 2 in this scenario are the only split-weeks because they both represent the same days of the week during different weeks of the year. They sum to 52 weeks to cover the entire year. The rest of the patterns will apply to the full year.

Intermediate Results

Values will automatically populate and update as the modeling inputs are completed.

Supply air due to persons (cfm): Calculated supply air needed to satisfy 18 cfm/person (certification & WUFI default, defined previously under PH Case)

Total extract air demand (cfm): Total exhaust air requirement based on the exhaust room requirements defined later in Rooms Ventilation.

Design air flow rate (cfm): Maximum air flow rate, determined by the largest of 2 factors:

1. Supply air requirement (based on occupancy)
2. Exhaust air requirement (based on kitchens, baths, etc.)

Process Tip: The capacity of the ventilation system installed needs to exceed whichever rate is greatest[26] (see Balanced Ventilation above). Keep this in mind when selecting a mechanical ventilation device.

Average air flow rate (cfm) / Average air change rate (1/hr): Calculated as a reduction from the "design air flow rate". These values are determined by the daily operation schedule and "fraction of design" airflow at the scheduled hours.

Daily operation schedule (h)

Enter 24 at the 'Maximum' setting to indicate that the ventilation device operates continuously.

[26] For design certification, it is recommended (but not required) that residential projects model with a ventilation rate of 0.3 ACH or higher.

Non-Residential: It is recommended to enter 24h at the Maximum setting to represent continuous ventilation for most non-residential projects.

This input may be revised to reflect the appropriate ratios of design airflow rates during occupied and unoccupied hours.

Fraction of design air flow

No entry is required if 24h was entered for the 'Maximum' setting as previously noted.

User defined fractions for the additional operation settings may be entered and will be applied to the ventilation rates entered in the Rooms Ventilation section later. A 'fraction' of 1 represents 100% of the design airflow rate (0.77 = 77%, etc.)

Non-Residential: No entry required if using the 'Maximum' setting and averaging the airflow over 24 hours.

Additional fractions of airflow may be appropriate if the mechanical ventilation device is programmed to operate at different speeds during scheduled hours.

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays (until 8pm, all day during Summer), and every weekend (Saturday & Sunday 10 am - 3pm).

When unoccupied, the mechanical ventilation devices operate at 50% of the design airflow.

- Pattern 1: 24h @ 1

OR

- Pattern 1: 10h @ 1 ; 14h @ 0.5
- Pattern 2: 24h @ 0.5
- Pattern 3: 24h @ 0.5
- Pattern 4: 10h @ 1 ; 14h @ 0.5
- Pattern 5: 8.5h @ 1 ; 15.5 @ 0.5

Additional calculation is needed for Pattern 5 because it is covering 3 days of the week that have different hourly operation patterns. This is done by averaging the quantity of hours per day at 100% airflow:

- Thursdays: 10h school day + 5h community group
- Saturday / Sunday: 5h community organization (10h total)
- (15 + 5 + 5) / 3 = 8.33 → 8.5h @ 1
- 24h - 8.5h = 15.5h @ 0.5

Hint: This approach can be used to further consolidate the example utilization patterns for the same space types, like the rest of the 'Typical school' patterns.

Rooms Ventilation

There are several methods available for modeling exhaust and supply ventilation in WUFI Passive. Follow the sections below.

General

Both exhaust rooms and supply rooms should be modeled to ensure the ventilation design is balanced. This may be modeled in multiple ways for certification compliance.

Process Tip: If multiple devices with different efficiencies are planned, do not consolidate rooms unless they are served by the same device.

Room-by-Room Method: This approach includes modeling every supply and exhaust room as unique line items. It is most appropriate for single family projects, but could be used for multifamily or non-residential projects if all spaces either share a device or are served by separate identical devices. This is helpful to quickly verify that minimum exhaust flow rates are met for kitchens and bathrooms per Section 1.3.4.2.

Process Tip: align the room name with the drawing set, and include the corresponding room number

Unit Method: This approach is appropriate for multifamily projects that include multiple units with identical flow rates that share, or are served by, identical devices (i.e. one rooftop DOAS unit; identical ventilation devices serving individual units). Unique line items should be created for common areas if applicable.

Process Tip: Align the room name with the number of bedrooms and bathrooms for the unit type (i.e. 1 bed/1 bath; 1 bed/2 bath, etc.)

Floor-by-Floor Method: This approach is most appropriate for multifamily projects with identical floor-to-floor layouts, or multifamily / mixed-use / non-residential projects with one device serving each floor. In the latter case, if the efficiencies of the devices vary, the 'Device Method' should be used.

Process Tip: Align the room name with corresponding floor number (i.e. 1st floor, 2nd floor, etc.)

Device Method: If multiple devices with different efficiencies are planned (i.e. large multifamily / mixed use / non-residential projects), each device may be entered as a unique line item in this section. A schedule should be provided to confirm airflow rate of each device. Plans must also be provided to confirm minimum exhaust flow rates are met for kitchens and bathrooms per Section 1.3.4.2.

Process Tip: Align the room name with corresponding device name (i.e. ERV-1, ERV-2, etc.)

Unfinished (UF): A continuous ventilation rate of 0.3 ACH (air changes per hour) will be assumed automatically. Create one line item in this section and follow the instructions in the following sections for default inputs that are required in order for results to populate.

Room Type

For exhaust rooms, if the 'Room-by-Room' method is used, select the appropriate room type from the available options:

- Kitchen
- Bathroom
- Shower
- WC

For supply rooms, or if using the 'Unit', 'Floor-by-floor', or 'Device' method, select 'User defined'.

Unfinished (UF): Select 'User defined'.

Quantity

This input will vary depending on which method is being used from the options previously described. In general, the quantity should align with the number of spaces that have identical flow rates and are served by the same ventilation device.

Example B: A single family project has 2.5 bathrooms and 4 bedrooms:

- Room 1: Bathrooms, quantity = 2
- Room 2: ½ bath, quantity =1
- Room 3: Bedrooms, quantity = 4
- Room 4: Kitchen, quantity =1
- Room 5: Living/Dining, quantity = 1

Example C: A 50-unit multifamily project has 13 x 2 bed / 2 bath units, and 37 x 2 bed / 1 bath units, and double-loaded corridors:

- Room 1: 2 bed / 2 bath, quantity = 13
- Room 2: 2 bed / 1 bath units, quantity = 37
- Room 3: Common areas, quantity = 1

OR

- Room 1: Bedrooms, quantity = 100
- Room 2: Bathrooms, quantity = 63
- Room 3: Kitchens, quantity = 50
- Room 4: Living / Dining, quantity = 50
- Room 5: Common areas, quantity = 1

Hint: Apply the same methodology for the 'Floor-by-floor' and 'Device' methods

Non-Residential: As previously described, for non-residential projects, one utilization pattern with airflow rates for unique spaces averaged over 24 hours can be used. Or, multiple may be modeled with varying daily operation schedules.

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays (until 8pm, all day during Summer), and every weekend (Saturday & Sunday 10 am - 3pm).

- Whole school continuous (1 utilization pattern)
  - Room 1: Typical School, quantity = 1
  - Room 2: Gymnasium, quantity = 1
- Multiple Utilization Patterns
  - Room 1: Typical school - school week, quantity = 1
  - Room 2: Typical school - summer week, quantity = 1
  - Room 3: Typical school weekends, quantity = 1
  - Room 4: Gymnasium Typical, quantity = 1
  - Room 5: Gymnasium After-Hours, quantity = 1

Hint: Note that the room names are aligned with the utilization patterns previously created for them.

Unfinished (UF): Enter 1.

Utilization Pattern

For most projects, assign the continuous utilization pattern that was previously created to all line items in this section.

If modeling multiple utilization patterns, assign them to their corresponding space types. All utilization patterns should be used if done correctly.

Design volume flow rate

All projects must meet the Minimum Ventilation Rates.

Non-Residential / MF Common Areas: Enter the design airflow rates according to the mechanical plans for the project.

Process tip: In early design, before true ventilation rates are unknown, the total exhaust/supply airflow rate of the space can be estimated by referencing local code requirements, or using the following calculation:

- 0.06 cfm **x** iCFA

Example A: An elementary school allows a local community organization to use the gymnasium after school on Thursdays, and every weekend. When unoccupied, the mechanical ventilation devices operate at 50% of the design airflow.

- Whole school continuous (1 utilization pattern)
  - Room 1: Typical school
    - Typical design airflow: 22,000 cfm
    - Total annual hours at 100% = 2000 hours
      - (10h/day)*(5days/wk)*(40wks/yr)
    - Total hours in 1 yr = 8760
    - Design volume flow rate (SA & EA) = **5,022.8 cfm**
      - (2000/8760) * 22,000
  - Room 2: Gymnasium
    - Typical design airflow: 3,000 cfm
    - Total annual hours at 100% = 2900 hours
      - (10h/day*4days/wk*40wks/yr) +
      - (15h/day*1day/wk*52wks/yr) +
      - (5h/day*2days/wk*52wks/yr)
    - Total hours in 1 yr = 8760
    - Design volume flow rate (SA & EA) = **960 cfm**
      - (2900/8760) * 3,000
- Multiple utilization patterns
  - Room 1: Typical school - school week
    - Design volume flow rate: **22,000**
  - Room 2: Typical school - summer week
    - Design volume flow rate: **22,000**
  - Room 3: Typical school weekends, quantity = 1
    - Design volume flow rate: **22,000**
  - Room 4: Gymnasium Typical, quantity = 1
    - Design volume flow rate: **3,000**
  - Room 5: Gymnasium After-Hours, quantity = 1
    - Design volume flow rate: **3,000**

Hint: The design volume flow rates are modeled at their maximum value because the fraction of design airflow has already been defined for the utilization pattern for each space.

Summer Ventilation

Inputs in this section should be mostly left blank, unless no cooling system is planned (atypical). Review Appendix I-3.12.1 for guidance on determining when this is appropriate and for modeling this scenario.

Average mechanical ventilation air change rate [1/hr]

By default, this value should be left empty, assuming that the E/HRV runs year-round (typical). WUFI will calculate this value automatically based on other modeling inputs.

Note: Occupants must provide other means of ventilation if turning off the continuous ventilation system.

Summer/HRV Humidity Recovery mode

Some heat recovery ventilation units (both ERVs and HRVs) can bypass heat recovery in the summer when outdoor temperatures are more favorable than indoor. If the E/HRV includes this feature, it is often noted on the device datasheet as 'economizer mode' or 'free cooling'. Typically, this is a temperature-controlled bypass mode. In WUFI, select from the options below:

Always:
This option should be selected if there is NO bypass mode, and recovery mode is always active. This should be the default input for all projects unless the device includes bypass mode as previously described.

Temperature-controlled bypass:
Select this option if the bypass mode is activated based on temperature (typical for devices with bypass mode).

Enthalpy-controlled bypass:
Select this option if the bypass mode is activated based on both temperature and humidity/moisture (less typical for devices with bypass mode).

None: This option should never be used.

ACH via natural ventilation (day)

If a cooling system is planned, no natural ventilation may be included in the model. Leave this entry blank or enter '0'.

ACH via natural ventilation (night)

If a cooling system is planned, no natural ventilation may be included in the model. Leave this entry blank or enter '0'.

Additional automatic control ventilation / Specific power consumption cooling

For most projects, this input should be left blank.

Use these inputs when implementing a mechanical exhaust system in addition to the E/HRV that is tied to sensors for either temperature or humidity difference that dictate the operation of the device. The estimated additional ACH (1/hr) should be input, as well as the device's specific power consumption in W/cfm.

Automatic control system via

This input depends on the Summer HRV/ERV recovery mode defined previously. Leave this input as 'Temperature difference' unless using a device that has 'Enthalpy controlled bypass' as its recovery mode. In the latter case, 'Humidity difference' should be selected.

Additional mechanical ventilation exhaust air / Specific power consumption

For most projects, this input should be left blank.

Use these inputs when implementing a mechanical exhaust device in addition to the E/HRV that does not have any heat recovery (i.e. timer controlled whole-house fan). The estimated additional ACH (1/hr) should be input, as well as the device's specific power consumption in W/cfm.

Exhaust Ventilation

Account for direct exhaust devices in this section. Devices entered in this section are independent of the mechanical ventilation system with heat recovery (E/HRV). Review Section 1.3.4.2 to determine whether a make-up air system will be required based on the direct exhaust devices planned.

If no direct exhaust devices are planned, skip this section.

Type: Exhaust Dryer:

If direct exhaust dryers are planned for a project, input a line item for this device type. A single line item accounts for the associated exhaust air based on the default annual usage pattern assumption for dryers. In the case of multiple exhaust dryers located in a stand-alone and separate building, review Appendix N-9.

Exhaust Volume Flow Rate: Input flow rate of an individual dryer

- 125 cfm default for residential dryers
- 220 cfm default for commercial dryers

Exception: Use the rated airflow from the manufacturer if available.

Example: A multifamily building has a common area laundry room with 5 direct exhaust dryers that each run independently of each other at 220 cfm.

1. Input a single line item in WUFI
2. Assign the 'Type' to 'Exhaust Dryer'
3. Input 220 cfm as the 'Exhaust volume flow rate'

Type: Exhaust Range Hood:

If direct exhaust range hoods are planned for a project, input a line item for this device type. A single line item accounts for the associated exhaust air based on the default annual usage pattern assumption for cooking.

Exhaust Volume Flow Rate: Input flow rate of a single range hood.

- 100 cfm default

Exception: Use the rated airflow from the manufacturer if available.

Example: A duplex building has direct exhaust range hoods in each kitchen. It is rated for 250 cfm.

4. Input a single line item in WUFI
5. Assign the 'Type' to 'Exhaust Range Hood'
6. Input 250 cfm as the 'Exhaust volume flow rate'

Type: Other exhaust appliances:

If other direct exhaust devices such as bathroom exhaust, trash exhaust, etc... are planned for a project, input a line item for this device type.

Bathroom direct exhaust:

1. Assume 60 min / bathroom / day[27]
   - Exhaust volume flow rate [cfm]:
     → Sum total bathroom exhaust fans in the building
   - Run time per year [min]:
     → **(**365 days/yr ***** 60 min/day**) =** 21,900 minutes/yr

Trash direct exhaust:

2. Assume continuous exhaust
   - Exhaust volume flow rate [cfm]:
     → Sum total trash exhaust fans in the building
   - Run time per year [min]:
     → 525,600 minutes/yr

Unbalanced Airflow:

One scenario where a direct exhaust input is required, relates to an unbalanced outdoor air ventilation system with heat recovery. Account for the scenario described in Section 1.3.4.2 where an individual ventilator is out of balance by >10% by inputting an 'Other exhaust appliance' running for 525,600 minutes/year.

[27] Per BAHSP protocol

Example: An ERV is measured to have 100 cfm of supply and only 85 cfm of exhaust. The ventilation balancer is unable to rectify the difference and the project must take a penalty on the heat recovery of the unit.
10% of the 100 cfm is 10 cfm as the allowed imbalance, while 15 cfm is present. 15 cfm - 10 cfm = 5 cfm of ventilation airflow penalty.

1. Input a single line item in WUFI
2. Assign the 'Type' to 'Other exhaust appliances
3. Input an exhaust volume flow rate of 5 cfm
4. Input a run time per year of 525600 min

1.4.4.11 Attached Zones

General

Attached zones may be used in the case of adjacent unheated or partially heated space that is fully enclosed (i.e. unheated garage, semi-heated stairwell, etc.). Click 'New' to create a new attached zone. Name the new zone in accordance with the space being modeled.

Fully conditioned adjacent spaces (i.e residential and occupied, non-residential and always conditioned) should not be modeled as attached zones. See Section 1.4.4.6.

Type

Regardless if the attached zone is unheated or semi-heated, the 'Type' should always be set to 'Unheated space'.

Attached Zone 1

Once the attached zone is created, click into the WUFI sub-branch that was created called 'Attached zone 1: [Attached zone name]'.

Temperature difference reduction factor

The lowest reduction factor currently allowed for Phius Certification is 0.95. An additional calculation must be provided for inputs lower than this conservative default. The Phius Temperature Reduction Factor & Auxiliary Space Heating Estimator can be used to calculate alternate values for semi-conditioned spaces.

- 1 = ambient temperature (outer air, no reduction)
- 0 = no heat loss (full reduction)

1.4.4.12 Remaining Elements

Any components not assigned to Zone 1 on either side will appear as remaining elements. This includes shading elements and other geometry that is outside of the thermal boundary (i.e. a roof over a vented attic, etc.)

Process tip: The remaining elements only influence the calculation via the dynamic shading calculation. No heat transfer is considered through these components.

1.4.4.13 Systems

In WUFI Passive, one system will consist of a set of devices. Often, only one 'System' is needed per building.

Exception: Multiple systems may be necessary to cover the cooling demand if the main system does not completely cover it, or if the system capacity exceeds 682 kBtu/sf.yr (~56 tons of cooling). This is due to software limitations, where WUFI is limited to a maximum cooling capacity per modeled system. More on this below under Distribution: Cooling.

System Type

This dropdown should not be changed from the default selection 'User defined (ideal system)'.

System 1: (User defined): General

Once a system is created, click into the 'System 1 (User defined)' sub-branch created.

Device/Equipment List

Add a new device for each system in the building for:

- Heating/Cooling
- Domestic hot water (DHW)
  - Water Heater
  - Storage tanks (if applicable)
- Mechanical Ventilation
- Photovoltaics / Renewable energy

Type: Select the appropriate equipment type for each system added.

Used For: Use the check-boxes to identify the purpose for each piece of equipment. Mechanical ventilation devices (E/HRVs) will not require a selection.

Coverage: Coverage is assigned below the device list. If more than one device serves the same purpose, all devices should be added, and the appropriate coverage should be assigned for each. This is generally applicable in the following scenarios:

1. Capacity of the cooling system exceeds the limit of a single system input (>682 kBtu/hr). Refer to Distribution: Cooling.
2. Different types of space heating or domestic hot water systems are planned

Example:

Heating Systems: A back-up or supplementary electric resistance system is provided in addition to the main heat pump system. Coverage can be determined by the split in the capacity of the systems or by a percentage of area covered by the supplementary system.

DHW Systems: Similar to the heating system, but the coverage may be determined by the capacity of the systems or the percentage of fixtures served by the supplementary electric resistance system.

Exception: The capacity limit of the cooling systems does not impact the heating system capacity.

Distribution: Hydronic Heating

If there are hydronic pipes used for heating in the project, they should be accounted for under this tab. These inputs account for the distribution losses of the hydronic piping to the surrounding space, or if the pipes leave the building envelope, the losses to the ambient conditions.

Design Flow Temperature

The temperature of the water in the piping. This can be determined by the mechanical sequence of operations, or leaving water temperature on the mechanical schedules for the heating plant equipment.

Length of Distribution Pipes

The total length of hydronic heating pipes in the project. This should be calculated by a takeoff on the drawing set between the heating plant and the terminal devices. Only include the length of hot water supply pipes, do not include hot water return piping.

Example: A project team is modeling hydronic heating for their building. They provide the takeoffs for the following pipe lengths, add them together, and enter the total length of pipes in WUFI.

- Between the boiler and the fan coil unit
- Between the boiler and the manifold for the radiant slab

Heat Loss Coefficient per ft Pipe

This input characterizes the heat loss from the piping per linear length.

Process Tip: Click into this input cell and use the [...] to open the built-in calculator. Input details about the pipe size and insulation.

Temperature of the Room the Pipes Pass Through

Input the average annual temperature for piping outside of the conditioned space.

Design System Heating Load

Leave blank for WUFI Passive to estimate or input the design system heating load for the hydronic heating system is different from the heating load calculated by WUFI, enter a design (peak) heating load for this system. Otherwise, leave blank.

Flow Temperature Controlled

If the flow temperature in the hydronic distribution is constant throughout the year, leave this box unchecked. If the flow varies throughout the year, for example if the water temperature changes in the cooling season, check this box.

Distribution: Domestic Hot Water (DHW)

Design Flow Temperature:

120-140°F is typical but shall be confirmed from DHW plans.

Circulation Pipes

This section should only be filled out if time-based or continuous recirculation is planned. This is only permitted in multifamily projects >5 stories and non-residential projects. Review the ZERH 'Exception' in Section 1.4.1.2. If modeling an on-demand recirculation system, define the Calculation method for individual pipes, then skip to 'Hot water piping' below.

Length of Circulation Pipes: The full length of continuous or time-based circulation pipes should be entered here.

Daily running hours of the circulation: 24 hours for continuous, or lower for time-based.

Process tip: Phius strongly discourages, but shall not prevent, the use of continuous or time-based hot water circulation systems in multifamily projects greater than 5 stories.

Individual Pipes – Calculation Methods

Review Appendix I-3.13 for other calculation methods that are available, but not used for Phius Certification.

Simplified Individual Pipes: Required for non-residential projects.

- Length of individual pipes: Determine the distance from the DHW source to each individual hot water tap. Sum these distances to find the total length of individual pipes.

Exception: Taps that are not exposed to the air such as clothes washers and dishwashers should not be included.

- Exterior Pipe Diameter: Add ⅛" inch to the nominal pipe dimension to determine the exterior dimension. Use a weighted average value for piping networks with a variety of pipe sizes.

Hot water piping calculator (unit method): Required for residential projects along with the 'Hot Water Piping' tab.

- This calculator estimates hot water distribution losses, as well as 'time to hot' used to aid in the design of a DHW distribution network.
- The length of Demand-based recirculation pipes SHOULD be entered here. The length of time-based or continuous hot water recirculation pipes SHOULD NOT be entered in this section, but rather above under Circulation Pipes.

Process tips:
When considering how to enter the DHW distribution network, consider the source of the 'hot' water, as well as the full path from the source of the hot water to each individual tap.

Refer to the Don't get yourself into [Domestic] Hot Water: Modeling Plumbing in WUFI Passive webinar and review the Sample DHW Distribution Layouts + Entries for WUFI Passive

Hot Water Piping: Residential Projects Only

Step 1: Fill out the upper portion of the Hot water piping tab.

- **Preselection effectiveness:** Determined by the type of hot water fixtures used in the project. If 'Low-Flow' fixtures are used as defined by the EPA WaterSense, choose 'Low flow'. This should be verifiable with a fixture schedule.
- **All pipes insulated:** Check this box if all hot water piping will be insulated. This should be verifiable from a note in the plans.
- **Count of units or floors:** PH case setting is the default and can be used for projects with a single unit configuration for water distribution.

Examples: Single-family and multifamily projects with identical dwelling units with individual water heaters.

Exception: For all other cases, this entry should be set to 'User Defined' so that the actual quantity of unique units can be input in Step 3 noted below.

Step 2: Identify the water distribution configuration and follow the Path from the chart below.

Recirculation Type	Path
None	A
On-Demand	B
Continuous or Time-Based	C

----- Follow the path below -----

PATH A: No Recirculation

Step 3A: For DHW distribution systems where no recirculation is provided.

Summarize DHW trunks create A list of each unique unit types. A unit type is designated as 'unique' if it has a unique DHW layout.

- **Name:** Name trunk based on Unit Type (i.e. A, B, C, etc).

Process Tip: For single unit buildings, only one trunk should be included from the water heater to where the first branch diverges.

- **Demand recirculation:** Leave unchecked if no on-demand recirculation is planned.
- **Length:** The trunk always starts at the water heater and should end where the first branch diverges from it. Takeoffs should be provided to verify this input.
- **Count of units or floors:** Number of times this unique unit occurs. Override this input as needed as noted in Step 1.
- **Pipe material, diameter, heat capacity, volume [oz] and cumulative volume [oz]:** Review definitions in Appendix N-10.

Step 4A: Summarize DHW twigs create a list of hot water fixtures in each unique unit type. The twig is the small diameter piping that serves an individual fixture.

Exception: Clothes washers and dishwashers should not be included.

- **Name:** Name based on DHW tap in the unique units listed above, with a 'T' at the front or end.
- **Length:** A twig only serves one fixture. To determine twig length, work from the fixture back to a central pipe that serves more than one fixture (branch).

Process Tip: Enter the entire twig length from the adjoining branch for each fixture no matter how many turns/twists.

Step 5A: Summarize DHW branches create list of branches connecting trunk to twig. Each twig will have its own branch, running from the trunk to the twig.

- **Name:** Name based on DHW tap in the unique units listed above (same as twig but without 'T')
- **Length:** Total length between twigs and trunks above.
- If a twig connects directly to a trunk, enter a branch with a length of '0' and connect the twig to that branch.

Process Tip: A branch off the trunk may only serve one fixture. In that case, it could all be considered a twig or could be split into a branch and a twig. If the pipe dimension and material are the same, either method will yield the same results.

Step 6a: Enter information from above into WUFI Passive.

- A segment must be entered first with the trunk, then connecting branch, then connecting twig.

Process Tip: Be careful to connect the appropriate segments.

Step 7A: Use the 'Watersense met?' column built into the twig entries to estimate whether all fixtures will pass the EPA WaterSense Hot Water Delivery requirement.

Process Tip: This tool is used to aid in the design of a DHW distribution network that will pass on-site testing, but does not guarantee it. If a twig is not passing in the model, it is recommended to revise the tap location or circulation strategy for that tap.

Exceptions:

The limit built into WUFI Passive of 0.5 gal is an option from ZERH V2 for single-family, duplex and townhouse projects. Alternative compliance paths taken should be communicated to Phius.

Multifamily projects with individual water heaters have a limit of 1.8 gallons while centralized systems have no limit.

Step 8A: Double check entries:

- All trunks must have branch entries
- All branches must have twigs connected.

Exception: If a summation is used for a single on-demand trunk entry, branch and twig inputs are not required.

- Quantities must appropriately represent the building distribution network.

PATH B: On-Demand Recirculation

Step 3B: For systems employing a demand recirculation strategy. Under DHW trunks Designate a trunk or trunks to account for the on-demand recirculation loop.

- ☐ **Demand Recirculation:** Check this box and review Appendix N-10 for description.

Process Tips: On-demand trunk entries are the only type of trunk that does not require a branch to be attached to it.

For multifamily buildings, additional trunks that are not part of the on-demand recirculation loop need to be included in separate trunk lines to account for unique dwelling unit configurations.

  - **Name:** Varies by trunk type.
  - On-Demand Trunks
    - Name 'On-Demand'

- Trunks to individual units off of circulation loop
  - Name based on unit number (i.e. 401, 402).
- ☐ **Length:** Varies by trunk type.
  - On-Demand Trunks
    - Enter the total length of the Supply side of the loop.

Process Tip: Omit the return portion: downstream of the last fixture and recirculation pump temperature sensor.

- ☐ **Count of units or floors:** Number of times this unique trunk condition occurs. Override this input as needed as noted in Step 1.
  - On-Demand Trunks

Process Tip: Multiple demand recirculation trunks are only required if the pipe diameter varies along the on-demand loop.

- Trunks to individual units off of circulation loop
  - Should match the quantity of each unique unit configuration.

Step 4B: Follow the same steps as PATH A.

PATH C: Time-based or Continuous Recirculation

Step 3C: For systems employing a continuous or time-based recirculation strategy.

Distribution DHW General Follow the instructions from Section 1.4.4.13

Process Tip: This type of recirculation system is only allowed in multifamily buildings of 6 stories or more with centralized DHW systems and non-residential projects.

Step 4C: Follow the same steps as PATH A.

Distribution: Cooling

Cooling system performance values are entered under System>Distribution>Cooling.

Process Tip: Projects using air source heat pumps should use the Phius Heat Pump Calculator.

To assign cooling, check all the boxes that best represent the cooling system planned:

☐ Cooling via ventilation air:

Check this box when using heat pump systems that cool incoming outdoor air supply, in-line with the ventilation device.

Note: WUFI Passive currently gives this cooling system 'priority' calculating the source and site energy use. If the capacity of that system covers the full sensible cooling load calculated by WUFI Passive, it is the only type of cooling that impacts the results source and site energy results.

Until this priority order can be better accounted for, Phius requests projects teams to model all cooling systems as if they were part of a recirculation cooling system.

Process Tip: Typical for combination cooling/ventilation units such as DOAS, CERV and Minotair.

<u>Minimum temperature of cooling coil (for supply air):</u> 45F default.

<u>Supply air cooling capacity:</u> From the manufacturer, based on available ventilation airflow and cooling coil.

Process Tip: Carefully review the units and convert to kBtu/hr as needed. (Btu/hr ÷ 1,000)

<u>Supply air cooling COP:</u> From manufacturer or calculate EER/3.412

☐ **Recirculation Cooling:**

Check this box when using heat pump systems that cool indoor, recirculated air only.

Recirculation air flow rate: Calculate this input based on the assumption of 300 cfm for every 12 kBtu/hr of total cooling capacity.

Example: The outdoor compressor of the cooling system has a rated cooling capacity of 18,000 Btu/hr. Convert to kBtu/hr: (18,000 Btu/hr ÷ 1,000) = 18 kBtu/hr ÷ 12 kBtu/hr **x** 300 cfm = 450 cfm

Exception: The manufacturer listed airflow may be used as long as there is no cooling warning in WUFI Passive.

Recirculation air cooling capacity: Rated value from manufacturer.

Process Tip: Carefully review the units and convert to kBtu/hr as needed. (Btu/hr ÷ 1,000)

Recirculation Cooling COP: This value must be calculated based on the performance data from the manufacturer. Typical cooling metrics are outlined under Heating & Cooling Equipment.

Process Tip: Regardless of what data is available for a project, use the Air Source Heat Pump Deration Calculator to calculate the COP input for WUFI Passive.

☐ **Dehumidification COP:**

Check this box when using a heat pump system and/or stand-alone dehumidifiers.

Dehumidification COP: Use a default of 1.2 for air or water-to-air source heat pumps.

Exception: If a stand-alone dehumidifier is specified, use the rated value from the manufacturer.

Process Tip: Click into this input cell and use the [...] to open the built-in calculator. Input the Liter/kWh rating.

☐ **Panel Cooling:**

Check this box when using radiant cooling systems.

Panel cooling COP: An external calculation is required.

Process Tip: Dehumidification control is required for projects that employ radiant cooling systems. Only typical to dry [B] climates.

Distribution: Ventilation

These are the ducts from the ventilator to the exterior of thermal boundary, not the ducts from the ventilator to interior spaces.

Duct Type

Each ventilator should have a supply and exhaust duct assigned.

Duct Shape

Choose round or rectangular per supply and exhaust duct.

Quantity

If there are multiple ventilators in the project covered by a single device entry, do not increase the quantity of duct lengths input here.

Example: If there are 50 identical ventilators in the project, the ventilation device will have a quantity of 50. Determine the average supply/exhaust duct length for those 50 ventilators, and input only one entry for a supply duct, and one for exhaust. Then, check the box to assign those two average-length ducts to the appropriate ventilator type. This will accurately assign those ducts to the 50 ventilators.

Duct Length

Review Section 1.4.2.6

Duct diameter or width and height

Depending on the duct shape, input the exterior diameter or cross-sectional width and height per supply and exhaust duct.

Insulation Thickness

This value must be input per duct line item.

Thermal Conductivity

This value must be input per duct line item and works with the insulation thickness to calculate the total R-value of the insulation.

Process Tip: The units for this entry are in Btu/hr.ft.F which is the inverse of the R-value divided by 12. To input the R-value/in of the insulation material used, click into the cell and select the [R/in] button that appears.

☐ Assigned ventilation units

As noted under Quantity, each supply and exhaust duct must be assigned to a ventilator using the checkbox here.

Distribution: Auxiliary Energy

Include additional pumps, fans and other auxiliary energy as noted below:

- Pumps associated with water systems such as:
  - Domestic hot water recirculation
  - Potable water (ie. booster, well)
  - Amenities (ie. pool, hot tub/spa)
- Fans associated with systems such as:
  - Make-up air
  - Direct-exhaust (ie. bathrooms, trashrooms, kitchen range hoods)
  - Recirculation (ie. transfer, kitchen range hoods)
  - Heating/Cooling air handler fans where the outdoor air ventilation ductwork is integrated
- Auxiliary energy associated with systems such as:
  - Exterior snow-melt or frost-protection
  - Amenities (ie. pool heaters, hot tub/spa heaters, space heaters outside the thermal envelope)

Exceptions:
Back-up or auxiliary heating systems within the thermal envelope of the building should not be modeled as auxiliary devices. Review the Coverage section under Device/Equipment List.

Systems that do not operate on a regular basis need not be accounted for. (ie. back-up generators, sump pumps, ejector pumps, fire pumps)

Pump and fan energy associated with the heating/cooling system (ie. air handling units, fan coil units, cooling towers, pumps associated with a GSHP etc..) should be accounted for with a COP deration outlined under Distribution: Cooling & Heating Devices.

☐ **Process Tip:** There is an option to 'Use Default values', which applies to many projects. When this box is unchecked, only the Ventilation fan energy and defrost energy are retained. Any pump entries for DHW recirculation and/or heating system circulation pumps are removed and must be added back to the model manually. (Note: The devices that remain are shown in the WUFI Passive reports under Auxiliary Energy).

Ventilation Winter (default)

No input required. This auto-calculated value accounts for the fan power of the ventilation system for months that require heating.

Ventilation Summer (default)

No input required. This auto-calculated value accounts for the fan power of the ventilation system for months that require cooling.

Process Tip: The sum of the runtimes for winter/summer ventilation will always equal the Ventilation/Rooms Utilization pattern runtime.

Ventilation Defrost (default)

No input required. This auto-calculated value accounts for energy associated with the ventilation device staying frost-free.

DHW Circulating Pump

Required entry for projects that provide active DHW recirculation which includes continuous, time-based, temperature controlled, on-demand and "smart" recirculation pumps. No run-time entry is required since WUFI Passive estimates a run-time based on the gross volume of the building.[28]

Energy Demand (rated) [W]: Use the default value per the calculation[29]: Wattage = (0.00007249 **x** Gross Volume ft^3) **+** 27W

Exception: Use manufacturer rated performance when available. This may be provided in Watts or converted from Horsepower to Watts.

Heating Circulating Pump

No input required. Any pumps associated with the space heating system should be accounted for per the deration method outlined under Heating Devices.

DHW Storage Load Pump

No input required.

Other

The energy estimations noted below are acceptable for all Phius projects and may be supplemented or replaced with project-specific calculations if available.

[28] (10+(1/(0.07+50/(Gross Volume*0.028317 m^3/ft^3*0.32))))*365

[29] 0.00007249 = 0.008 x 0.32 x 0.028317 m^3/ft^3

Table 1.4.4.13.0 Other Devices: Pumps

Device	Quantity	Energy demand (rated) [W]	Period of Operation [khr/yr]
Booster Pump	1	Phius Water Pressure Booster Pump Estimator	1
Well Pump		400 x F_{scale}[30]	
Pool Pump		2,264 x F_{scale}	
Hot tub/spa Pump		1,008 kWh/yr x F_{scale}	

Table 1.4.4.13.1 Other Devices: Fans

Device	Quantity	Energy demand (rated) [W]	Period of Operation [khr/yr]
Make-Up Air	# Fans	W/cfm x cfm	Varies
Bathroom Exhaust[31]			0.365
Trash Room Exhaust			8.76
Range Hood Exhaust			0.033 x # bedrooms
Transfer			Varies
Heating / Cooling AHU[32]			8.76

[30] F_{scale} = 0.5 + (Nbr / 12) + (iCFA / 7,680)

[31] 0.3 W/cfm may be used as a placeholder if fan power is not available.

[32] Only used if the outdoor air supply is connected to an air handling unit for distribution into bedrooms, the air handling unit fan energy must be input here and assumed to run 8760 hrs/yr. See Section 1.3.4.2.

Table 1.4.4.13.2 Other Devices: Miscellaneous Electric			
Device	**Quantity**	**Energy demand (rated) [W]**	**Period of Operation [khr/yr]**
Snow Melt / Frost Protection[33]	1	Varies	Varies
Pool Heater (electric)		2,295x F_{scale}	1
Hot tub/spa Heater (electric)		1,021 x F_{scale}	1

Table 1.4.4.13.3 Other Devices: Miscellaneous Gas			
Device	**Quantity**	**Energy demand (rated) [W]**	**Period of Operation [khr/yr]**
Pool Heater (gas)	1	3,454 x F_{scale}	1
Hot tub/spa Heater (gas)		1,275 x F_{scale}	
Fireplace (gas)		982 x F_{scale}	
Grill (gas)		30 x F_{scale}	
Lighting (gas)		18 x F_{scale}	

[33] Contact Us for estimating the energy use of this system type.

1.4.4.14 Devices

Heating Devices

Heat Pumps

If heat pump technology is used for space heating, use the 'Heat Pump' device type. Within this device type, there are two options:

1. **Heat Pump Rated Monthly COP:** When COP data for two rated ambient temperatures can be found, use this device type. Use the Heat Pump Calculator to determine inputs.

Process Tip: This takes the monthly heating demand and climate data into consideration to calculate a more accurate COP. Generally, air source heat pumps are rated at 17°F and 47°F. By entering the rated performance at both temperatures, WUFI Passive can calculate an annual average heating COP based on the monthly heating demand and climate. This follows Phius' heat pump protocol.

2. **Heat Pump:** For water source and ground source heat pumps. Use the Heat Pump Calculator to determine inputs.

Electric Resistance Heater

Assign the Type to 'Electric resistance space heat / DHW'. No efficiency inputs are required under the device itself.

Boiler or Furnace

Assign the Type to "User Defined". Find the Thermal Efficiency (%) or Annual Fuel Utilization Efficiency (AFUE) of the planned device.

Performance Ratio of Heat Generator: Inverse of the efficiency or AFUE.

Example: Result should be input in WUFI Passive.

- Efficiency = 95%: 1/0.95 = 1.05
- AFUE = 97 or 0.97: 1/0.97 = 1.03

Source Energy Factor: 1.1 default for natural gas.

CO2 Emissions Factor: 73.28 default input required, but has no impact on the results.

Wood or Pellet Stove

Assign the Type to "User Defined". Set the coverage to 0.25 as a default[34]. Use 60% as a default or the Thermal Efficiency (%) from the planned device.

Performance Ratio of Heat Generator: Inverse of the efficiency

Example: Result should be input in WUFI Passive.

- Efficiency = 60%: 1/0.60 = 1.67

Source Energy Factor: 0.2 default for biomass fuel

Domestic Hot Water Devices

Heat Pump Water Heaters

If heat pump technology is used for domestic hot water heating, use the 'Heat Pump' device type. Within this device type, there are two options:

1. **Heat Pump Water Heater (HPWH) Inside:** When both the tank and compressor are located within the thermal envelope of the building, use this device type. This device type will de-rate the efficiency of the HPWH due to the compressor 'stealing' heat from the building and causing the space heating system to work harder during the heating season.
    a. Annual Heating Coefficient of Performance (COP): Enter the average COP of the space heating system.
    b. Total System Performance Ratio of Heat Generator: Enter $\frac{1}{Heating\ System\ COP}$ as a decimal.
    c. HPWH EF: Enter the rated Energy Factor (EF) for the Heat Pump Water Heater.
        i. If UEF is provided: HPWH EF = 1.201 x UEF - 0.6052

2. **Heat Pump:** When any combination of the compressor and/or tank are located outside of the thermal envelope of the building, use this device type.
    a. Annual Heating Coefficient of Performance (COP):
        i. For the following CO_2 HPWHs follow the instructions directly below and review the Water Heaters with Tank instructions:
            1. SanCO_2: Use the Phius Calculator.
            2. QAHV CO_2: Contact Us for climate specific calculator.
        ii. For other HPWHs located outside of the thermal envelope: Contact Us for climate specific calculator.
    b. Total System Performance Ratio of Heat Generator: Enter $\frac{1}{DHW\ System\ COP}$ as a decimal.

Tankless Water Heater

If a tankless water heater is used for domestic hot water heating, assign the Type to 'User Defined':

1. Performance Ratio of Heat Generator: Inverse of the EF or UEF.
2. Source Energy Factor:
    a. 2.0 default for electricity.
    b. 1.1 default for natural gas.
3. CO2 Emissions Factor: Input required, but has no impact on the results.
    a. 199.31 default for electricity.
    b. 73.28 default for natural gas.

[34] A typical "off the shelf" wood stove is likely oversized for single-family passive buildings. If using a system designed for a lower heat load or a more low-steady heating system, such as a masonry heater or pellet stove, a calculation may be provided to increase the coverage.

Water Heater with Tank

If a tanked water heater is used for domestic hot water heating, the modeling method depends on the fuel type and performance data available:

1. If EF or UEF is available: assign the Type to 'User Defined'.
    a. Performance Ratio of Heat Generator: Enter $\frac{1}{EF}$ as a decimal.
        i. Electric: EF[35] = 2.4029 x UEF -1.2844
        ii. Natural Gas: EF = 0.9066 x UEF + 0.0711
    b. Source Energy Factor:
        i. 2.0 default for electricity.
        ii. 1.1 default for natural gas.
    c. CO2 Emissions Factor: Input required, but has no impact on the results.
        i. 199.31 default for electricity.
        ii. 73.28 default for natural gas.
2. If AHRI Rating with storage losses is available and fuel type is:
    a. Electric: Assign the type to 'Electric resistance space heat / DHW' and create a new device for 'Water Storage' and assign coverage to DHW.
        i. Input Options: Set to 'Total Losses'
        ii. Storage Capacity: Enter the tank size in gallons.
        iii. Within thermal envelope: Check this box if the storage tank is located within the thermal envelope.
        iv. Average Heat Released From Storage [Btu/hr]: 8.3454 x Tank Size [gal] x AHRI Standby Loss [F/h]
    b. Natural Gas: Assign the type to 'User Defined', follow the Boiler or Furnace instructions, then follow the water storage instructions above.
3. If no storage loss rating is available and fuel type is:
    a. Electric: Assign the type to 'Electric resistance space heat / DHW' and create a new device for 'Water Storage' and assign coverage to DHW.
        i. Input Options: Set to 'Specific Total Losses'
        ii. Storage Capacity: Enter the tank size in gallons.
        iii. Specific Total Thermal Storage Losses [Btu/hr.F]: Tank U-Value[36] [Btu/hr.ft^2.F] x Tank Surface Area [ft^2]
        iv. Within thermal envelope: Check this box if the storage tank is located within the thermal envelope.
    b. Natural Gas: Assign the type to 'User Defined', follow the Boiler or Furnace instructions, then follow the water storage instructions above.

Process Tip: It is recommended to de-rate the efficiency by a factor of 0.92 (as in RESNET protocol), to account for the discrepancies between the heavy draws used in the DOE water heater testing protocol and the real world.

[35] Minimum of 0.96 or calculated energy factor.

[36] A default of U-0.0833 Btu/hr.ft^2.F may be used as a placeholder for Design Certification which is equivalent to R-12.

Solar Collector

In cases where the energy model report shows a solar fraction above 65%, a predicted annual output from the solar inspector as to the kBTU/yr energy production is required.

Exception: A BEopt model run according to the Phius Solar DHW Fraction BEopt Protocol may be used.

Drain Water Heat Recovery

The drain water heat recovery device is used to adjust the temperature of the incoming water supply by recovering warm drain water and pre-heating the incoming cold freshwater.

- DW heat recovery unit indoor temp: Default 97F
- DW Heat Recovery Unit Efficiency: As rated and labeled in accordance with CSA 55.1
- Pipe Length: Measured length of hot water piping from the hot water heater to the farthest hot water fixture. Measured longitudinally from plans, assuming the hot water piping does not run diagonally. Plus 10 feet of piping for each floor level, plus 5 feet of piping for unconditioned basements (if any).
- Supplies pre-heated water to: Select if the system supplies both hot and cold water, or just one of the two.

Process Tip: DWHR device does not work in combination with the 'Simplified individual pipes' hot water distribution calculation method.

Mechanical Ventilation Devices

Inputs here are reserved for ventilation devices that have passive heat heat recovery.

Exceptions: The following devices provide active and passive heat recovery.
CERV from Build Equinox
Default values may be used for performance of refrigerant-based heat recovery devices. Or, Phius-approved calculation methodology may be used to determine performance entries.
Default accepted values:

- Sensible Recovery Efficiency: 0.75
- Latent Heat Recovery: 0.40
- Electric Efficiency [W/cfm]: 1.0

PentaCare V12 from MINOTAIR
This system requires dynamic (hourly) climate data and a Phius project specific calculator to determine the performance values for WUFI Passive modeling. Provide the project number and Phius climate location through the Contact Us form to receive this calculator.

Unfinished (UF): Inputs noted below shall match the average for the rest of the building.

Sensible Recovery Efficiency:

Review Section 1.4.2.5 for accepted sources for this decimal input.

Process Tip: For ventilation units with HVI ratings, use either the ASRE or ATRE.

Latent/Humidity Recovery Efficiency:

Review Section 1.4.2.5 for accepted sources for this decimal input.

Exceptions:
0.40 default is acceptable for ERVs if not specified.
0.00 default is acceptable for HRVs if not specified.

Process Tip: For HVI ratings, use the NMT or LRMT.

Electric Efficiency [W/cfm]:

Review Section 1.4.2.5 for accepted sources for this decimal input.

Process Tip: Ventilator fan power is one of the measurements required for final certification and can have a significant impact on the source energy result. For large centralized ventilation units, Phius recommends modeling the fan power conservatively during design review (between 1.2-1.5 W/cfm).

Exceptions: Ventilator fan power measurements are not required for the CERV from Build Equinox or the PentaCare V12 from Minotair.

☐ Equipped with frost protection:

This box must always be checked.

☐ Assigning 'rooms ventilated by this unit':

All ventilation rooms defined in Section 1.4.4.10 will appear as a list under each mechanical ventilation device modeled. Each room must be assigned to its corresponding ventilation device by checking the box within this list for the device it is served by (see example below)

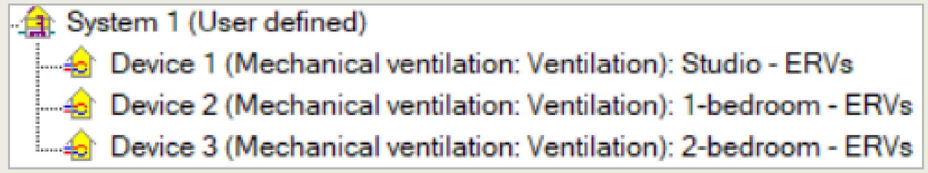
Quantity:

Input the quantity of identical ventilation devices. Unique ventilation devices should each be entered as a separate device.

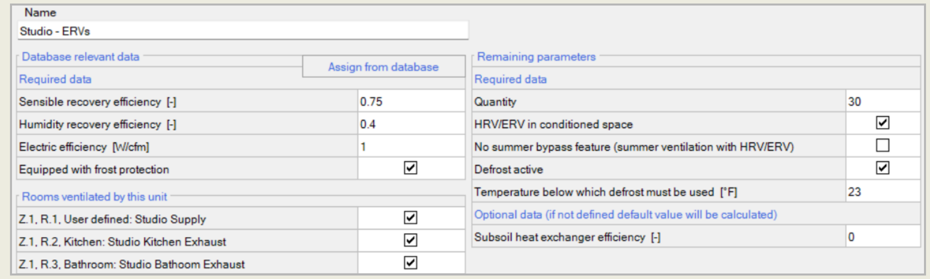
Process Tip: Identical devices should have the same model number, planned airflow rate and therefore same performance inputs.

Example:

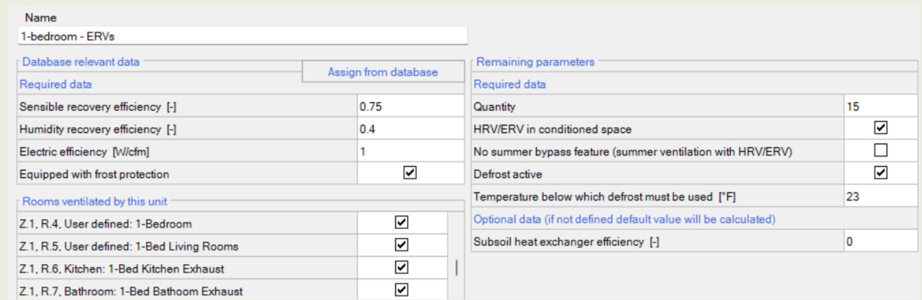
A 50-unit multifamily has one identical ERV per dwelling unit. The building consists of 30 studios, 15 one-bedrooms and 5 two-bedrooms.



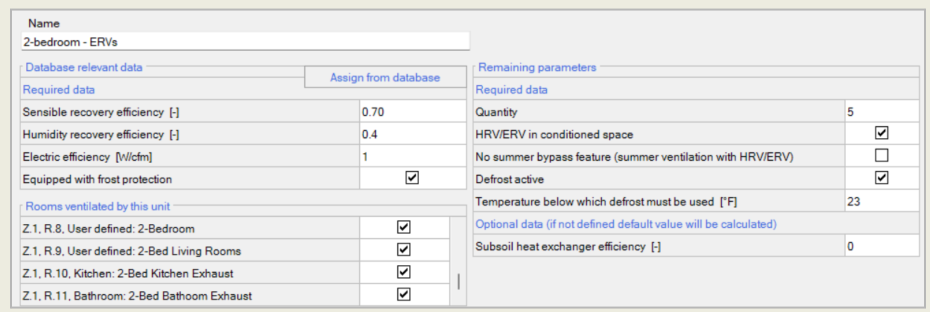
The studio dwelling units would be input as noted below:



The one-bedroom dwelling units would be input as noted below:



The two-bedroom dwelling units would be input as noted below:



☐ **HRV/ERV in conditioned space:**

- Check this box if the ventilation device is within the thermal and airtight envelope.
- Uncheck this box if the ventilation device is outside of the thermal envelope. Follow the Mechanical Room Temperature instructions.

Exception: WUFI Passive cannot currently account for a mix of ventilation units and inside and outside the thermal envelope. If any ventilator has the box for 'HRV/ERV in conditioned space' checked, WUFI Passive assumes all of the ventilators in the model are in conditioned space. For certification modeling purposes, the following protocol should be followed.

- If 50% or more of the planned average airflow through the outdoor air ventilation system with heat recovery is within the thermal envelope, check the box for 'HRV/ERV in conditioned space' for all ventilation units.
- If less than 50% of the planned average airflow through the outdoor air ventilation system with heat recovery is within the thermal envelope, uncheck the box for 'HRV/ERV in conditioned space' for all ventilation units and follow the Mechanical Room Temperature instructions.

☐ **No Summer Bypass Feature:**

- Uncheck this box if the ventilation device has a bypass mode that allows the outdoor air to bypass the heat recovery core or wheel when outdoor conditions are beneficial.
- Check this box if the ventilation device does not have a bypass mode and runs continuously in heat recovery mode.

Process Tip: Higher end ventilators typically have advanced controls that enable bypass mode, while simpler ventilators do not.

☐ **Defrost:**

This box shall always be checked. No matter the method of defrost, Phius requires accounting for defrost energy and entering between 23°F-28°F for the temperature in which defrost must be used.

Exception: If using a ground loop pre-heater/subsoil heat exchanger, defrost energy does not need to be accounted for in the energy model and this box may be unchecked.

Subsoil Heat Exchanger:

Use for earth air tubes and liquid-based ground loops for tempering supply air. Typical efficiency ranges from 40-60%. For entries above 60% efficiency, a corresponding calculation is required for certification.

Renewable Energy Systems:

For any renewable energy, on-site or off-site, add a 'Photovoltaic / renewable energy' device. Add a new device for each unique type of renewable energy.

For design certification, on-site renewable energy must be documented. For any off-site renewable energy, Phius requires the project owner to sign a letter of intent for contracting enough renewable energy before Design Certification is awarded.

Name:

Use a descriptive name for the device that includes the array capacity (kW) and manufacturer (if available)

Location:

On-Site: Available for Phius CORE & ZERO projects.
Off-Site: Available for Phius ZERO projects only.

Onsite Utilization:
For Phius CORE:
- Residential: 'PV Utilization Calculator' required.
- Non-Residential: 'User Defined' required.

Utilization:
For Phius ZERO: Options include
- Directly owned off-site renewables
- Community renewable energy
- Virtual power purchase agreement
- Renewable energy certificates (RECs)

Photovoltaic / Renewable Energy [kWh/yr]:
Phius CORE
- Residential: Input the total annual production of the renewable system planned.[37]
- Non-Residential: Follow one of the methods below.
  - Multiply the total annual production of the planned renewable system by 0.75 as a conservative utilization factor.
  - Contact Us to coordinate a dynamic simulation to calculate a project-specific utilization factor. (additional consulting fee will apply)
  - Projects with custom targets will receive a custom utilization factor automatically. Review Appendix N-1 for more information.

[37] NREL's PV Watts Calculator is an accepted method for estimating annual energy production from an on-site PV Array. Please include a PVWatts report in document submission

Phius ZERO
Input the total annual production of the renewable system planned.

Electric Vehicle Charging

There is no requirement to include EV charging energy use for certification compliance. The energy use from vehicle chargers is categorized as part of the transportation sector and not included in the source energy limit for Phius Certification.

1.5 On-Site Review

Table 1.5.0 Performance Path: QA/QC Guidance	
Required Documentation	Refer to Section 1.5.1 for the documentation needed for the Final Certification Process to begin.
QA/QC Requirements	Refer to Section 1.5.2 for guidance on the Phius Quality Assurance Workbook.
Co-Requisite Programs	Refer to Section 1.5.3 for more information about specific program versions.

This section is generally written for Raters and Verifiers to review and understand the Final Certification process. The following documents laid out in this section should be completed and uploaded by the Rater or Verifier. Please Contact Us for any broken hyperlinks.

1.5.1 Required Documentation

When submitting a project for Final Review, it is important for the project team to know what documentation is required. Before conducting the first round of Final Review, Phius conducts what is referred to as the 'Initial Review.' This Initial Review serves as a "documentation review" to ensure the project team has uploaded the correct documentation to achieve Final Certification, as required by the Phius QA/QC team.

During the Initial Review, the Phius QA/QC team verifies the project team has completed:

- Phius Quality Control Field Checklist (see Section 1.5.2.1)
- Phius Quality Assurance Workbook (see Section 1.5.2.1)

The Phius QA/QC team will review all required documentation within the project On Site QA folder for completeness. Once all documentation has been provided, the first round (F1 Review) of Final Review can begin.

Table 1.5.1.0 identifies the breadth of documentation that must be uploaded to the project Dropbox folder.

Table 1.5.1.0 QA/QC Required Documentation

Project Type	Single-Family, Duplexes & Townhouses	Multifamily	Non-Residential
Co-requisite and External Requirements			
EPA Energy Star	EPA Energy Star Single-Family New Homes (SFNH) certificate	Multifamily New Construction (MFNC) certificate	Exempt from certificate requirement, however co-requisite program checklists are required (see below for more information)
EPA indoor airPLUS	EPA Indoor airPLUS certificate(s)		
DOE Zero Energy Ready Home	DOE Zero Energy Ready Home certificate(s)		
HERS Rating or Other External Documentation	REM/Rate or Ekotrope Building Summary (pdf format)	REM/Rate or Ekotrope Building Summary, or A Home Energy Rating Certificate (pdf format), for every dwelling unit, or Energy Star, IAP, and DOE ZERH certificates for every dwelling unit	n/a
Phius Requirements			
Phius Quality Control Field Checklist	Complete Phius Quality Control Field Checklist		
Phius Quality Assurance Workbook	Complete Phius Single-Family Quality Assurance Workbook Duplex and Townhouse projects must use the Multifamily Quality Assurance Workbook	Complete Phius Multifamily Quality Assurance Workbook	Complete Non-Residential Quality Assurance Workbook
Air Sealing Report	Automated Whole Building Airtightness Report in compliance with ANSI/RESNET/ICC Standard 380-2022 (or later version) or ASTM E-779		
TAB Reports	n/a	Ventilation Testing and Balancing Report Heating & Cooling Testing and Balancing Report (ducted heating and/or cooling systems)	

1.5.2 Performance Path: QA/QC Requirements

It is imperative to the Final Certification process for each project to complete and upload a Phius Quality Assurance (QA) Workbook and Phius Quality Control (QC) Field Checklist. In addition, a Home Energy Rating System (HERS) energy model must be created, and its corresponding Building Summary uploaded to the project Dropbox folder. Please see the table below for more options in regard to the HERS Building Summary. The table below summarizes requirements for the QA/QC Final Review process.

Table 1.5.2.0 Performance Path: QA/QC Requirements

		Single-Family, Duplexes & Townhouses	Multifamily	Non-Residential
Project Type		**Single-Family, Duplexes & Townhouses**	**Multifamily**	**Non-Residential**
Program Version		CORE & ZERO (for differences refer to Table 1.3.1)		
External and Building Envelope Documentation and Requirements				
Key Documents		Refer to Section 1.5.2.1		
HERS Building Summary or Other External Documentation		Refer to Section 1.5.2.2		-
Building Envelope	**Blower Door Testing**	Refer to ANSI/RESNET/ICC Standard 380-2022 & Appendix C-2		
	Compartmentalization	Duplexes & Townhouses must meet 0.3 cfm/sf	Multifamily and Non-Residential projects must meet 0.3 cfm/sf	
Mechanical Equipment Documentation and Requirements				
Ventilation		Refer to Section 1.3.4.2		
Heating & Cooling		Refer to Section 1.5.2.5		
Domestic Hot Water		Refer to Section 1.5.2.6		
Appliance and Electrification Documentation and Requirements				
Appliances & Electrical	**Appliances**	Identify all appliances that relate to the project		
	Additional Major Electrical / Other Loads	Identify if there are any additional major electrical/other loads		
Renewables & Electrification	**Energy Systems**	Determine if a Solar Thermal System and/or a Solar Photovoltaic System was installed		
	Electric Vehicle	Electric Vehicle Readiness and Capability		

1.5.2.1 Key Documents

Phius Quality Control Field Checklist

New to the Phius Final Certification process, the rater or verifier must complete and upload the Phius Quality Control Field Checklist. This checklist is intended for on-site use. Unless noted otherwise, the sections below apply to all project types. Please also visit phius.org to download the most recent documents.

On-Site Photos

Refer to the Phius Quality Control Field Checklist for a non-exhaustive list of required photo documentation.

Phius Quality Assurance Workbooks

In addition to the Phius Quality Control Checklist, it is required to complete and upload the Phius Quality Assurance Workbook. Below is guidance on how to choose which workbook to use based on project type.

Phius Single-Family Quality Assurance Workbook

"Single-family" refers to single-family detached homes. What may elsewhere be called "single-family attached" housing is here considered to be "multifamily." Single-family projects should follow the Phius Single-Family Quality Assurance Workbook, linked above.

Phius Multifamily Quality Assurance Workbook

Multifamily projects are defined as anything residential other than "single-family," "duplex," or "townhouse." They should follow the Phius Multifamily Quality Assurance Workbook, linked above, for quality assurance, prescriptive design requirements, and commissioning. All performance-based certification criteria remain the same as for single-family.

Though the definition of 'Multifamily projects' excludes duplexes and townhouses, when beginning the Final Certification process for a duplex or townhouse project, please use this Phius Multifamily Quality Assurance Workbook.

Phius Non-Residential Quality Assurance Workbook

Non-Residential projects are commercial projects that follow the same criteria as residential projects, apart from the Source Energy requirement set out in Design Certification. They should follow the Phius Non-Residential Quality Assurance Workbook, linked above, for quality assurance, prescriptive design requirements, and commissioning.

Compliance Tool

Please ensure that the most recent version of the project's compliance tool is uploaded to the project's Dropbox. For performance path projects, this compliance tool will be the WUFI Passive model. For more information on who should make as-built changes to this model, refer to Section 1.1.6.

1.5.2.2 HERS Building Summary or Other External Documentation

Single-Family, Duplexes, and Townhouses

Provide one Building Summary for the entire dwelling, upload as a PDF. Ensure that all assembly and fenestration types present in the project are built out in the HERS Energy Model. Include overall R-values or U-values and areas of components.

Multifamily

ERI Path through Energy Star:

Provide one Building Summary or Home Energy Rating Certificate, per dwelling unit, upload as a PDF:

- Organize all dwelling unit Building Summaries in folders within project's Dropbox, collated by dwelling unit type, i.e. 1BR, 2BR, 3BR, etc

- If Building Summary is uploaded, ensure that all different assembly and fenestration types for the project are built out in the HERS Energy Model and include overall R-value or U-value.

Process Tip: These will likely show up in different dwelling units depending on how many units have exposure to the exterior assemblies.

ASHRAE or Prescriptive Paths through Energy Star:

Provide Energy Star, IAP, and DOE ZERH certificates for every dwelling unit. Refer to Section 1.5.3.2 for more information.

Process Tip: Organize all dwelling unit Building Summaries in folders within project's Dropbox, collated by dwelling unit type, i.e. 1BR, 2BR, 3BR, etc

Non-Residential

EPA Energy Star MFNC, IAP and DOE ZERH Checklists must be completed for all applicable items.

The checklists shall be applied to non-residential projects "as if" certification would be achieved, however, certification is not required.

1.5.2.3 Building Envelope

Mid-Construction Inspections

A minimum of two mid-construction inspections shall be required; one at foundation phase to verify foundation insulation systems, and another pre-drywall. Photo documentation is required.

RESNET Standards and program requirements for Energy Star Certified Homes and Energy Star Multifamily New Construction Program requires a minimum number of inspections to verify projects. Please ensure the work scope for services includes the minimum number of required inspection visits.

Process Tip: More frequent inspections and testing may be required or requested by the project team depending on project scope, and if agreed upon by Rater/Verifier.

Blower Door Testing

For townhouses, multifamily, and non-residential projects, development of a Blower Door Testing Plan is highly encouraged.

Process Tip: If building airtightness passes during an un-taped test, a taped test is not required.

Preliminary Test (optional, but encouraged)

Because a preliminary test can be conducted at any point during construction, there is no direct protocol for this test. Please be sure to follow ANSI/RESNET/ICC Std 380-2022 (or latest version) for preparing the building.

Final Test (Un-taped - Mandatory)

The following list of requirements applies to all projects for the final blower door test:

- Conducted in both pressurization and depressurization modes.
- The test reports shall indicate a minimum of a 5-point multipoint test, meeting either the provisions of:
    - ANSI/RESNET/ICC Standard 380-2022 (or latest version), **or**
    - ASTM E-779
- Measured infiltration air flow test results shall have a projected accuracy within 10%.
- The test reports shall indicate a Correlation Coefficient of 0.95 or greater.
- Confirm the building envelope area is consistent with WUFI the model.

Final Test (Taped - if necessary)

In addition to the requirements outlined in the Untaped section above, refer to Appendix C-2.3 for the list of items that may be taped for this test and refer to the following for more information:

- ANSI/RESNET/ICC Standard 380-2022 (or later version), **or**
- ABAA Standard Method for Building Enclosure Airtightness Compliance Testing

Compartmentalization

For Duplexes, Townhouses, Multifamily projects, and Non-Residential projects testing shall be performed following ANSI/RESNET/ICC Standard 380-2022 (or later version) and RESNET Standards for Multifamily Energy Ratings, in addition to the Phius Whole Building Airtightness requirements.

Individual dwelling unit compartmentalization testing shall be performed to test the air barrier integrity of each dwelling unit. Testing shall be performed as an "unguarded" test as described under the section Procedures for Multifamily Dwelling unit/Building Airtightness Testing, Test 1 from the RESNET Guidelines for Multifamily Energy Ratings document, and shall not be adjusted by any multifamily infiltration correction coefficient.

Dwelling unit compartmentalization testing shall be performed in single-point depressurization mode following RESNET Chapter 8 protocol unless the testing condition at the time of the test qualifies as a Reduced Level of Accuracy testing condition per RESNET Chapter 8. Any adjustments for temperature, altitude or reduced accuracy as specified by Chapter 8 shall be applied to the measured CFM@50 Pa leakage rate.

This adjusted compartmentalization value shall be divided by the square footage of the dwelling unit enclosure shell area to demonstrate compliance with this requirement. For apartment-style dwelling units, "band joist" surface area accounted for as the perimeter of the ceiling cavity space of the dwelling unit shall be applied to the lower dwelling unit, and shall only be added if the entire perimeter of the ceiling cavity space is blocked and sealed.

Example: An open floor truss that is not blocked for the ceiling cavity spaces between building zones cannot have the "band joist" surface area included in this calculation.

1.5.2.4 Ventilation

Unless noted otherwise, the sections below apply to all project types.

Ventilation System Airflow Testing Verification

Room-by-room balancing

Testing shall be performed using devices noted below:

- Retrotec Flow Finder
- Energy Conservatory Flowblaster
- Energy Conservatory Exhaust Fan Flow Meter (for flows under 35 CFM)
- Testo 417 (for flows under 100 CFM) with flow straightener and capture hood
- CFM-range appropriate non-powered flow hood
- Duct tester devices with custom capture hood attachment

Process Tip: Any other device or methodology must be preapproved by Phius and listed in ANSI/RESNET/ICC Standard 380-2022 (or later version)

Exception: A certified third-party air balancer or product commissioning agent can provide a detailed air balancing report in lieu of the Rater or Verifier performing this task. A minimum number of air flows must be measured by the Rater or Verifier per the QA Workbook requirements.

Individual room supply and exhaust airflows:
This is automatically calculated within the QA Workbook once design and measured values are input.

Process Tips:
Note minimum exhaust airflows are mandated per ventilation requirements outlined in Section 1.3.4.2

For jurisdictions enforcing the 2021 International Mechanical Code, use the exhaust ventilation requirements in Table 403.3.1.1 of that code.

Pressure balanced bedrooms:
This is automatically calculated within the QA Workbook once design and measured values are input.

Exception: Measurements of the outdoor air inlet and exhaust outlet of the ventilation system can be made on the exterior of a building using a pressure matching tool such as a duct tester or powered flow hood, so long as:

- Measurements can be made safely
- The ducts connecting the system to outside are well sealed
- Environmental conditions (wind) will not adulterate the test results
- Ventilation in/outlets are possible to test without building products or architectural features interfering

Power Consumption

Ventilation fan power must be measured and recorded in watts for ventilation units operating in typical 24/7 mode using one of the following methods, post commissioning and with clean filters:

- Using a power-factor adjusted wattage clamp meter, such as the Amprobe NAV-51, power is measured at the electrical panel, disconnect, outlet or other accessible location.
- Using a plug-in watt meter such as the Kill-a-Watt™, so long as the system has a 110v electrical plug.
- Using measured total system airflow or external static pressure and a manufacturer's fan curve or table.

Exceptions:
Power measurements incorporating power factor recorded by a third-party balancing firm, HVAC contractor or Electrician in the presence of the Phius Rater/Verifier with the power reading recorded.

For Zehnder Q Series only: The power consumption from the unit display may be used, provided the system has been balanced and commissioned. Photo documentation of the display power consumption is required. This is contingent upon Zehnder providing a Bi-annual Product Declaration Statement validating the accuracy of their internal power measurement to Phius. Validation documents should include the following:

- Provide table of validation data with a minimum 3 data points over the flow range capabilities of the unit, for air flow rates and static pressures
- Validate measured energy consumption with a traceable, calibrated power, airflow and static pressure meters (traceable through NIST or other standard testing agency)

Ventilation System Installation Verification

For multifamily projects, this information is necessary for each ERV, HRV, or central system within the sample set. Refer to Appendix C-3 for more information.

1.5.2.5 Heating & Cooling

Heating/Cooling System

Bedroom pressure balancing for ducted heating and cooling systems

Single-family: Refer to Energy Star's SFNH National Rater Field Checklist, Section 6.2 for more information

Multifamily: Refer to Energy Star's MFNC Rater Field Checklist, Section 6.2 for more information

Heating and Cooling Air Distribution System Tightness Testing

Single-family: Refer to Energy Star's SFNH National HVAC Commissioning Checklist for more information

Multifamily: Refer to Energy Star's MFNC HVAC Functional Testing Checklist for more information

Hydronic Heating, Cooling, and Hot Water Systems Appropriately Tested and Balanced

Hydronic heating and cooling systems fall outside of the scope of ESv3 and ZERH standards. Nevertheless, their design, installation and performance are critical to building performance.

All hydronic heating and cooling systems shall be designed, sized and installed per local or municipal code requirements. Additionally, systems shall be balanced by installing contractor or third-party balancing professionals. It is recommended that balancing be performed following either National Environmental Balancing Bureau (NEBB) PROCEDURAL STANDARDS FOR TESTING ADJUSTING AND BALANCING OF ENVIRONMENTAL SYSTEMS - SEVENTH EDITION, ACCA Manual B, or another professional industry-accepted testing and balancing standard. Documentation of balancing shall be provided to Rater or Verifier with design flows, tested flows and locations of all terminal devices.

1.5.2.6 Domestic Hot Water

Refer to Phius QA Workbook and Phius QC Field Checklist for more information on required inputs and documentation.

1.5.2.7 Appliances & Electrical Load

Refer to Phius QA Workbook and Phius QC Field Checklist for more information on required inputs and documentation.

1.5.2.8 Renewables & Electrification

Renewable Energy Systems

All projects shall either have renewable energy systems installed or shall comply with the DOE Zero Energy Ready Home PV-Ready Checklist. Refer to DOE Zero Energy Ready Home Program Requirements for more information.

Electric Vehicle (EV) Charging Infrastructure

Refer to Section 1.3.4.3

1.5.3 Co-Requisite Programs

Refer to Table 1.3.0. Phius works with the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE) in requiring compliance with Energy Star, Indoor airPLUS, and Zero Energy Ready Home.

It is the responsibility of the whole project team to ensure a project is fully compliant with Phius certification requirements. It is highly recommended that the CPHC and the Rater or Verifier ensure that all critical project team members understand the Phius Final Certification process. Phius program requirements include partner programs such as the EPA ENERGY STAR Single-Family Homes, EPA ENERGY STAR Multifamily New Construction Program, EPA Indoor airPLUS and DOE Zero Energy Ready Homes programs.

It is not the responsibility of the Rater or Verifier to train builders, building subcontractors, designers, or any other project team member on specific scopes of work to construct Phius compliant projects, other than to make them aware of the requirements listed in the Phius Workbook or allied documents. The Rater or Verifier may choose to provide such guidance at their own discretion. It is the responsibility of the Project Team, and in particular the builder, to ensure the Rater or Verifier is notified of the construction schedule and afforded the opportunity to conduct inspections as required by Phius and the accompanying EPA and DOE Programs.

Table 1.5.3.0 Co-Requisite Program Versions

Scope	Single-Family, Duplexes & Townhouses	Multifamily	Non-Residential
EPA Energy Star	Single-Family New Homes (SFNH) Version 3.2	Multifamily New Construction (MFNC) Version 1.2	Exempt from certification requirement, however co-requisite program checklists are required *(see below for more information)*
EPA Indoor airPLUS[38]	Version 1, Rev. 4	Version 1, Rev. 4	
DOE Zero Energy Ready Home	Single-Family Version 2, Rev. 1	Multifamily Version 2	

1.5.3.1 Additional Information Program Eligibility Criteria

Energy Star SFNH Eligibility Criteria

The ENERGY STAR Single-Family New Homes (SFNH) program is available for all single-family homes, duplexes, and townhouses. Both site-built and modular construction methods are available to be used for compliance with this program.

[38] Version 2 is now available, but not required until permits after 1/1/2026.

Energy Star MFNC Eligibility Criteria

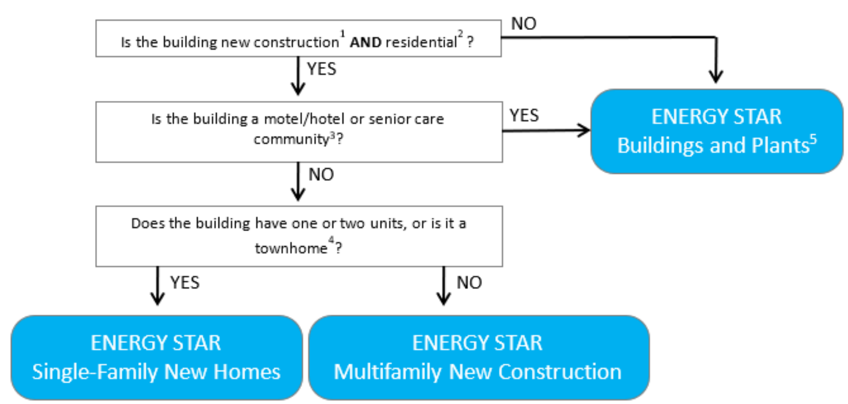
The ENERGY STAR Multifamily New Construction Program (MFNC) program is available for all residential new construction, except single-family detached homes and two-family dwellings. Follow the decision tree below to determine which program your multifamily building can use to earn ENERGY STAR certification. Additional footnotes regarding eligibility for multifamily buildings are contained in the footnotes of the ENERGY STAR MFNC National Program Guidelines. Any part of the building that is part of the project that meets the eligibility criteria for these programs shall be fully certified under those programs, with the exception of projects in California and outside the USA.

Exceptions:
Projects located in California shall follow the ENERGY STAR Certification program requirements from EPA specific to that California.

Projects located outside of the United States must meet the certification criteria even though actual certification is not required.

Refer to Section 1.4.1 and Non-Eligible Buildings for more information.

EPA ENERGY STAR Multifamily New Construction Program Decision Tree



EPA Indoor airPLUS Eligibility Criteria

Any multifamily buildings with dwelling or sleeping units that is not a two-family dwelling; OR

Mixed-use buildings, where dwelling units and common space exceed 50% of the building square footage

Residential units in ENERGY STAR MFNC certified buildings of any height are eligible to earn the Indoor airPLUS label, including mixed-use buildings, where dwelling units and common space exceed 50% of the building square footage.

Residential-associated common spaces, as defined by the ENERGY STAR MFNC National Program Requirements, must also meet the Indoor airPLUS Construction Specifications to earn the Indoor airPLUS label.

For further clarification, refer to the EPA Indoor airPLUS Policy Record

DOE ZERH Eligibility Criteria

ZERH Single-Family Version 2

Detached single-family homes, Duplexes and Townhouses[39]

For further clarification refer to the DOE ZERH Single-Family Version 2 Specifications.

[39] Defined as a single-family dwelling unit constructed in a group of three or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides.

ZERH Multifamily Version 2

Multifamily buildings with any number of stories, Mixed-use buildings[40] with dwelling or sleeping units with any number of stories and Townhouses.

Exception: Townhouse projects aiming to achieve certification through ZERH Multifamily Version 2 are only allowed to use the ERI path. These projects are not allowed to use the Prescriptive path, ASHRAE 90.1 path, or Title 24 path (California).

Refer to Section 1.5.2.2 for more information.

For further clarification refer to the DOE ZERH Multifamily Version 2 Specifications.

Exceptions:
For projects located in California, the California Single-Family Version 2 program requirements shall be met.

Projects located outside of the United States must meet certification criteria from the National Single-Family Version 2 program, even though actual certification is not required.

Refer to Section 1.4.1 and Non-Eligible Buildings for more information.

Non-Eligible Buildings

Generally, the only cases where a Phius project does not need to earn ENERGY STAR, EPA Indoor airPLUS and DOE ZERH certifications are:

- Non-residential buildings
- Existing buildings
- Projects located outside of the United States

[40] Where the dwelling units, sleeping units, and common space exceed 50% of the building's square footage.

Non-Residential Buildings

Though non-residential buildings (and non-residential spaces within mixed-use buildings) are not eligible for certification to the programs outlined above, the certification checklist criteria for these programs shall be completed "as if" they will be certified.

Existing Buildings

Refer to Section 3

Projects Outside of the US

Though projects outside of the US are not eligible for certification to the programs outlined above, the certification checklist criteria for these programs shall be completed "as if" they will be certified.

1.5.3.2 Demonstration of Compliance with Co-Requisite Program Certification Criteria

For projects where ES MFNC, IAP and DOE ZERH certification are required, the project team shall choose to comply with either the ES MFNC Prescriptive Path, the ASHRAE 90.1 Path, or ERI Path.

The Phius Path

Under the ASHRAE 90.1 path, there is an alternate route for Phius projects where the WUFI Passive energy modeling may be used in lieu of the ASHRAE 90.1 modeling.

Choosing the ASHRAE 90.1 path requires the use of an EPA approved Multifamily Review Organization (MRO).

Process Tip: Many utility and state energy efficiency programs offer incentives for HERS-based performance verification, and thus projects may benefit overall from using the ERI Path.

The appropriate version of the ES MFNC, IAP and ZERH standards shall be based on the permit date of the project. For more information on these programs, please see the following links:

EPA Energy Star Program Requirements
EPA Indoor airPLUS Requirements
DOE ZERH Requirements

Process Tip: Phius encourages, but does not require, certification under the EPA WaterSense New Homes program.

2 - New Construction - Prescriptive Path

2.1 Process

Table 2.1.0 New Construction - Prescriptive Path - Process Matrix		
AIA Project Phase	**Phius Benchmarks**	**Phase Summary**
Pre-Design (PD) / Schematic Design (SD)	**Phase 0** Prescriptive Snapshot	**2.1.1 Prescriptive Snapshot** -A free online tool that can be used to quickly establish technical design limits
	Phase 1 Paperwork	**2.1.2 Inquiry** -Project team requests a quote, invoice, & contract.
	Milestone 1 Project Registered	**2.1.3 Registration** -Invoice paid, contract signed, project number created. -The Project is now publicly visible on Phius' Certified Project Database. -A project Dropbox folder is shared with the project team.
Design Development (DD) / Construction Drawings (CD)	**Phase 2** Design Review	**2.1.4 Design Review** -CPHC document upload. -Phius Review & Feedback. -CPHC Revisions & Response. -Repeat until all comments resolved
Bidding & Procurement	**Milestone 2** Design Certification	**2.1.5 Design Certification** -The design is certified by Phius. An official letter of Design Certification will be sent to the project team.

Table 2.1.0 New Construction - Prescriptive Path - Process Matrix (continued)		
AIA Project Phase	**Phius Benchmarks**	**Phase Summary**
Construction Administration (CA) / Commissioning (Cx)	**Phase 3.1** Construction, Observation & Testing	**2.1.6 Construction, Observation & Testing** -Rater/Verifier performs site visits and communicates all changes to the Submitter/CPHC. -All changes should be recorded in the Phius Prescriptive Checklist.
	Phase 3.2 Final Review	**2.1.6 Final Review** -Rater/Verifier document upload -Phius Review & Feedback -Rater or Verifier Response -Repeat until all comments resolved
Post-Construction (PC)	**Milestone 3** Final Certification	**2.1.7 Final Certification** -The as-built project is certified by Phius -A Phius plaque will be sent to the project owner -A digital certificate will be sent to the project team

2.1.1 Phase 0: Prescriptive Snapshot (Optional)

The Prescriptive Snapshot is a free online tool developed to allow project teams to quickly generate the certification requirements based on project-specific parameters including:

- Project location
- iCFA [ft^2]
- Number of bedrooms
- Number of stories
- Mechanical system type

2.1.2 Phase 1: Paperwork

Refer to Section 1.1.2

> **Exception:** Certification fees for the Prescriptive Path are outlined in Section 2.2

2.1.3 Milestone 1: Project Registered

Refer to Section 1.1.3

2.1.4 Phase 2: Design Review

Refer to Section 1.1.4

> **Exceptions:**
> The Prescriptive Checklist will act as the main form of communication between the Submitter/CPHC and Phius.
>
> Most prescriptive projects undergo 2 rounds of design review but there is no limit to the number of reviews included for design certification.

2.1.5 Milestone 2: Design Certification

Refer to Section 1.1.5

2.1.6 Phase 3: Construction & Final Review

Refer to Section 1.1.6

> **Exception:** The Prescriptive Checklist replaces the WUFI Passive energy model and the Phius Certification Feedback Document.

2.1.7 Milestone 3: Final Certification

Refer to Section 1.1.7

2.1.8 Phius Prescriptive Checklist

The Prescriptive Checklist is the main channel of communication between Phius and the project Submitter/CPHC during design and final review. It is required for submission for all prescriptive projects. The document is used to track project information and any changes that occur during the certification process. The Phius reviewer will comment on the information entered in the Checklist, drawings, and specifications submitted to the project Dropbox.

This document must be uploaded to the Phius provided Dropbox Folder for each round of review. The Submitter/CPHC should be diligent about aligning feedback responses with updates made to the Checklist or project documentation between rounds of review. Read more about how to use this tool for modeling in Section 2.4.

Any external communication via email, phone call, etc. should be noted in the checklist and email threads should be uploaded to the Dropbox in PDF format to the related subfolder.

2.1.9 Review Timeline

Refer to Section 1.1.9

2.2 Fee Schedule

Table 2.2.0 Prescriptive Path Certification Fees	
Single-Family Detached	$1,000
Attached Single-Family & Townhouses	$1,000 per unique dwelling unit $750 per duplicate unit type
Expedited Review	An expedited review may be available for an additional 50% up-front cost in addition to the base fee

2.2.1 Prescriptive Path Certification Fee

Certification fees are a flat rate, based on project type as outlined in the table above.

2.2.2 Expedite Fee

An expedited review may be available for an additional 50% up-front cost on the base fee. See details in Section 1.2.3

2.2.3 Discounts

No discounts are available for the Prescriptive path.

2.2.4 Additional Consulting

Refer to Section 1.2.4

2.2.5 Certification Plaque

Refer to Section 1.2.5

2.2.6 Payment Options

Refer to Section 1.2.6

2.3 Prescriptive Path Requirements

Table 2.3.0 Prescriptive Path: Building Certification Requirements	
Project Type	**Single-Family, Duplexes & Townhouses**
Program Type	**CORE**
Co-requisite Requirements	
Personnel	Refer to Section 1.3.2.1
EPA Indoor airPLUS	Construction Specifications Version 1 (Rev. 04) Refer to Section 1.4.1.1
EPA ENERGY STAR	Single-Family New Homes Version 3.2 Refer to Section 1.4.1.1 & Section 1.5.3
DOE Zero Energy Ready Homes	Single-Family Version 2 Refer to Section 1.4.1.1 & Section 1.5.3
Phius Passive Conservation Requirements	
Airtightness	Whole building blower door test is required to show compliance with limit outlined in Section [C] 2.1
Moisture Risk Mitigation & Comfort	Opaque assembly, detailing and fenestration requirements are outlined in Section [C] 6
Phius Active Conservation Requirements	
Mechanical Ventilation	Balancing, efficiency, defrost, duct insulation, minimum airflow and distribution requirements are outlined in Section [C] 7
Renewable Energy	
On & Off-Site Renewables	Not credited.
Combustion Equipment, Fireplaces and Appliances	
Fossil-Fuel based Equipment & Appliances	Not allowed
Fireplace Insert or Wood Stove (Biomass-burning)	Allowed if vented to the outside, with an airtight stove or fireplace box.

2.3.1 Scope Limitations

Refer to Table 1.3.1. Note the differences below:

2.3.1.1 Project Type

Only new construction single-family, duplex and townhouse projects located within the United States or Canada are eligible for the Prescriptive Path.

2.3.1.2 Program Version

Only CORE projects are eligible for the Prescriptive Path.

2.3.1.3 Renewable Energy

Refer to Section 2.3.5

2.3.1.4 Combustion Equipment, Fireplaces and Appliances

Refer to Section 2.3.6

2.3.2 Co-Requisite Requirements

2.3.2.1 Personnel Required

Refer to Section 1.3.2

2.3.3 Passive Conservation Requirements

2.3.3.1 Airtightness Limits

Refer to Section 1.3.3.2

Exception: The airtightness limit for a Prescriptive path project is 0.04 cfm50/ft^2. For more information, refer to 2 Airtightness.

2.3.3.2 Moisture Risk Mitigation & Comfort Requirements

Please refer to [C] 6 Moisture Risk Limitation and Appendix B for further information.

2.3.4 Active Conservation Requirements

Refer to [C] 7 Mechanical Ventilation for further information.

2.3.5 Renewable Energy

Renewable energy is not credited for Prescriptive path projects.

2.3.6 Combustion Equipment, Fireplaces and Appliances

Fossil-fuel based equipment and appliances are not allowed in Prescriptive path projects.

Biomass-burning fireplace inserts or wood stoves are allowed under two conditions:

- They must be vented to the outside
- The fireplace or stove must be airtight
- Please also refer to Section 1.3.6 for further information.

2.4 Design Guidance

Table 2.4.0 Prescriptive Path: Design Guidance	
Co-Requisite Programs	Refer to this Section 1.4.1.1 for design requirements that stem from the co-requisite programs.
Required Documentation	Refer to this section for all required documentation.
Compliance Tool	Phius CORE Prescriptive 2024 Checklist v24.1.0 (or newer)
Compliance Tool Protocol	Refer to this section for required compliance tool protocol using the checklist noted above.

2.4.1 Co-Requisite Program Requirements

Refer to Section 1.4.1

2.4.2 Required Documentation

Table 2.4.2.0 Required Design Documentation	
Compliance Tool	Phius CORE 2024 Prescriptive Checklist
Drawings	Refer to Table 1.4.2.0
Technical Datasheets	
Calculations & Analyses	Refer to Required Documentation for Submission below
Letter of Intent	Refer to Section 0.4.5 and Section 0.4.6

2.4.2.1 Required Documentation for Submission

Refer to Section 1.4.2.1

Exception: The Phius Prescriptive 2024 Checklist is the Compliance Tool and the Phius 2024 Performance Path Criteria Calculator is not used.

2.4.2.2 Required Documentation for Design Certification

Refer to Section 1.4.2.1

2.4.2.3 Compliance Tool

The Phius CORE Prescriptive 2024 Checklist is required for all Prescriptive path projects. Review Section 2.4.3.2 for more information. Design review is meant to begin before the building design is finalized and well-before construction begins.

2.4.2.4 Drawings

Refer to Section 1.4.2.4

2.4.2.5 Technical Datasheets

Refer to Section 1.4.2.5

2.4.2.6 Calculations & Analyses

Unlike the Performance Path, the Prescriptive Path does not allow for external calculation methods to adapt to new construction techniques, materials, equipment and styles. To certify using the Prescriptive Path, all requirements must be satisfied as per the prescriptive guidelines outlined in the checklist. The Prescriptive Path does not allow for hygrothermal analysis or thermal bridge analysis to resolve non-conforming details and assemblies.

Take-off Documents

Take-offs should be provided in drawn form and supplemented with calculations required to best summarize the data outlined in the drawings or diagrams provided.

Interior Conditioned Floor Area (iCFA)

Refer to Section 1.4.2.6.

Exterior Enclosure Area

Refer to 0.6 Project Specifics, Exterior Enclosure Area and 3 Compactness, [C] 3.1 Building Enclosure Area.

Glazed Fenestration Area

Refer to 4 Solar Protection, [C] 4.2.1 Window-to-Wall (WWR) Area Ratio and [C] 4.2.2 Skylight-to-Roof (SRR) Area Ratio.

Fixed Overhang Dimensions

Applicable to climate zones 0-3. Refer to 4 Solar Protection, [C] 4.4 Fixed Overhangs.

ERV / HRV Supply & Return Duct Dimensions

These dimensions should be taken from the ERV/HRV unit to the exterior of the thermal envelope. Refer to [C] 7 Mechanical Ventilation.

2.4.3 Prescriptive Path Checklist

Information below pertains only to projects pursuing the Prescriptive Path and are not applicable to projects certifying under the Performance Path. The approved compliance tool for the Phius Prescriptive path is Phius CORE Prescriptive 2024 Checklist as noted in Table 2.4.0.

2.4.3.1 Getting Started

Phius has several resources available that may assist project teams before diving into the Prescriptive Checklist.

- Phius CORE Prescriptive Snapshot
- Phius CORE Prescriptive Climate Map
- Phius CORE Prescriptive - Climate Zone Table

Accepted Compliance Tool

For Phius CORE Prescriptive 2024:

Phius CORE Prescriptive 2024 Checklist v24.1.0 (or newer) as per Table 2.4.0

Macro-enabled Microsoft Excel Files

The Prescriptive Path Checklist is a Macros-enabled Microsoft Excel Spreadsheet. Macros are a tool in Excel that allow the spreadsheet to be automated and provide reactive feedback to data inputs. In order to activate the Macros, and run the Prescriptive Checklist correctly, a password must be entered when opening the file. As Microsoft Excel opens, you will be prompted to enter the password: phius2024

Navigating the Prescriptive Checklist

The Prescriptive Checklist is divided into 9 sections which expand and contract using the "+" and "-" icons in the left margin of the document. There is further expansion within each individual section based on the project criteria and compliance paths chosen within the prescriptive path.

A color-coded key at the top of the checklist indicates checklist cells that require input as well as whether the input meets the requirements.

Endnotes

A helpful Macro is enabled that provides the ability to navigate to endnotes using hyperlinks found in the cell to the left of line items. If there is an applicable endnote, a numbered hyperlink will appear next to the checklist requirement. By left-clicking the numbered hyperlink, the document will automatically navigate to the relevant note. Left-clicking the number within the endnote list will navigate back up to the original Checklist item.

Filling out the Prescriptive Checklist

The Prescriptive Checklist, is a shared compliance tool between the Phius CPHC and Phius Certification Review Team. New to the Prescriptive Checklist, there is only a specific location intended for the Phius CPHC to note 'Design Verified' in its respective column and an "NA" column (Not Applicable) for all line items that may not be relevant to the project in focus. In order for Design Certification to be issued, every item in the Prescriptive Checklist must be addressed as either 'Design Verified' or 'NA'. A 'User Notes' column is provided for explanations of certain inputs and other miscellaneous notes from the project team to the Phius review team.

During Design Review, Phius staff will provide comments to the right of the checklist and note the round of review. Each of the 9 sections will either be marked as "Ok for Design Certification" or noting further comments in the section below. There is a 'Submitter Response' Column which should be used for the next round of review to communicate specific information to the Phius review team.

2.4.3.2 Prescriptive Checklist Section-by-Section Input Walk-Through

The numbering of this section aligns with the numbering within the Phius CORE 2024 Prescriptive Checklist, but has a [C] preface to differentiate them from section numbering in the rest of this Guidebook. Only line-items from the checklist that were deemed to require additional explanation are included in this Guidebook.

[C] 0 Project Information

The Project Information Section records the basic project information and sets up required information that is associated with inputs later on in the checklist. It is critical that all information in this section is updated when changes occur as it may impact the compliance of the project in subsequent sections.

[C] 0.3 Climate Information

The prescriptive certification path is limited to projects within the United States and Canada at this time. Foreign projects should instead follow the performance path.

The weather station chosen must meet the following criteria:

- ≤50 linear miles from the project location
- ≤400' difference in elevation from the project location

Projects located outside of these parameters are ineligible for the prescriptive path and should instead follow the performance path.

Please note, the closest weather station may not be in the same state or province as where the project is located. If this is the case, please make a note in the 'User Notes' column.

[C] 0.6 Project Specifics

Interior Conditioned Floor Area (iCFA)

The reference floor area. The occupant density and building compactness requirements are determined by this input. See Section 1.4.2.6 for the definition of iCFA.

Exterior Enclosure Area

The reference exterior enclosure area. This value helps to determine the window-to-wall ratio allowed. Note that the exterior enclosure area is similar to the envelope area found in Section 1.4.3. However, for infill row-house projects, wall area that is in contact with conditioned buildings should be excluded from this calculation.

Number of Stories

The total number of stories (above and below grade) should be input here. This value impacts the duct length limit allowed for the project.

Number of Bedrooms

The total number of bedrooms should be input here, see Section 1.4.3 for more information. Please note that it is best practice to count spaces that may be referred to as 'Future Bedroom' and certify the project as it would be in its most final stage.

South Facade Azimuth

The south facade azimuth helps to confirm the orientation of the project which can impact values within '4 Solar Protection' of the Prescriptive Checklist.

[C] 1 General

Outline of scope limitations and co-requisite program requirements that the CPHC and Rater are required to understand.

[C] 1.1 Scope

[C] 1.1.1

The prescriptive certification path is limited to single-family detached and single-family attached buildings that are vertically partitioned (i.e. stacked units are not eligible).

[C] 1.1.2

A maximum limit of 900 ft^2 interior conditioned floor area (iCFA) per bedroom is enforced.

> **Process Tip:** This requirement limits sprawling floor plans and encourages higher occupant density of the building which is an important consideration for passive buildings.

[C] 1.2 Co-Requisites

These US building certification programs include important quality assurance and quality control requirements. See Section 1.4.1 and Section 1.5.3 for more information on co-requisite requirements.

[C] 2 Airtightness

[C] 2.1 Measured building airtightness q50 ≤ 0.04 cfm/ft^2 enclosure area.

The above metric is the minimum airtightness threshold to achieve certification through the Phius prescriptive path. This is the maximum value that must be achieved during the final blower door test.

> **Process Tip:** The airtightness threshold for prescriptive path projects is intentionally more stringent than performance path projects.

[C] 3 Compactness

Appendix N-11.1 outlines the logic behind the compactness requirement.

[C] 3.1 Building Enclosure Area

The building enclosure area must be verified by providing takeoff drawings that calculate the sum of enclosure area for each individual elevation, roof face and ground interface.

[C] 4 Solar Protection

The solar protection section is largely dependent on the climate zone in which the project is located. This section accounts for overhangs, solar heat gain coefficients and overall fenestration area and orientation.

[C] 4.1 Glazed Fenestration Solar Heat Gain Coefficient (SHGC)

This section establishes the maximum SHGC threshold value for all of the glazing in the project to prevent potential overheating in warmer climates.

Process Tip: The required value is the NFRC value, or whole-window SHGC, not the center of glass value as used in the performance path.

[C] 4.2 Glazed Fenestration Area

This section looks at the window-to-wall ratio per elevation as well as skylight-to-roof ratio.

[C] 4.2.1 Window-to-Wall (WWR) Area Ratio

Enter the total window area and gross above-grade wall area per elevation. The total calculated window-to-wall ratio is derived from these values and must be less than or equal to 18%.

[C] 4.2.2 Skylight-to-Roof (SRR) Area Ratio

Enter the total skylight area and gross roof area of the entire building. The total calculated skylight-to-roof ratio is derived from these values and must be less than or equal to 3%.

[C] 4.3 Fenestration Orientation - Adequate Exposure Diversity (AED)

Appendix N-11.2.1.1 outlines the logic behind the AED requirement.

Exception: (Endnote 11) This requirement does not apply to attached housing, such as side-by-side duplexes, rowhouses or townhouses.

[C] 4.4 Fixed Overhangs

The prescriptive path requires fixed overhang shading devices for south-facing glazing in certain climate zones. This section generates the projection factor that defines the depth of overhang based on window height and by climate.

[C] 4.4.1 Projection Factor

If a projection factor is required (PF), it will be listed as a threshold value. This applies to glazing located in all bedrooms and living spaces (not circulation areas) that are equator-facing within 45 degrees azimuth. Additional limits are in place for climate zones 4-8 when no cooling system is planned. The projection factor is the horizontal depth of the overhang out from the glazing surface divided by the height from the sill to the bottom of the overhang.

[C] 4.5 Net Gain Score

Appendix N-11.2.1.2 outlines the logic behind the net gain requirement.

Exception: (Endnote 11) This requirement does not apply to attached housing, such as side-by-side duplexes, rowhouses or townhouses.

[C] 5 Thermal Enclosure

This section verifies compliance with the climate-specific assessment criteria for all project assemblies. Two pathways are available to demonstrate compliance. Section 5.1.1 or Section 5.1.2.

[C] 5.1.1 Individual Component Compliance

The compliance path requires individual opaque (walls, roofs, floors, opaque doors) and transparent (windows, skylights, doors) portions of the building envelope meet the minimum prescriptive threshold on a component-by-component basis.

[C] 5.1.1.1 User-defined Materials

Default material R-values are built into the checklist and may be used through Final Certification. It may be beneficial to model project specific materials. Product datasheets are required to verify the performance of user-defined materials. The R-value per inch should be taken at 75F. Once the material is listed in this section, it will become a selection option for opaque assemblies in Section [C] 5.1.1b, [C] 5.1.1c, [C] 5.1.1d and [C] 5.1.1e below.

[C] 5.1.1a Fenestration U-values

This section defines a maximum U-value for all windows in the project. The U-value requirement applies to the whole-window or whole-door value and performance data is required for each type of fenestration in the building to demonstrate compliance.

> **Process Tip:** U-value is the inverse of the R-value. A maximum U-value limit is equivalent to a minimum performance requirement.

[C] 5.1.1b Above-grade walls and cantilevered floors

For each unique above-grade wall and cantilevered floor type, enter the details of the individual assembly layers to verify compliance.

> **Process Tip:** Input cells are either dark or light teal, none of the calculated or auto-populated cells should be overridden.

Step 1: Choose Wall Assembly Type

Use the dropdown menu to select the wall or overhang floor type that aligns with the project specific assemblies proposed. There are six predefined wall types and three predefined overhang floor types programmed into the checklist. A short description of each will populate after the associated assembly type is selected from the dropdown menu. For more information on the assembly types, review Appendix B.

Review the 'Material Layer' column for the pre-populated outline of generic material layers that are associated with each predefined assembly type. If the project specific assembly proposed does not align with any of the pre-defined assembly types listed, 'user defined' options are available.

Step 2: Fill in Assembly Materials, Thicknesses and Framing

Select the material appropriate to each layer from the dropdown selection tool. If a user-defined material has been created in Section 5.1.1.1, it will appear here. Enter the thickness of the material and use the dropdown selection tool to de-rate the layer for framing (if applicable).

Step 3: Review Hygrothermal & Moisture Guidelines

This section verifies the compliance of the wall assembly against climate-specific and assembly-specific guidelines. It lists individual requirements for each assembly type and calculates the specific calculated ratio of the input assembly.

Step 4: Review Effective R-Value

This section shows the calculated effective R-value of the assembly and is used to demonstrate compliance with the minimum performance requirements.

[C] 5.1.1c Roof or Ceiling

For each unique roof or ceiling type, enter the details of the individual assembly layers to verify compliance. Then, follow the steps listed above in 5.1.1b.

[C] 5.1.1d Below-grade walls

For each unique below-grade wall type, enter the details of the individual assembly layers to verify compliance. Then, follow the steps listed above in 5.1.1b.

[C] 5.1.1e Unconditioned Basement/Crawl Space Ceiling
For each unique unconditioned basement/crawl space type, enter the details of the individual assembly layers to verify compliance. Then, follow the steps listed above in 5.1.1b.

[C] 5.1.2 Total UA Alternative
The UA path may be used when individual assemblies or fenestration cannot meet the prescriptive requirements outlined in Section 5.1.1.

[C] 5.1.2a Whole Building UA Calculation
A U-value times Area calculation is performed for the assemblies proposed for the project and the result must be less-than-or-equal-to the Prescriptive U-values outlined in Section 5.1.1 times Area.

[C] 6 Moisture Risk Limitation
[C] 6.2 Fenestration
This section applies to all windows, doors, skylights, sidelite, storefront and curtainwall systems.

[C] 6.2.1 Minimum Condensation Resistance
Six paths are available to demonstrate compliance with the condensation requirements for fenestration. A minimum of one must be chosen, but multiple paths may be used depending on the data available for different types of fenestration used in the project.

[C] 6.2.1.1 General Frame Type U-Value

In this simplified option, select the frame type and demonstrate compliance with manufacturer documentation or shop-drawings that indicate the frame make-up.

[C] 6.2.1.2 U-frame Inferred by Window U-value and Center of Glass U-value

If the U-frame value is not available, it can be inferred using the Whole window U-value and the U-Cog (Center of glass). For this entry to work, entries must be completed for all unique single lite and 2-lite window types. Enter corresponding NFRC values in the teal cells and select the operation type of the window to determine compliance. All windows must comply to use this as an acceptable compliance path.

[C] 6.2.1.3 AAMA 1503 Condensation Resistance Factor (CRF)

If a CRF value is available, it may be entered here to show compliance.

[C] 6.2.1.4 NFRC 500-2020 Condensation Resistance

If a Condensation Resistance value is available, it may be entered here to show compliance.

[C] 6.2.1.5 CAN/CSA A440.2 Temperature Index

If a temperature Index value is available, it may be entered here to show compliance.

[C] 6.2.1.6 fRSI Method

If a fRSI value is available, it may be entered here to show compliance. This is available for all Passivhaus Institut (PHI) Certified components (Endnote 32).

[C] 7 Mechanical Ventilation
The mechanical ventilation section ensures balanced ventilation and the efficiency of the ventilation equipment.

[C] 7.1.1 Ventilation is balanced
Review Section 1.3.4.2 Balanced Ventilation for more information.

[C] 7.2 Mechanical Ventilation Efficiency

[C] 7.2.1 Sensible Recovery Efficiency

The prescriptive checklist generates a minimum sensible recovery efficiency (SRE) value based on the selected climate.

> **Process Tip:** Review the Endnotes in this section of the checklist carefully for accepted documentation.

[C] 7.2.2 Total Recovery Efficiency

The prescriptive checklist will generate a minimum total recovery efficiency (TRE) or humidity recovery efficiency (HRE) value based on the selected climate. An ERV is not required in all climates and 'NR' will show up in the threshold column.

[C] 7.2.3 Electrical Efficiency meets the criteria below:

A 0.83 W/cfm limit is set on the maximum W/cfm of the ventilation system. For ventilators that cannot meet this requirement, the performance path outlined in Section [C] 9.1.2 is available.

[C] 8 Mechanical Systems

The mechanical systems section covers heating/cooling equipment requirements and thresholds; Energy Star requirements about ventilation fans and humidifiers; and confirms no heating equipment or heated spaces outside of the thermal envelope.

[C] 8.2 Minimum required heating/cooling equipment efficiency is met based on climate zone and system type as calculated.

The prescriptive requirements for the mechanical equipment are noted below:

[C] 8.2.1 Cooling System Planned?

1. Select if a cooling system is planned
    a. Use the dropdown selection to select 'yes' or 'no'.
2. Choose the cooling system type
    a. Use the dropdown selection to select 'air source heat pump' or 'ground source heat pump'.
3. Ensure minimum threshold requirements are met
    a. Minimum threshold requirements will be displayed toward the right depending on the inputs selected in Steps 1 and 2.

[C] 9 Lighting, Appliances & Water Heating

The lighting, appliances, and water heating section offers two compliance paths to limit the overall energy use of these non-space conditioning related devices and appliances.

[C] 9.1 Builder-installed lighting, appliances, & water heating comply with 9.1.1 or 9.1.2.

Use the dropdown selection to choose a compliance path: 9.1.1 Component Compliance or 9.1.2 Performance Tradeoff.

[C] 9.1.1 Component Compliance

This path outlines the minimum efficiencies of appliances, lighting and domestic hot water systems that must be met to follow this path. All line items are required to be met to use this path.

[C] 9.1.2 Performance Tradeoff Calculation

This path acts as an alternate to the component compliance path and should be used if any individual light fixture, appliance or domestic hot water system does not comply with the component level minimum requirements.

> **Process Tip:** Each section outlined below must be filled out for the trade-off path to be used and demonstrate that the project complies.

[C] 9.1.2.1 Lighting

Fixture cut sheets and reflected ceiling plans depicting fixture type and quantity are required to verify inputs in this table.

[C] 9.1.2.2 Outdoor Air Ventilation System Electric Efficiency

A total annual energy consumption calculation is run based on the maximum of either the ASHRAE 62.2 2022 or IMC 2021 airflow rate calculated for the project and the rated efficiency of the ventilator planned.

[C] 9.1.2.3 Appliances

Appliance cut sheets are required to confirm the inputs in this table.

[C] 9.1.2.4 Water Heating

DHW system performance datasheet is required to confirm the inputs for this calculator.

Process Tip: For Heat Pump Water Heaters that have the storage tank and compressor as a combined unit located within the thermal envelope, data on the heat pump used for space conditioning is required to calculate a derated efficiency of the system as a whole.

2.5 On-Site Review

Table 2.5.0 Prescriptive Path: QA/QC Guidance	
Required Documentation	Refer to Section 1.5.1 for the documentation needed for the Final Certification Process to begin.
QA/QC Requirements	Refer to Section 1.5.2 for guidance on the Phius Quality Assurance Workbook.
Co-Requisite Programs	Refer to Section 1.5.3 for more information about specific program versions.

2.5.1 Required Documentation

Refer to the Single-Family, Duplex and Townhouse portions of Section 1.5.1

2.5.2 QA/QC Protocol

Refer to the Single-Family, Duplex and Townhouse portions of Section 1.5.2

Exceptions:

Compliance Tool:

The compliance tool will be the Phius Prescriptive Checklist. For more information on who should make as-built changes to this checklist, refer to Section 2.1.6.

Preliminary Blower Door Test:

The optional, but encouraged preliminary blower door test is required for prescriptive path projects and should be included in the scope of work of the Rater or Verifier.

2.5.2 Co-requisite Programs

Refer to the Single-Family, Duplex and Townhouse portions of Section 1.5.3

3 - Retrofit - REVIVE 2024

3.1 Process

Table 3.1.0 Phius REVIVE 2024 Process Matrix

AIA Project Phases	Phius Benchmarks	Phase Summary
Pre-Design (PD)	**Phase 0** Programming	**3.1.1 Rationale for Retrofit** -A free online tool used to conduct a preliminary assessment for retrofit buildings **Multi-Facility Planning** -Project team creates initial Program Plan and establishes general scope of work to be completed
	Phase 1 Paperwork	**3.1.2 Inquiry** -Project team requests a contract.
	Milestone 1 Project Registered	**3.1.3 Registration** -Invoice paid, contract signed, project number created. -The project is now publicly visible on Phius' Certified Project Database. -A project Dropbox folder is shared by Phius with the project team.
Schematic Design (SD)	**Phase 2** Assessment, Investigation & Review	**3.1.4 Assessment & Investigation** -Commissioning Provider (CxP) conducts existing building assessment and investigation, including creating and running the performance model **3.1.4 Assessment & Investigation Review** -CxP submits Assessment & Investigation deliverables to Phius -Phius Review & Feedback -CxP Revisions & Response -Repeat (as needed)
	Milestone 2 Assessment & Investigation Approval	**3.1.5 Assessment & Investigation Approval** -Phius approves the Assessment & Investigation deliverables. An official letter of approval is sent to the design team.

Table 3.1.0 Phius REVIVE 2024 Process Matrix (continued)		
AIA Project Phases	**Phius Benchmarks**	**Phase Summary**
Design Development (DD) / Construction Drawings (CD)	**Phase 3** Design & Review	**3.1.6 Design** -Selection of design approach based on performance modeling completed during the investigation phase **3.1.6 Design Review** -CxP document upload -Phius Review & Feedback -CxP Revisions & Response -Repeat (as needed)
Bidding & Procurement	**Milestone 3** Design Certification	**3.1.7 Design Certification** -The design is certified by Phius. An official letter of design certification will be sent to the design team
Construction Administration (CA) / Commissioning (Cx)	**Phase 4.1** Implementation, Observation & Testing	**3.1.8 Onsite Review** -Rater/Verifier performs site visits and communicates all changes to the Submitter/CxP -All changes should be recorded in the Phius REVIVE Workbook **Multi-Phase Projects** -When all phases are complete, the project will be eligible to submit documentation for final certification
Post-Construction (PC)	**Phase 4.2** Final Review	**3.1.8 Final Review** -Rater/Verifier Provider document upload -Phius Review & Feedback -Rater/Verifier Provider Response -Repeat (as needed)
	Milestone 4 Final Certification	**3.1.9 Final Certification** -The as-built project is Final Certified by Phius when all project phases are complete. A digital certificate and physical plaque will be sent to the project team. -Building resumes typical or new intended operation

Table 3.1.0 Phius REVIVE 2024 Process Matrix (continued)		
AIA Project Phases	**Phius Benchmarks**	**Phase Summary**
On-going Commissioning (OCx)	**Phase 5.1** Monitoring	**3.1.10 Monitoring** -Non-residential projects are required to register with and allow Phius access to the Energy Star Portfolio Manager
	Phase 5.2 Ongoing Commissioning (Optional)	**3.1.10 Ongoing Commissioning (OCx) & Monitoring Electives** -Additional monitoring and commissioning electives are encouraged for all projects, but not required

3.1.1 Phase 0: Programming (Recommended)

All retrofit projects should begin by considering if retrofitting is the right choice. In the case of multiple facilities, it should also be determined in which order they should be retrofitted. The following section summarizes the methods for making the initial determination to begin a retrofit project, and the suggested information to collect before choosing to register a project. See Section 4.5 of the Phius REVIVE 2024 Standard for more detailed information and guidance on the programming phase.

3.1.1.1 Rationale to Retrofit

The Rationale for Retrofit tool is built-in to the Phius REVIVE 2024 Assessment & Investigation Workbook and should be used to quickly establish the rationale to retrofit, or not to retrofit, an existing building based on the following parameters:

- Intended building life
- Existing vs Intended building functionality
- Climate migration risk[41] (county specific)

Process Tip: This assessment must be done during Phase 2: Assessment, Investigation, & Review, so it is a highly recommended step to complete before committing to certification. Review Section 4.5.1 of the Phius REVIVE 2024 Standard document for more detailed information on making this determination, and alternate pathways for buildings that may not be appropriate to retrofit.

[41] Shaw, Al, Abrahm Lustgarten, and Jeremy W Goldsmith. "New Climate Maps Show a Transformed United States." ProPublica, September 15, 2020.

3.1.1.2 Multiple-Facility Planning (optional)

Review Section 4.5.2 of the Phius REVIVE 2024 Standard document for more detailed information on developing the program plan. The following list summarizes the deliverables (for multi-facility projects only):

- (Std Sec 4.5.3.1) Program Plan Deliverables
    - Facility identification
    - Ranking metrics
    - Prioritized list of facilities
    - Phase plan / Execution schedule
    - Program planning team

3.1.2 Phase 1: Paperwork

Refer to Section 1.1.2

3.1.3 Milestone 1: Project Registered

Refer to Section 1.1.3

3.1.4 Phase 2: Assessment, Investigation & Review

3.1.4.1 Assessment & Investigation

Complete the Phius REVIVE 2024 Assessment & Investigation Workbook and compile all required documentation for Phase 2. Review Sections 8.6 and 8.7 of the Phius REVIVE 2024 Standard document for detailed requirements and additional recommendations.

3.1.4.2 Phius Review

1. The Submitter and/or CxP must upload project documentation into the Phius Project Dropbox folder.
2. The Submitter and/or CxP must submit the project into the Phius Certification Review Queue. The queue indicates when the project team can expect Phius to complete the current round of review.Review this blog post for a breakdown of important queue dates and timelines.

Process tip: Submissions can be made in one of two ways:
1. The Submitter and/or CPHC can log into the Phius Portal.
2. Any team member may navigate to the Phius Certification Review Queue and submit via the link at the top.

3. A Phius Building Certification staff member will review and provide comments directly in the Phius REVIVE 2024 Assessment & Investigation Workbook. Comments will focus on items that must be addressed in order to reach Milestone 2: Assessment & Investigation Approval.
4. The Submitter and/or CxP will be notified via email when Phius' review has been completed. The project will be removed from the Phius Project Certification Review Queue.
5. The Submitter and/or CxP must reply to comments made by the Reviewer and may need to provide new or updated documentation.
6. The Submitter and/or CxP must then repeat the process by re-submitting to the Project Certification Review Queue as described in Step 2.
7. When no remaining items need to be addressed for Assessment & Investigation Approval, the project moves to Phase 3: Design Review.

3.1.5 Milestone 2: Assessment & Investigation Approval

The CxP will receive a notice of 'Approval to Proceed' via email once all Phase 2 deliverables are reviewed and approved by Phius. Review Section 8.7.10 of the Phius REVIVE 2024 Standard document for more detailed information.

3.1.6 Phase 3: Design Review

3.1.6.1 Design

Complete the Phius REVIVE 2024 Design Workbook and compile all required documentation for Phase 3. Review Section 8.8 of the Phius REVIVE 2024 Standard document for detailed requirements and additional recommendations.

NOTE: The Phius REVIVE 2024 Design Workbook is still in development at this time. Check back regularly for when this document is released and available for use.

3.1.6.2 Phius Review

Refer to Section 1.1.4

Exception: The Phius REVIVE 2024 Design Workbook will act as the main form of communication between the Submitter/CxP and Phius.

3.1.7 Milestone 3: Design Certification

Refer to Section 1.1.5

3.1.8 Phase 4: Implementation, Observation & Testing

To improve the efficiency of the final review process, the Phius Rater or Verifier should work closely with the Submitter and/or CxP.

- During construction, across various site visits, the Phius Rater or Verifier must complete all of the on-site inspections and tests. Refer to Section 3.6 for more information.
- Once the on-site inspections and tests are complete, the Phius Rater or Verifier must communicate all as-built envelope changes to the Submitter and/or CxP.
- The Submitter and/or CxP must re-run the REVIVEcalc tool to match any known as-built changes per the Phius Rater or Verifier from Design Certification before submitting for final review.

NOTE: The Phius REVIVE 2024 Implementation Workbook & Documentation Requirements are still in development at this time. Check back regularly for when this document is released and available for use.

3.1.9 Milestone 4: Final Certification

Refer to Section 1.1.7

3.1.10 Phase 5: Monitoring & Ongoing Commissioning

The project is officially handed-off to the Owner by the Cx Team. The Cx team should deliver and review the OCx Plan, as well as the Systems manual, and provide training for operations and maintenance personnel. Review Section 8.11 of the Phius REVIVE 2024 Standard document for more detailed information on process requirements and recommendations.

3.1.11 The Phius REVIVE 2024 Workbooks

The Phius REVIVE 2024 Workbooks will act as the main channel of communication between Phius and the project Submitter/CxP during the certification process. It is required for submission for all REVIVE projects. The document is used to track project information and any changes or discoveries that occur during the certification process. The Phius reviewer will comment on the information entered in the Workbook, drawings, and specifications submitted to the project Dropbox. This document must be uploaded to your project's designated Dropbox Folder for each round of review. The Submitter/CxP should be diligent about aligning feedback responses with updates made to the Workbook or project documentation between rounds of review.

Any external communication via email, phone call, etc. should be noted in the Workbook so the project reviewer is aware. Email threads should be uploaded to the Dropbox in PDF format in the related subfolder.

3.1.12 Review Timeline

Refer to Section 1.1.9

3.2 Fee Schedule

Refer to Section 1.2

3.3 Requirements

Table 3.3.0 Phius REVIVE 2024: Building Certification Requirements by Project Type			
Project Type	**Single-Family, Duplexes & Townhouses**	**Multifamily**	**Non-Residential**
Co-requisite Requirements			
Personnel	Phius Certified Rater or Verifier with Multifamily Designation	Phius Certified Verifier with Multifamily Designation	Phius Certified Verifier
EPA Energy Savings Plus Health	Publication No. EPA 402K21001	Publication No. EPA 402K21002	
Energy Star Portfolio Manager	Monitoring recommend, but not required		Monitoring required per Section 3.3.2.3
Hazard Mitigation[42]			
Earthquake	Refer to Section 3.3.3		
Flood / Tsunami			
Hail, Snow Loads & Ice Dams			
Structural / High Wind			
Wildfire			
Phius Passive Conservation Requirements			
Seasonal Resilience	Winter and Summer requirements outlined in Section 3.3.4.3		
Airtightness	Blower door testing is required to show compliance with limits outlines in Section 3.3.4.2		
Moisture Risk Mitigation & Comfort[43]	Opaque assembly, detailing and fenestration requirements are outlined in Section 1.3.3.3		
Phius Active Conservation Requirements			
Life Cycle Cost Limit	The ADORB cost for all projects must not exceed that of a baseline case. See Section 3.3.4.4		

[42] Where geographically relevant.
[43] Per Section 5.1.1 of the Phius 2024 REVIVE Standard Document projects may use ASHRAE Standard 227P Section 7.5: "Moisture Control" as an alternative compliance path to satisfy moisture risk mitigation & comfort requirements.

Table 3.3.1 Phius REVIVE 2024: Building Certification Requirements by Program Version		
Project Type	**Single-Family, Duplexes, Townhouses, Multifamily & Non-Residential**	
Program Version	**CORE**	**ZERO**
Renewable Energy		
On-Site Renewables	**Credited & PV Readiness Required.**	**Credited & Required.**[44]
Off-Site Renewables	**Not credited.**	**Credited with utilization factors applied as outlined in Appendix N-4.**
Battery Storage	**Battery readiness required.**	**Required.**[45]
Combustion Equipment, Appliances & Fireplaces		
Space Heating (natural gas furnace, boiler etc...)	**Not Allowed**[46]	**Not Allowed**
Domestic Hot Water (natural gas water heaters)		
Other Fossil-Fuel based Equipment		
Appliances (natural gas cooking, natural gas dryer etc...)		
Fireplace (Natural Gas, Open / Unvented / Ethanol)		
Fireplace Insert or Wood Stove (Biomass-burning)	Allowed if vented to the outside, with an airtight stove or fireplace box.	

[44] **Exceptions:** Not required for projects choosing to satisfy the Seasonal Resilience requirements via an electrical microgrid or thermal energy network **AND** subscribing to community solar to satisfy the Operational Decarbonization requirements.

[45] **Exceptions:** Alternative non-fuel-based and electrically-interacting energy storage is also permitted, such as electrochemical or gravity batteries, flywheels, compressed air, pumped hydroelectric, etc.

[46] **Exceptions:** On-site stored combustion fuel is permitted for emergency backup electricity generation and/or outdoor cooking only.

3.3.2 Co-requisite Requirements

All electives listed in the Phius REVIVE 2024 Standard document are entirely up to the discretion of the project team to pursue, but are outside of the scope of Phius Certification.

3.3.2.1 Personnel Required

Refer to Section 1.3.2.1.

3.3.2.2 EPA Energy Savings Plus Health Guidelines

All project teams must complete, at a minimum, the following in regards to the EPA Energy Savings Plus Health guidelines:

- Perform all Assessment Protocol items
- Complete all applicable Minimum Actions

3.3.2.3 Energy Star Portfolio Manager

Refer to Section 3.1.10.1 above.

3.3.2.4 EPA Indoor airPLUS

Additions and expansions are required to comply with the requirements outlined in Construction Specifications Version 1 (rev. 04).

3.3.2.5 EPA ENERGY STAR

Additions and expansions are required to comply with the requirements outlined below although certification under Energy Star is not required.

Single-family, duplexes and townhouses:

Single-Family New Homes Version 3.2. Refer to Section 1.4.1.1 & Section 1.5.3.1

Multifamily & Non-residential:

Multifamily New Construction (MFNC) Version 1.2. Refer to Section 1.4.1.2 & Section 1.5.3.1

3.3.3 Hazard Mitigation

Refer to Section 5.2 of the Phius REVIVE 2024 Standard for detailed requirements and available electives where geographically applicable.

All electives listed in the standard document are entirely up to the discretion of the project team to pursue, but are outside of the scope of Phius Certification.

3.3.3.1 Earthquake

Earthquake mitigation requirements apply only to projects that fall under Seismic Design Categories (SDC) C-E.

- Within scope of FEMA P-50
    - Seismic Performance Grade B-minus or higher
- Outside of scope of FEMA P-50
    - Projects must have licensed engineer or architect experience in structural engineering

3.3.3.2 Flood

Flood mitigation requirements apply only to projects that fall under FEMA Zones: V, A, B, D, X.

- IBHS FORTIFIED Commercial (Sec 3.2.4 & 3.2.5)

3.3.3.3 Hail

All PV modules must meet one of the following:

- Flexible PV Modules
    - FM Approval Standard 4476 (Severe Hail rating)
- Rigid PV Modules
    - FM Approval Standard 4478 (Class 4 rating) or UL 1703
- All Modules
    - FM Approval for hail

3.3.3.4 Structural & High Wind

Applies to single family, duplexes, and townhomes on a dry stack foundation and/or when the Ultimate design wind speed (Vult) is ≥115.0.

Dry Stack:

- Professional engineering plan required; signoff on compliance with HUD Permanent Foundation Guide

Vult ≥115.0.

- IBHS FORTIFIED Roof (Hurricane designation) OR
- FEMA P-804 Sec. 4.1

3.3.3.5 Snow Load and Ice Dams

Only required if a history of ice dams is known. All projects recommended to review the resource below.

- De-Icing Ice Dams (Lstiburek, 2018)

3.3.3.6 Wildfire

Applies to all projects with FEMA Risk: Relatively Moderate, Relatively High, or Very High.

- Berkeley Fire Dept Checklist

3.3.4 Performance Requirements

Refer to Section 6 of the Phius REVIVE 2024 Standard for detailed requirements.

3.3.4.1 Simulation Requirements

Refer to Section 6.1 of the Phius REVIVE 2024 Standard for detailed requirements.

All Phius projects must use the Phius REVIVEcalc for certification purposes. See Section 3.4.3 for more information about the tool.

3.3.4.2 General Resilience

Enclosure Air-Sealing

Refer to Section 6.2.1 of the Phius REVIVE 2024 Standard for detailed requirements. In general, projects must meet the following thresholds for airtightness:

- Residential: 0.28 cfm50/ft^2 (env.)
- Non-Residential: 0.4 cfm75/ft^2 (env.)

3.3.4.3 Seasonal Resilience

Winter Resilience

Refer to Section 6.3 of the Phius REVIVE 2024 Standard for detailed requirements.

There are two tiers of winter resilience that may be achieved, which align with the Phius certification paths as indicated below:

Phius ZERO REVIVE 2024

6.3.1.1 Tier A Winter Resilience - Decarbonized:

- On-site renewables must be capable of covering all winter-critical electrical and process loads

Exception: Non-residential projects may also cover winter-critical electrical and process loads via an electrical microgrid having primary energy sources that are renewable and combustion-free.

Phius CORE REVIVE 2024

6.3.1.2 Tier B Winter Resilience:

- Winter-critical electrical and process loads must be covered by any type of on-site backup power generation

Additional relevant chapters for reference to meet the winter resilience requirements are indicated below:

- 6.3.2 Winter Thermal Resilience Criteria
- 6.3.3 Winter Resilience Evaluation Protocol

Summer Resilience

Refer to Section 6.4 of the Phius REVIVE 2024 Standard for detailed requirements.

There are two Tiers of summer resilience that may be achieved, which align with the Phius certification paths as indicated below:

Phius ZERO REVIVE 2024

6.4.1.1 Tier A Summer Resilience Decarbonized:

- Onsite renewables must be capable of covering all summer-critical electrical and process loads

Exception: Non-residential projects may also cover summer-critical electrical and process loads via an electrical microgrid having primary energy sources that are renewable and combustion-free.

Phius CORE REVIVE 2024

6.4.1.2 Tier B Summer Resilience

- Summer-critical electrical and process loads must be covered by any type of on-site backup power generation

Additional relevant chapters for reference to meet the summer resilience requirements are indicated below:

- 6.4.2 Summer Thermal Resilience Criteria
- 6.4.3 Summer Resilience Evaluation Protocol

3.3.4.4 Life Cycle Cost & Impact Control

Refer to Section 6.5 of the Phius REVIVE 2024 Standard for detailed requirements and available electives.

Life Cycle Cost Limit

Per Section 6.5.1 of the Phius REVIVE 2024 Standard, the total ADORB cost of the proposed retrofit must be less than that of the baseline case (which assumes the building is operated and maintained as-is).

Exception: In the scenario where a project includes changes to any of the following:

- Number of dwelling units
- Design occupancy
- iCFA

The specific (per dwelling unit, occupant, or square footage of iCFA) ADORB cost of the proposed retrofit must be less than that of the baseline case.

Additional Decarbonization Effort

Per Section 6.5.2 of the Phius REVIVE 2024 Standard, additional decarbonization strategies must be employed as described below.

Operational Decarbonization

Refer to Section 6.5.2.1 of the Phius REVIVE 2024 Standard for detailed requirements and available electives.

Phius ZERO REVIVE 2024:

Tier A, Option 1:

- Project must be fully electrified by the final phase AND Comply with the requirements for Phius ZERO as outlined in Appendix N-4.
- Battery-readiness is required

Tier A, Option 2:

- Subscribe to a community solar project at a level of commitment that would cover 100% of the building's expected annual electrical energy consumption in its post-retrofit condition for each phase

Phius CORE REVIVE 2024:

Tier B

- Project must be fully electrified by the final retrofit phase
- PV and battery-readiness are required

Exception: Combustion fuel is permitted only for emergency backup generation and/or outdoor cooking

Embodied Decarbonization

Refer to Section 6.5.2.2 of the Phius REVIVE 2024 Standard for detailed requirements and available electives. All projects must include at least one Level 2 embodied carbon measure (material substitution, business practice change, or personal choice change).

3.3.5 Monitoring Requirements

Residential

Monitoring is recommended, but not required.

Non-Residential

Monitoring is required for projects applicable under the Energy Star Portfolio Manager. Review Section 7.1.2 of the Phius REVIVE 2024 Standard document.

3.3.6 Ongoing Commissioning (OCx) & Monitoring Electives (Optional)

Several monitoring electives are also available for categories including indoor environment, energy end-use, water quality, waste, and materials. Review Section 7.2 of the Phius REVIVE 2024 Standard document for more detailed information.

Although these electives are not required for certification, monitoring and tracking data is highly encouraged in order to assist in future development of the standard. As more scenarios, project types and solutions pass through the certification process, Phius pays it forward to future project teams through building the public Certified Project Database and ongoing updates to this Guidebook. To take it a step further, tracking and reporting performance metrics allows Phius to fine-tune its standards through data-driven adjustments, provide an extra layer of quality assurance to building owners, and confirm the validity of building performance modeling.

3.4 Assessment and Investigation

Table 3.4.0 Required Documentation for Phius REVIVE 2024: Phase 2 - Assessment & Investigation	
Required Documentation	Refer to this Section for all required documentation
Modeling Software	Accepted: Phius 2024 REVIVEcalc
Modeling Protocol	Refer to this section for a walkthrough of the Phius 2024 REVIVEcalc tool

3.4.1 Required Documentation

Every retrofit project must first begin with assessment and investigation of the existing conditions. Table 3.4.1.0 outlines the specific documentation requirements for certification compliance. All of the deliverables listed should be fulfilled by using the Phius REVIVE 2024 Assessment & Investigation Workbook. Review the expanded sections below for detailed guidance on using and completing the A&I Workbook.

Table 3.4.1.0 Required Documentation for Phius REVIVE 2024: Phase 2 - Assessment & Investigation			
		Compliance Tool	**Phius 2024 REVIVEcalc Results & Supporting Documentation**
		Additional Documentation[47]	DOE Multifamily Building Efficiency Screening Tool (MBEST) Workbook
Phius REVIVE 2024 Assessment & Investigation Workbook		**Issues & Resolutions Log**	Feedback channel between Cx team members
		Updated Program Plan	Completed for each individual building
		Rationale for Retrofit	Must be conducted for every building
		Site Hazard Mitigation Worksheet	Automatically generates project-specific requirements based on hazard zones
		Owner Worksheet	Basic facility information, documentation, & occupant survey
	Process Tip: Begin development of the CFR Document.		
	Existing Buildings Commissioning (Cx) Plan - Part 1	**Assessment Planning**	IAQ Assessment site visit plan
		Investigation Planning	IAQ Investigation site visit plan
	Existing Buildings Commissioning (Cx) Report - Part 1	**Current Facility Requirements (CFR[48])**	Regulatory, financial, & functional requirements
			On-going commissioning (OCx)
			Facility Summary
		Additional Reports	IAQ Assessment & Investigation Reports
			Initial Performance Modeling Report
			Initial phase plan report
			Site hazard risk report

[47] For Multifamily residential projects only

[48] New Construction equivalent → Owner's Project Requirements (OPR)

3.4.2.2 Compliance Tool

All Phius REVIVE 2024 projects must use the Phius 2024 REVIVEcalc for certification compliance. Refer to Section 3.4.4 below for modeling protocol using this tool. Review Section 6 of the Phius REVIVE 2024 Standard document for detailed information on simulation requirements and calculation details.

Supporting Documentation

To confirm all inputs in Phius 2024 REVIVEcalc, the Cx Team must provide project documentation in addition to the Assessment & Investigation Workbook to confirm the baseline modeling inputs. At a minimum, this includes:

- Existing project drawings
  - Floor plans
  - Building section
  - Elevations
  - Site plan
- Baseline assembly assumptions
- Baseline mechanical system assumptions
- Existing appliance information/assumptions
- Proposed design drawings (schematic)[49]

3.4.2.3 Issues & Resolutions Log

The Issues & Resolutions log should be used by the Cx Team to communicate and track information about issues that arise during the assessment & investigation phase. The CxP should verify that all issues reported in the I&R log are resolved by the time of submission, unless deemed unresolvable or deferred to a later phase, in which case an explanation should be provided for justification and Phius approval. All submission items should be ready for review going into Round 1 of Assessment & Investigation Review. Any issue marked 'Unresolved' or 'Deferred' by the end of assessment & investigation will be carried into the design phase as an issue to be remedied, unless otherwise deemed unresolvable.

[49] Only applicable if there is a change in occupancy, dwelling units, building function, or floor area (i.e. new additions)

3.4.2.4 Updated Program Plan (Multiple Facility Planning only)

Review Section 4.5.2 & 4.5.3 of the Phius REVIVE 2024 Standard document for detailed information on developing the Multiple Facility Program Plan. In the case of multiple facilities, it's good to have an idea of which buildings to prioritize, or in which order to retrofit them. The Cx team should use the Multi-Facility Program Planning Worksheet and make an initial determination of a priority order for all buildings in the program before beginning assessment & investigation on individual buildings.

Each building in the program plan will require its own certification, therefore the Phius REVIVE 2024 Assessment & Investigation workbook must be completed for each individual building in the program.

At the conclusion of assessment and investigation of all buildings in the program, the Cx team should re-evaluate the rank for each building and record the finalized order in the Multi-Facility Program Planning Workbook.

3.4.2.5 Rationale for Retrofit

Review Section 4.5.1 of the Phius REVIVE 2024 Standard document for detailed information on making the initial determination of whether a building should be excused from retrofit.

In the Phius REVIVE 2024 Assessment & Investigation workbook, the CxP should complete the Rationale for Retrofit worksheet.

3.4.2.6 Owner Worksheet

The intent of the owner worksheet is for the CxP to gather as much information about the project as possible before conducting the on-site assessment. The worksheet includes a list of possible existing project documents or information that may be helpful to the CxP.

The last section is a general occupant survey. This is an opportunity for the owner to reflect on the comfort of their building and report on any specific complaints regarding occupant comfort.

> **Process Tip:** High-level information is expected in this section, the owner is not expected to know everything about their building).
>
> To minimize the transfer of files and technical difficulties, the CxP may fill this sheet out on behalf of the owner, or with the owner. Schedule a meeting, in-person or virtual, or phone call to discuss the owner worksheet items and survey questions. Give the owner time to collect and prepare facility documentation prior to the on-site meeting.

3.4.2.7 Current Facility Requirements (CFR)

Facility Requirements

The CxP should work with the owner to establish a list of current facility requirements. New requirements can be added at any time throughout the project, as retrofit projects are expected to have unknown issues arise throughout the duration of the project.

The Workbook has broken the facility requirements into 3 overarching categories (4 for non-residential projects). To limit potential scope-creep and encourage prioritization of deliverables, the Workbook limits the Cx Team to 15 CFR items (5 elected requirements per category). It is at the Cx Team's discretion to decide how many CFR items to include for certification. Consider the following question(s) for each category when creating the list of facility requirements:

Regulatory

- What must be done to meet all code requirements for the intended function of the building?

Financial

- What is the project budget?
- Will outside financial assistance need to be pursued?
- What kind of financial assistance programs are available?

Functional

- What must be done to the floor plan in order for the intended operation to function properly?
- What must be done to the mechanical systems for proper operation?
- What is/isn't working well?

Critical loads & occupancy (Non-Residential projects only)

- Which process loads are critical to maintain operation during an outage?
- What is the occupancy schedule during the outage?

> **Process Tip:** Elected CFR deliverables must be addressed to earn Final Certification, unless otherwise justified as unresolvable.

Ongoing Commissioning (OCx) and M&V Electives

The CxP should have an initial conversation with the owner about any monitoring electives they would like to learn more about. All of the options in the Workbook are optional, but all project teams are encouraged to review Section 3.3.6 on the value of collecting project data for future development.

Facility Summary

The initial CFR should be completed by creating the facility summary. The Cx team should review all of the project information gathered up to this point, and write a brief summary of the findings.

3.4.2.8 IAQ Assessment Worksheet

The CxP should use the Assessment Worksheet to plan and report on the outcome of conducting all Assessment Protocol items defined in the EPA Energy Savings Plus Health guideline.

Site Visit Log

A tool for the Cx team to use to track when a site visit occurs, who conducts the site visit, and any important notes or findings from the visit.

Assessment Planning

The CxP should use the 'Planning' column of the Assessment Worksheet to determine which IAQ Assessment Protocol items can be accomplished during a walkthrough or deemed to be of no concern by discussion. The intent of this worksheet is for the Cx team to create a plan to optimize time on-site and ensure that all on-site assessment deliverables are met, discussed, or deferred to a later phase. Items deferred or found to need further investigation will be automatically carried over to the Investigation Worksheet.

Assessment Reporting

The CxP should use the 'Reporting' column of the Assessment Worksheet to record all findings during the walkthrough in-line with the assessment items determined during Assessment Planning. The CxP should then update the status of each Assessment Protocol item by marking it as resolved, definitely requiring remediation, needs further investigation, or no further investigation required. Items requiring remediation or further investigation will be automatically carried over to the Investigation Worksheet.

The CxP should update the CFR Worksheet with new findings, record new requirements, or eliminate remediated requirements.

3.4.2.9 IAQ Investigation Worksheet

The CxP should use the Investigation Worksheet to plan the investigation of remaining IAQ assessment items and report on all action items to be implemented by project completion. The worksheet is similar to the assessment report.

Site Visit Log

A tool for the Cx team to use to track when a site visit occurs, who conducts the site visit, and any important notes or findings from the visit.

Investigation Planning

The CxP should use the 'Planning' column of the Investigation Worksheet to plan the investigation or testing methods for the remaining IAQ Assessment Protocol items. The intent of this worksheet is for the Cx team to create a plan to optimize time on-site and ensure that all on-site assessment deliverables are met, discussed, or deemed unable to be investigated with a reasonable justification (i.e. inflicting extensive damage on the building to gather information during the investigation phase is not required).

Investigation Reporting

The CxP should use the 'Reporting' column of the Investigation Worksheet to record all findings during site visits and testing in-line with the assessment items remaining from the Assessment phase. The CxP should finalize the status of each Assessment Protocol item by marking it as resolved, requires remediation, unable to investigate, or no further investigation required. Items requiring remediation will be recorded in the Cx Report.

The CxP should update the CFR Worksheet with new findings, record new requirements, or eliminate remediated requirements.

3.4.2.10 Initial Performance Modeling Report

Review Section 3.4.3 for more information on the REVIVEcalc Modeling tool.

Complete the 'Phase 2: Performance Modeling' tab of the Assessment & Investigation workbook to verify that all of the required project documentation has been collected and uploaded to the project Dropbox folder for review. The Phius Reviewer will cross reference the REVIVEcalc Runlist inputs and project documentation, then provide feedback in the form of requesting modeling revisions or documentation clarifications.

3.4.2.12 Site Hazard Risk Report

The Cx team should use the Hazard Mitigation Worksheet in the Phius REVIVE 2024 Workbook to identify potential site hazard mitigation requirements. Use the resources linked in the Workbook to determine the project-specific site hazard zones / designations. The Workbook will populate with project-specific certification requirements per hazard category as inputs are completed.

3.4.3 Phius REVIVEcalc Modeling Tool

In order to support the resilience analysis, annual hourly energy model, and ADORB cost calculation, Phius has developed a modeling tool that will take simplified user inputs and build two dynamic models in EnergyPlus[50]. The results are calculated and generated into a simple table that allows for quick assessment and comparison of the output cases. The tool has been developed to support design for certification modeling of the project, and allows the user to define multiple cases and run them in parallel so that tedious, manual adjustments need not be made while designing. All guidance below applies to **v24.2.0** of the software which was released July 18, 2024. The tool, along with additional resources and tools, can be downloaded from the Phius Github Repository.

3.4.4 Phius REVIVEcalc Modeling Protocol

Please refer to the following resources for guidance and official protocol for modeling using REVIVEcalc v24.2.0:

- Phius 2024 REVIVEcalc Handbook
- Training videos

NOTE: The Phius REVIVE 2024 Design Workbook is still in development at this time. Check back regularly for when this document is released and available for use.

[50]The DOE flagship energy modeling engine

3.5 Design

3.5.1 Required Documentation

Upon completion of the Assessment & Investigation phase, the Cx team will have several retrofit approach options available to pursue during the Design Phase. Every retrofit project will be unique in its design requirements based on the selected retrofit approach, and therefore will have a unique set of required design documentation to be submitted during Design Review. All of the deliverables listed in the following sections should be fulfilled by completing the Phius REVIVE 2024 Design Workbook, which will be issued to the Cx team during Assessment & Investigation Approval.

Table 3.5.1.0 Required Documentation for Phius REVIVE 2024: Phase 3 - Design

Phius REVIVE 2024 Design Workbook		**Issues & Resolutions Log**	Feedback channel between Cx team members
		Approach Declaration	Define the selected retrofit approach
	Existing Buildings Commissioning (Cx) Plan - Part 2	**CFR Deliverables Plan**	Complete the workbook sections relating to the CFR deliverables solutions
		Passive Systems Plan	Complete the workbook sections relating to passive design strategies
		IAQ Remediation Plan	Complete the workbook sections relating to IAQ remediation strategies
		Active Systems Plan	Complete the workbook sections relating to active building systems
		Site Hazards Mitigation Plan	Complete the workbook sections relating to site hazard mitigation strategies
	Existing Buildings Commissioning (Cx) Report - Part 2	**Design Review Report**	Automatically updated based on acceptance, rejection and/or feedback on established design deliverables
Additional Documents			Refer to Section 1.4.2 for aa comprehensive, but non-exhaustive list of possible required design documentation[51,52] Refer to Section 3.5.1.10 for possible retrofit-specific documentation

[51] Required documentation for retrofit projects is based on the specific selected approach. Not all projects will have the same documentation requirements.

[52] **Exception:** No compliance tool is required for this phase. The design should align with the selected design approach from the options established during the Assessment & Investigation phase

3.5.1.2 Issues & Resolutions Log

The Issues & Resolutions log should be used by the Cx Team to communicate and track information about issues that arise during the design phase. All issues reported in the I&R log must be resolved or deferred to the Implementation phase,unless deemed unresolvable, in which case an explanation should be provided for justification and Phius approval.

3.5.1.3. Approach Declaration

The Cx team should select a specific retrofit approach from the 5 options that were established during Phase 2: Assessment & Investigation. The CxP should record which option was selected, and complete the remainder of the Approach Declaration worksheet. The worksheet will require the CxP to indicate all applicable project design categories necessary to fulfill the selected approach deliverables, including:

Envelope

- Walls
- Roof
- Floor/Slab
- Fenestration
- Airtightness

Mechanical systems

- Heating/Cooling
- Plumbing
- Ventilation
- Appliances

Process Tip: Note that all categories selected on this worksheet will have a corresponding section later in the workbook that must be completed by the CxP, reviewed and approved by Phius.

3.5.1.4 CFR Deliverables Plan

Regulatory (code) and functional (owner elected / program) requirements defined in the CFR of the Assessment & Investigation Workbook during Phase 2 will be carried over to the CFR Deliverables Plan in the Design Workbook. For each deliverable, the CxP must report the following information in the Design Workbook:

Regulatory / Functional Requirements

- Design category
  - Envelope (assemblies, airtightness)
  - Mechanical systems (HVAC, plumbing, appliances)
  - Functional (i.e. reconfiguration of a space into a bedroom)
- Solution summary
- Supporting documentation location (i.e. detail / sheet #)

3.5.1.5 IAQ Remediation Plan

IAQ Assessment Protocol items still defined as ‘Requires remediation’ by the end of the Assessment & Investigation Phase will be carried over to the IAQ Remediation Plan Worksheet in regards to the corresponding Minimum Actions (MA) as defined in the EPA Energy Savings Plus Health documents. The Submitter / CxP must report the following information in the Design Workbook:

- Design category
  - Envelope, systems, construction, lifestyle, etc.
- Solution summary
- Supporting documentation location (i.e. detail / sheet #)

3.5.1.6 Passive Systems Plan

All Passive Systems Planning tabs in the Design Workbook will be colored yellow. They will also be designated with a 'P-' before the name of the section (i.e. P-Assemblies). The CxP must complete the sections for all project-specific design categories defined in the Approach Declaration and CFR Deliverable Plan Worksheets. Sections that do not need to be completed will be automatically 'grayed' out, indicating that they may be skipped. The following list is a summary of the possible information needed to complete the Passive Systems Planning section of the Workbook:

Envelope

Assembly configuration

Material properties

Fenestration

Performance data

Airtightness

Junction details

3.5.1.7 Active Systems Plan

All Active Systems Planning tabs in the Design Workbook will be colored blue. They will also be designated with a 'A-' before the name of the section (i.e. A-Space Conditioning). The CxP must complete the sections for all project-specific design categories defined on the Approach Declaration and CFR Deliverable Plan Worksheets. Sections that do not need to be completed will be automatically 'grayed' out, indicating that they may be skipped. The following list is a summary of the possible information needed to complete the Active Systems Planning section of the Workbook:

Heating/Cooling

- Distribution plan
- Equipment information
    - Manufacturer
    - Model number

Plumbing

- Distribution plan
- Equipment information
    - Manufacturer
    - Model number

Ventilation

- Distribution plan / Ventilation schedule
- Equipment information
    - Manufacturer
    - Model number

Appliances

- Manufacturer
- Model number

3.5.1.8 Site Hazards Mitigation Plan

Only where geographically applicable, CxP must complete the Site Hazards Mitigation Plan Worksheet to confirm compliance with the requirements defined in Section 3.3.3. The CxP must also complete verification of any hazard mitigation electives selected during the Assessment & Investigation Phase. To do so, the CxP must report the following information in the Design Workbook:

- Solution summary
- Supporting documentation location, if applicable (i.e. detail / sheet / note #)

3.5.1.9 Design Review Report

The Design Review Report will automatically generate in the background as the project progresses through each round of review. When all deliverables are met, this report will reflect that Phius has accepted all design solutions in terms of the deliverables established during the Assessment & Investigation Phase.

3.5.1.10 Unique REVIVE Documentation

Some retrofit projects may have deliverables that cannot be verified with a typical set of construction documents. The following list is a non-exhaustive summary of possible unique documentation that the Cx team may be asked to provide during design review to confirm design solutions will be sufficient in satisfying all project deliverables.

Examples:

- Letter of intent from asbestos removal contractor (noting methods will comply with EPA Energy Saving Plus Health Minimum Actions)
- Wind-resistant PV mounting documents
- Structural engineer sign-off for seismic-related requirements
- Professional mold-remediation testing & reports
- Ice-damming mitigation plan
- etc...

3.6 On-Site

3.6.1 Required Documentation

When submitting your project for Final Review, it is important for the project team to know what documentation is required. Before conducting the first round of Final Review, Phius conducts what is referred to as the 'Initial Review.' This Initial Review serves as a "documentation review" to ensure the project team has uploaded the correct documentation to achieve Final Certification, as required by the Phius QA/QC team.

The Phius QA/QC team will review all required documentation within the project OnSite QA folder for completeness. Once all documentation has been provided, the first round (F1 Review) of Final Review can begin. The table below identifies the breadth of documentation that must be uploaded to a project's Dropbox folder.

Table 3.6.1.0 Required Documentation for Phius REVIVE 2024: Phase 4 - Implementation

Phius REVIVE 2024 Implementation Workbook	**Issues & Resolutions Log**		Feedback channel between Cx team members
	Existing Buildings Commissioning (Cx) Plan - Part 3	**Final CFR**	Add additional CFR deliverables to the Implementation Workbook as needed
		Final Phase Plan	If doing a phased retrofit, use the Phase Planner to track phase deliverables, construction schedules, etc.
		Final M&V Plan[53]	Use the M&V Planner to schedule and track the completion of M&V requirements
		Final Maintenance Plan	Record strategy for maintaining implemented measures (i.e. filter replacement schedule)
	Existing Buildings Commissioning (Cx) Report - Part 3	**Executive Summary**	Summarize the implemented measures, and indicate possible future improvements.
		Final Findings & Recommendations	Update the performance analysis based on findings during the implementation process
		New Discovery Report	Record any new discoveries made during Implementation that may impact the project's ability to meet the certification requirements. Describe method of resolution.
		Final Testing & Verification Reports	Complete the required checklists to verify that all tests have been performed and that all documentation has been collected and provided to Phius for Final Review
		Final Training Report[54]	Schedule and track any training sessions for ongoing maintenance and operation of building systems

[53] For non-residential projects only.
[54] Only for projects that include property / building managers / building operators other than the Owner

NOTE: The Phius REVIVE 2024 Implementation Workbook & Documentation Requirements are still in development at this time. Check back regularly for when this document is released and available for use.

Process tips:
A new set of results for the as-built project should be created to verify the impact of implemented systems vs the design-certified results. The as-built results file should be uploaded to the Dropbox for final review with the naming convention: ####_As-Built-Updates_YYYY.MM.DD

It is imperative that the CxP record all as-built changes post-Design Certification. This should be done using the Issues & Resolutions Log that is carried over to and continued in each certification Workbook.

In the event of on-site test failure, review Appendix C-2.4

3.6.1.2 Issues & Resolutions Log

The Issues & Resolutions log should be used by the Cx Team to communicate and track information about issues that arise during the implementation phase, including the date the issue was found, which team member identified the issue, and the date, team member, and description of the solution to each issue. The CxP should verify that all issues reported in the I&R log are resolved by the time of submission, unless deemed unresolvable, in which case an explanation should be provided for justification and Phius approval. All submission items should be ready for review going into Round 1 of Final Review. Any issue marked 'Unresolved' during final review must be approved by a Phius Final Certification Specialist before certification can be issued. If no justification is provided, the Cx team will be asked to provide one, or resolve the issue.

3.6.1.2 Final CFR

Regulatory (code) and functional (owner elected / program) requirements addressed during design in the CFR Deliverables Plan of the Design Workbook during Phase 3 should be carried over to the Final CFR. For each deliverable, the CxP must report the following information in the Implementation Workbook:

Regulatory / Functional Requirements

Design solution summary

- Define whether or not the deliverable was able to be implemented
- Define the solution for the deliverable (if changed since Design phase)
- Supporting documentation location (i.e. detail / sheet #)

3.6.1.2 Final Phase Plan

Applicable to phased retrofits only. Use the Phase Planner tab to track the following:

- Quantity of phases
- Major deliverables for each phase
- Date of phase commencement
- Date of phase completion (target & actual)
- Unmet deliverables

Process Tip: All phases of the project should be complete before submitting for Final Review. The Cx team should upload relevant documents as they become available to the project Dropbox.

3.6.1.3 Final M&V Plan

For non-residential projects only. Provide access information to the project's Energy Star Portfolio Manager.

3.6.1.4 Final Maintenance Plan

Record maintenance strategy for all applicable implemented systems. This could include filter replacement, regular systems testing, appliance/equipment replacement timeline, etc.

3.6.1.5 Executive Summary

The Cx team should review and summarize all of the implemented project deliverables for the executive summary.

3.6.1.6 Final Findings & Recommendations

The final findings & recommendations should include plans for possible future improvements and lessons learned during the implementation phase.

3.6.1.7 New Discovery Report

The Cx team should report on any new findings during implementation. This may include IAQ Assessment protocol items that could not be addressed previously.

3.6.1.8 Final Testing & Verification Reports

The Cx team should complete the final Implementation Worksheets in the Phius REVIVE 2024 Workbook.

Typical Verification Reports

The following testing should be performed in compliance with the corresponding New Construction requirements described in Section 1.5 above:

- 1.5.2.3 Building Envelope

> **Exceptions:** Additional blower door testing methods are outlined in Section 8.9.4.1 of the Phius REVIVE 2024 Standard

- 1.5.2.4 Compartmentalization

> **Exceptions:** Compartmentalization requirements do not apply to single family or non-residential projects.

- 1.5.2.5 Ventilation
- 1.5.2.6 Heating & Cooling
- 1.5.2.6 Domestic Hot Water
- 1.5.2.7 Appliances & Electrical Loads
- 1.5.2.8 Renewable Energy Systems

Site Hazard Verification Documentation

Where geographically applicable, the Cx team must also upload the following supplemental documentation to Dropbox to confirm compliance with all site hazard mitigation requirements:

Earthquake

Single Family: FEMA P-50-1 Simplified Seismic Assessment Form (Post-retrofit)

Multifamily/Non-residential: Drawings must be stamped by a professional engineer

Flood

All projects must comply with IBHS FORTIFIED Commercial Silver Sections 3.2.4 and 3.2.5.

Hail / Wildfire (PV Modules)

All modules: FM Approval for hail OR

Flexible modules: FM Approval Standard 4476 (Severe Hail rating)

Rigid modules: FM Approval Standard 4478 (Class 4 rating)

Structural and High Wind

Dry stack foundations:

- Professional engineering plan
- Signoff from professional engineer confirming compliance with HUD4930.3G (Sep. 1996 or later)

Roof (Single-Family):

- IBHS FORTIFIED Home Section 3, OR
- FEMA P-804 Section 4.1

Roof (Multifamily / Non-res): IBHS FORTIFIED Commercial, Section 3.1

Wildfire

Defensible Space & Home Hardening Self-Inspection Checklist (Post-retrofit)

3.6.1.9 Final Training Report

The CxP should record any training (maintenance personnel, Owner, etc) that occurred during implementation, including who attended, dates, length of time, training subjects, training materials, and trainer.

3.6.2 Corequisite Programs

It is the responsibility of the whole project team to ensure a project is fully compliant with Phius certification requirements. It is highly recommended that the CPHC and the Rater or Verifier ensure that all critical project team members understand the Phius Final Certification process. For all REVIVE projects, compliance with the EPA Energy Savings Plus Health Guidelines is required, as well as specific sections of various other programs. Depending on the scope and location of the project, additional partner programs may include ENERGY STAR Single-Family Homes, EPA ENERGY STAR Multifamily New Construction, EPA Indoor airPLUS, FEMA, and IBHS FORTIFIED. Because REVIVE projects aren't eligible to be certified under the additional programs, documentation must be submitted to confirm that the *intent* of the applicable program requirements are met.

Table 3.6.2.0 Corequisite Program Versions

Scope	Single-Family, Duplexes & Townhouses	Multifamily / Non-Residential
EPA Energy Savings Plus Health	Publication No. EPA 402K21001	Publication No. EPA 402K21002
EPA Indoor airPLUS[55]	Version 1, Rev. 4	
EPA Energy Star[55]	EPA ENERGY STAR Certified Homes v3.2	Multifamily New Construction (MFNC) v1.2
FEMA[56]	P-50-1, P-348 & P-804 (Sec 4.1)	-
IBHS FORTIFIED	Home (Section 3)	Commercial (Sections 3.1) Commercial Silver (Sections 3.2.4 & 3.2.5)

[55] Applies ONLY to new additions. Eligibility limitations do not apply. The verification, partnership, training, and credentialing requirements do not apply because they are superseded by the *commissioning* requirements of the Phius REVIVE 2024 Standard v24.0.

[56] Only where geographically applicable

Appendix A - Target Setting Methodology

The factor nomenclature are as follows:

\$elec [\$/kWh]: The marginal price of electricity varies per state or province.

CDD50 [°F.days]: Cooling degree days from the ASHRAE Handbook - Fundamentals 2021.

DDD [lb/lb.days]: Dehumidification "degree-days" base 0.010 lb/lb. [Phius / Meteonorm]. Multiply by 7000 to convert to grains/lb-days.

EnvFlr [ft^2/ft^2]: The ratio of the envelope area divided by the floor area (iCFA). Calculation range limits based on the buildings studied are incorporated with a minimum of 0.71. The maximum varies by project size: Projects >1,000 sf have a maximum calculation range limit of 3.07 while projects ≤1,000 sf have a limit of 9.19.

HDD65 [°F.days]: Heating degree days from the ASHRAE Handbook - Fundamentals 2021.

IGA [$kWh/m^2.yr$]: Annual global solar irradiance.

IGCL [$Btu/hr.ft^2$]: Global solar irradiance at the cooling design condition.

IGHL [$Btu/hr.ft^2$]: Global solar irradiance at the heating design condition.

TCD [°F]: Temperature at the cooling design condition.

THD / THD-1 [°F]: Temperature at the colder of the two heating design conditions.

UnitDens: The inverse (1 over) of the ratio of the floor area (iCFA) divided by the number of dwelling units.

Residential: A calculation range limit based on the buildings studied is incorporated with a minimum of 2,058 sf per dwelling unit.

Non-Residential: 0.0008647 is used which represents the middle value of the studied range of buildings.

Occ: The inverse (1 over) the number of occupants per square foot of floor area (iCFA).

Residential: The number of occupants is calculated as the number of bedrooms + 1 per dwelling unit. Calculation range limits based on the buildings studied are incorporated with a minimum iCFA per person of 86 and a maximum iCFA per person of 750.

Non-Residential:

Annual Cooling Demand

The number of occupants is calculated as the average occupancy over the 24-hour period of a typical day. Calculation range limits based on the buildings studied are incorporated with a minimum iCFA per person of 86 and a maximum iCFA per person of 1,029.

Peak Heating and Cooling Load

The number of occupants is calculated as the design or maximum occupancy of the building at the peak occupancy hour. Calculation range limits based on the buildings studied are incorporated with a minimum iCFA per person of 86 and a maximum iCFA per person of 1,029.

A-1 Regression Formulas for Performance Path Space Conditioning Criteria

The best-fit regression formulas for the space conditioning criteria are shown in the figures below.

A-1.1 Annual Heating Demand [kBtu/ft^2.yr]

A-1.1.1 Buildings (>1,000 sf iCFA)

$$
\begin{aligned}
&2.5457921063 \\
&+ 0.0006964273 \cdot \text{HDD65} \\
&+ -0.001754102 \cdot \text{IGA} \\
&+ -12.84284075 \cdot \text{\$elec} \\
&+ 2.0656632454 \cdot \text{EnvFlr} \\
&+ 1566.1974476 \cdot \text{UnitDens} \\
&+ \left(\text{HDD65} - 5674.3866667 \right) \cdot \left(\left(\text{HDD65} - 5674.3866667 \right) \cdot \text{-}8.222261\text{e-}8 \right) \\
&+ \left(\text{HDD65} - 5674.3866667 \right) \cdot \left(\left(\text{IGA} - 1451.0633333 \right) \cdot \text{-}3.521982\text{e-}7 \right) \\
&+ \left(\text{HDD65} - 5674.3866667 \right) \cdot \left(\left(\text{\$elec} - 0.2029193333 \right) \cdot \text{-}0.002089994 \right) \\
&+ \left(\text{HDD65} - 5674.3866667 \right) \cdot \left(\left(\text{EnvFlr} - 1.7740848024 \right) \cdot 0.0003487784 \right) \\
&+ \left(\text{\$elec} - 0.2029193333 \right) \cdot \left(\left(\text{EnvFlr} - 1.7740848024 \right) \cdot \text{-}3.472274709 \right)
\end{aligned}
$$

Rsq = 0.88, minimum results of 1.0.

A-1.1.2 Buildings (<200 sf iCFA)

$$
\begin{aligned}
&6.3652258193 \\
&+ 0.0038587347 \cdot \text{HDD65 [F.days]} \\
&+ \left(\text{HDD65 [F.days]} - 4880.725 \right) \cdot \left(\left(\text{THD-1 [F]} - 21.5575 \right) \cdot 0.0000322794 \right)
\end{aligned}
$$

Rsq = 0.92, minimum results of 1.0

A-1.1.3 Buildings (200 - 1,000 sf iCFA)

A sliding scale calculation is used to determine the targets for buildings that fall between the tiny (<200 sf) and non-tiny (<1,000 sf) ranges. The calculation is as follows:

Non-Tiny Result + ((Tiny Result - Non-Tiny Result) ÷ ((200 sf - 1,000 sf) x (iCFA - 1,000 sf)))

A-1.2 Annual Cooling Demand [$kBtu/ft^2.yr$]

A-1.2.1 Buildings (>1,000 sf iCFA)

$$
\begin{aligned}
&-2.891826273 \\
&+ 0.0016600925 \cdot CDD50 \\
&+ 2.7134372315 \cdot DDD \\
&+ -1.072883835 \cdot EnvFlr \\
&+ 3347.3086058 \cdot UnitDens \\
&+ \left(CDD50 - 3785.076\right) \cdot \left(\left(CDD50 - 3785.076\right) \cdot 1.5194385e\text{-}7\right) \\
&+ \left(IGA - 1451.0633333\right) \cdot \left(\left(DDD - 0.3233057482\right) \cdot 0.0075130061\right) \\
&+ \left(CDD50 - 3785.076\right) \cdot \left(\left(\$elec - 0.2029193333\right) \cdot -0.002710065\right) \\
&+ \left(IGA - 1451.0633333\right) \cdot \left(\left(EnvFlr - 1.7740848024\right) \cdot 0.0021353042\right) \\
&+ \left(EnvFlr - 1.7740848024\right) \cdot \left(\left(EnvFlr - 1.7740848024\right) \cdot 2.1308341827\right) \\
&+ \left(DDD - 0.3233057482\right) \cdot \left(\left(UnitDens - 0.0009781131\right) \cdot 7123.3552616\right) \\
&+ \left(EnvFlr - 1.7740848024\right) \cdot \left(\left(UnitDens - 0.0009781131\right) \cdot -1680.206998\right)
\end{aligned}
$$

Rsq = 0.93, Inclusivity adjustment of +2.0768, minimum result of 1.0

A-1.2.2 Buildings (<200 sf iCFA)

$$
\begin{aligned}
&-4.511787896 \\
&+ 0.0053698658 \cdot CDD50\ [F.days] \\
&+ \left(IGA\ [kWh/m2.yr] - 1493.525\right) \cdot \left(\left(DDD\ [lb/lb.days] - 0.3829363138\right) \cdot 0.0179690723\right)
\end{aligned}
$$

Rsq = 0.96, Inclusivity adjustment of +3.5806, minimum result of 1.0

A-1.2.3 Buildings (200 - 1,000 sf iCFA)

Same logic used as described in Appendix A-1.1.3.

A-1.3 Peak Heating Load [Btu/ft^2.hr]

A-1.3.1 Buildings (>1,000 sf iCFA)

$$
\begin{aligned}
&5.6821964801 \\
&+ -0.000235297 \cdot \text{HDD65} \\
&+ -0.099841715 \cdot \text{THD} \\
&+ -0.035892961 \cdot \text{IGHL} \\
&+ -4.56550204 \cdot \text{\$elec} \\
&+ 1.0569432276 \cdot \text{EnvFlr} \\
&+ 1507.4024576 \cdot \text{UnitDens} \\
&+ (\text{THD} - 14.7102) \cdot ((\text{THD} - 14.7102) \cdot -0.000212828) \\
&+ (\text{THD} - 14.7102) \cdot ((\text{\$elec} - 0.2029193333) \cdot 0.1493251072) \\
&+ (\text{THD} - 14.7102) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot -0.021651966) \\
&+ (\text{EnvFlr} - 1.7740848024) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.5502304525) \\
&+ (\text{THD} - 14.7102) \cdot ((\text{UnitDens} - 0.0009781131) \cdot -26.25479205)
\end{aligned}
$$

Rsq = 0.94, Inclusivity adjustment of +0.6565, minimum result of 1.0

A-1.3.2 Buildings (<200 sf iCFA)

$$22.101821646 + -0.272673414 \cdot \text{THD-1 [F]} + -0.070776876 \cdot \text{IGHL [Btu/h.ft2]}$$

Rsq = 0.95, Inclusivity adjustment of +2.0033, minimum result of 1.0

A-1.3.3 Buildings (200 - 1,000 sf iCFA)

Same logic used as described in Appendix A-1.1.3.

A-1.4 Peak Cooling Load [Btu/ft^2.hr]

A-1.4.1 Buildings (>1,000 sf iCFA)

$$
\begin{aligned}
&-7.799196768 \\
&+ 160.56676643 \cdot \text{Occ} \\
&+ -0.000064641 \cdot \text{CDD50} \\
&+ 0.1087419716 \cdot \text{TCD} \\
&+ 0.0114553286 \cdot \text{IGCL} \\
&+ -0.144119045 \cdot \text{EnvFlr} \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{CDD50} - 3785.076) \cdot 3.108567\text{e-}8) \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{TCD} - 78.127) \cdot 5.7628526\text{e-}6) \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.0000487234) \\
&+ (\text{TCD} - 78.127) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.0112936538) \\
&+ (\text{EnvFlr} - 1.7740848024) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.893136984) \\
&+ (\text{TCD} - 78.127) \cdot ((\text{UnitDens} - 0.0009781131) \cdot 41.014256753)
\end{aligned}
$$

Rsq = 0.91, Inclusivity adjustment of +0.3616, minimum result of 1.0

A-1.4.2 Buildings (<200 sf iCFA)

$$-17.74649471 + 0.2985447435 \cdot \text{TCD [F]}$$

Rsq = 0.90, Inclusivity adjustment of +0.8927, minimum result of 1.0

A-1.4.3 Buildings (200 - 1,000 sf iCFA)

Same logic used as described in Appendix A-1.1.3.

A-2 Regression Formulas for the Performance Path Source Energy Target

A-2.1 Residential [kWh/person.yr]

$$-2857.033962$$
$$+ 12.109301597 \cdot \text{iCFA/p}$$
$$+ 2674374.9714 \cdot \text{UnitDens}$$
$$+ \left(\text{iCFA/p} - 474.68053023 \right) \cdot \left(\left(\text{UnitDens} - 0.0014444453 \right) \cdot 6165.3716584 \right)$$

Inclusivity adjustment of +787.39. Result multiplied by 2.0/1.8 to rescale for the Phius 2024 source energy factor of electricity.

A-2.2 Non-residential [kBtu/ft^2.yr]

In order to better fit the non-residential source energy targets to climate and building size, Phius reevaluated the source energy criteria. The previous target was a one size fits all limit, with the potential for allowances for special use buildings. By refining this, more non-residential projects should be able to meet the Phius CORE 2024 source energy limit without the need for renewable generation.

ASHRAE Standard 100-2018 contains data on the site energy uses for existing buildings. A curve fit through the ASHRAE data was compared with a curve fit through Certified Phius projects to determine a climate specific percentage savings. This was applied to a curve fit through the ASHRAE 100 Median Office energy use, broken out by climate. Using the resulting formula, the matrix of source energy targets was determined. Climates in the extremes, very hot or very cold, saw an increased allowance for more heating or more cooling. Type 'A' climates (humid) also saw an increased allowance for dehumidification.

A-3 Regression Formulas for the Prescriptive Path Opaque Enclosure R-Values

A-3.1 Above-grade Wall & Cantilevered Floors

$$2.975122788$$
$$+ 0.0038967312 \cdot \text{HDD65 [F.days]}$$
$$+ 59.886974326 \cdot \text{\$elec [\$/kWh]}$$
$$+ \left(\text{HDD65 [F.days]} - 5520.8545455 \right) \cdot \left(\text{\$elec [\$/kWh]} - 0.2016890909 \right) \cdot 0.0111932731$$

Rsq = 0.88, Conservative fit adjustment +5.3792

A-3.2 Roofs

$$33.972385485$$
$$+ 2.1434846549 \cdot \text{EnvFlr}$$
$$+ 0.0025310881 \cdot \text{HDD65 [F.days]}$$
$$+ -0.276768354 \cdot \text{THD99 [F]}$$
$$+ 66.938407603 \cdot \text{\$elec [\$/kWh]}$$
$$+ \left(\text{EnvFlr} - 3.14219615 \right) \cdot \left(\text{EnvFlr} - 3.14219615 \right) \cdot -1.607593659$$
$$+ \left(\text{THD99 [F]} - 12.486818182 \right) \cdot \left(\text{\$elec [\$/kWh]} - 0.2016890909 \right) \cdot -1.8168457$$

Rsq = 0.65, Conservative fit adjustment +8.4234

A-3.3 Whole slab foundations, below-grade walls and floors of conditioned basements and crawlspaces

$$-18.64576148$$
$$+ 5.9003677205 \cdot \text{EnvFlr}$$
$$+ 0.0026621341 \cdot \text{HDD65 [F.days]}$$
$$+ 38.923653317 \cdot \text{\$elec [\$/kWh]}$$
$$+ \left(\text{CDD50 [F.days]} - 3890.5772727 \right) \cdot \left(\text{TCD [F]} - 78.59 \right) \cdot 0.0000576588$$
$$+ \left(\text{HDD65 [F.days]} - 5520.8545455 \right) \cdot \left(\text{\$elec [\$/kWh]} - 0.2016890909 \right) \cdot 0.0060470435$$

Rsq = 0.84

A-3.4 Ceilings of unconditioned basements or crawl spaces and pier and beam floors

$$-18.64576148$$
$$+ 5.9003677205 \cdot \text{EnvFlr}$$
$$+ 0.0026621341 \cdot \text{HDD65 [F.days]}$$
$$+ 38.923653317 \cdot \text{\$elec [\$/kWh]}$$
$$+ \left(\text{CDD50 [F.days]} - 3890.5772727 \right) \cdot \left(\text{TCD [F]} - 78.59 \right) \cdot 0.0000576588$$
$$+ \left(\text{HDD65 [F.days]} - 5520.8545455 \right) \cdot \left(\text{\$elec [\$/kWh]} - 0.2016890909 \right) \cdot 0.0060470435$$

Rsq = 0.84, Conservative fit adjustment + 5.9089

Appendix B - Opaque Assembly Moisture Control Guidelines

Excerpted from Straube (2012), Section 3.4.1, with revisions.

Vapor control requirements vary by assembly type. Higher insulation value leads to colder exterior surfaces and less heat available to evaporate water in the assemblies.[57]

B-1 General Moisture Control Guidelines

Vapor Permeability by Material:

The following is a non-exhaustive list of permeability characteristics of different materials for reference.

Vapor Permeable (>10 perms)
Fiberglass, mineral wool, cellulose, open-cell spray polyurethane foam

Class III | Vapor Semi-Permeable (>1.0 perms, ≤10 perms)
Latex paint, fiberglass-faced polyisocyanurate, graphite polystyrene (GPS), ≥6" of open-cell spray polyurethane foam (OCSPF)

Class II | Vapor Semi-Impermeable (>0.1 perms, ≤1 perms)
Plywood, OSB, expanded or extruded polystyrene (EPS or XPS), ≥2" closed-cell spray polyurethane foam (CCSPF), foil-faced polyisocyanurate

Class I | Vapor Impermeable (≤0.1 perms)
Glass, sheet metal, polyethylene sheets, rubber membranes, non-perforated vinyl wallpaper, reflective foil, epoxy paint

Compliance Paths for Certification:

Opaque assemblies shall show compliance using one of the following paths:

1. Follow the prescriptive moisture control guidelines listed in this Appendix B.
2. Meet performance criteria through a WUFI hygrothermal analysis, following Phius' Moisture Risk Analysis & Assessment Protocol. (fee may apply, see also Section 1.2.4)
3. Present a moisture-engineered design by a qualified licensed professional engineer that includes the following:
    a. Acknowledgement that Phius flagged the assembly for potential hygrothermal or moisture concern
    b. Note that Phius is not held responsible for any moisture issued
    c. Outline that the potential hygrothermal or moisture risk of the assembly as designed is acceptably low

B-1.1 Things to Avoid

In general, Phius recommends against using wet spray cellulose.

"Vapor-sandwiched" or "double vapor barrier" assemblies:
These should generally be avoided and can make a project uncertifiable. There are some subtleties, e.g., it may be acceptable in compact roof assemblies. See these articles for a more detailed discussion [BSI-073] [BSI-092].

- Building Science Corporation BSI-073: Macbeth Does Vapor Barriers
- Building Science Corporation BSI-092: Doubling Down-How Come Double Vapor Barriers Work?

[57] Lstiburek, Joseph. BSI-028: Energy Flow Across Enclosures. Building Science Corporation, 1 Dec. 2009. Web. 13 May 2016.

B-2 Wall Moisture Control Guidelines

B-2.1 Above-Grade Wall Assemblies

Above-grade wall assembly categories:

a) Framed assemblies with only vapor permeable cavity insulation.
b) Framed assemblies with vapor permeable cavity insulation and continuous exterior insulation.
c) Assemblies with all of the insulation outboard of the structure.
d) Assemblies composed only of air-impermeable and Class II vapor control insulation.

a) Framed wall assemblies with only vapor permeable cavity insulation.

The goal of the vapor control design is to prevent vapor diffusing easily and condensing on either the cold sheathing in cold weather or the cold interior finish during warm weather. Zone-by-zone requirements are outlined below with a separate section for double-stud walls:

Zones 0, 1, 2, 3, 4A and 4B

- No interior vapor control layer is required.

Process Tip: Smart membranes such as Membrain & Intello are not recommended in hot/humid and mixed/humid climates.[58]

[58] The climate zones noted here are defined by the Building America Zoning system.

Zones 4C, 5, 6, 7 and 8

- A Class I[59] or Class II vapor control layer is required on the interior side of framed walls.

Exceptions:
Basement walls, below-grade portions of any wall, and wall construction that is not sensitive to moisture or freezing (e.g., concrete).

A Class III vapor retarder may be used instead of a Class I or Class II when the following are met:

- Zones 4C and 5: Vented cladding is used over sheathing with a perm rating of more than 1 (wet-cup), i.e., OSB, plywood, or exterior gypsum sheathing.
- Zone 6: Vented cladding is used over high permeance (more than 10 perm) sheathings such as fiberboard and exterior gypsum.

Process Tip: Vented claddings include vinyl siding, metal panels, terra cotta, wood or fiber cement sidings on air gaps, and masonry veneers with clear airspaces and vent openings top and bottom. A minimum clear gap of ⅜" (10mm) is required to provide sufficient airflow to allow for ventilation for most claddings, except masonry walls, which require a minimum of 1.

Double-Stud Wall

Exterior-load bearing

This wall type does not have a prescriptive path for Phius Certification. Compliance Paths 2 and 3 are available.

Interior-load bearing

Larsen or standoff truss walls are allowed in all climates and should align with one of the following design resources:

[59] Class I vapor control layers are not recommended on the interior of air-conditioned buildings in (A) climates with humid summers in zones 1-6. The dividing line between dry (B) and moist (A) can be found in ASHRAE 90.1. Enclosures clad with unvented water absorbent claddings (e.g., stucco, masonry, fiber cement, wood) are at especially high risk of summer condensation.

- ETW: Wall - Double Stud Wall Construction. Building Science Corporation, 15 Nov. 2014. Web. 16 May 2016.
- Bailes III, Allison A. Lstiburek's Ideal Double-Stud Wall Design. Green Building Advisor. The Taunton Press, 29 Apr. 2015. Web. 16 May 2016.

b) Framed wall assemblies with vapor permeable cavity insulation and continuous exterior insulation.

The use of insulation on the exterior of the sheathing increases its temperature in cold weather, thereby relaxing the need to control cold-weather vapor diffusion.

Insulated sheathing can be installed in the form of expanded polystyrene (EPS), extruded polystyrene (XPS), semi-rigid fiberboard (glass, rock or wood), polyisocyanurate (PIC) or closed-cell spray foam. Exterior insulation made of foamed plastic has the benefit that it also tends to reduce inward vapor drive during warm weather. Semi-rigid fiberboard insulation works differently in that they allow more outward drying.

Class III vapor control layer is required on the interior of framed walls in zone 4c and higher and the following criteria must be met:

Zone 4c (e.g., Vancouver, Seattle, or Portland)

- Sheathing-to-cavity R-value ratio of >0.20

Example: 2x4 with R-3.8/in cavity insulation
3.5" x R-3.8/in = R-13.3
R-13.3 x 0.2 = R-2.7 insulated sheathing

Zone 5 (e.g., Chicago, Windsor, Boston)

- Sheathing-to-cavity R-value ratio of >0.35

Example: 2x6 with R-3.8/in cavity insulation
5.5" x R-3.8/in = R-20.9
R-20.9 x 0.35 = R-7.3 insulated sheathing

Zone 6 (e.g., Toronto, Ottawa, Helena, Montreal, Halifax, Minneapolis)

- Sheathing-to-cavity R-value ratio of >0.50

Example: 2x6 with R-3.8/in cavity insulation
5.5" x R-3.8/in = R-20.9
R-20.9 x 0.50 = R-10.5 insulated sheathing

Zones 7 and 8 (e.g., Calgary, Edmonton, Whitehorse, Anchorage, Fairbanks)

- Sheathing-to-cavity R-value ratio of >0.70

Example: 2x8 with R-3.8/in cavity insulation
7.25" x R-3.8/in = R-27.6
R-27.6 x 0.70 = R-19.3 insulated sheathing

Process Tip: For walls, the sheathing-to-cavity R-value ratio is specified. This is different from the roof, which specifies a sheathing R-value as a percentage of the total assembly R-value.

c) Wall assemblies with all of the insulation value located outboard of the structure.

This is the simplest and most robust wall to design with respect to vapor control. Such walls should ideally have all moisture sensitive components and materials located on the inside of the insulation. In this location, a Class I or II layer on the inside of all or most of the insulation value is acceptable and recommended if all outboard components are moisture tolerant. A Class III layer on the interface of a high permeance (more than 10 perms) insulation layer outboard of a moisture-sensitive structure should only be used if warm weather and inward vapor drive condensation are not an issue or are controlled by other means.

d) Wall assemblies composed only of air-impermeable and Class II vapor control insulation.

The EPS and urethane foam cores of wood or metal SIPS, board foams, and medium density closed cell spray foam (between wood or steel studs), if installed as continuous layers, all provide their own vapor control layers and require no additional vapor-diffusion control in any climate. Wood studs and small cracks between steel or wood studs do not allow significant vapor to flow by diffusion, however cracks between framing members and insulation boards are often significant for airflow control and must be addressed.

B-2.2 Below-Grade Wall Assemblies

Below-grade spaces, such as basements, are of particular concern with respect to improperly located Class I vapor control layers. Because the moisture drive in below-grade walls is always from the exterior to the interior in zones 6 and lower, installing a low-permeance layer on the interior side of insulation will cause moisture related durability issues by trapping moisture in the enclosure. A Class I vapor control layer outside a concrete or masonry basement wall is recommended to control the flow of vapor from damp soil into the assembly. Installing a Class II vapor control layer on the inside of below-grade framed assemblies is recommended for zones 7 and higher.

In cold climates (zone 5 and higher), condensation may occur on the interior side of concrete/masonry structure of a below-grade wall assembly if insulated on the inside with an air and vapor permeable (Class II or more, e.g., fibrous insulation) layer. To control both inward and outward drives, it is recommended that a Class II or III insulation product (e.g. most foams) be used in contact with the interior face of the concrete/masonry, and any insulation installed between interior framing follow the rules of wall type b.

B-2.3 Masonry Walls and Freeze-Thaw

Interior insulation retrofits of masonry walls in cold climates can cause durability problems. Please review the information in these articles.[60,61,62] Phius may require a “hold harmless” agreement.

[60]Straube, John, and Chris Schumacher. Interior Insulation Retrofits of Load-Bearing Masonry Walls in Cold Climates. *Journal of Green Building* 2.2 (2007): 42–50. Web. 31 May 2016.
[61] Lstiburek, Joseph. “BSI-011: Capillarity—Small Sacrifices. Building Science Corporation, 3 June 2014. Web. 31 May 2016.
[62] BSI-095: How Buildings Age. Building Science Corporation, 13 May 2016. Web. 31 May 2016.

B-3 Roof Moisture Control Guidelines

Roofing behaves differently than walls from a vapor control point of view for several reasons: most roof membranes are located on the exterior and provide Class I vapor control. Roof membranes, shingles, metal roofing are all vapor impermeable.

Roof assembly categories:

a) Vented, framed assemblies with only vapor permeable cavity insulation.
b) Unvented, framed assemblies with vapor permeable cavity insulation and Class II vapor-retarding insulation.
c) Unvented assemblies with all Class II vapor control insulation outboard of the structure.
d) Unvented assemblies composed only of air-impermeable and Class II vapor control insulation.

a) Vented, framed roof assemblies with only vapor permeable cavity insulation.

Well-Vented Compact Roof

If well-vented above the insulation (i.e., with soffit and ridge vents connected by an open air-space of 1.5”/38mm or more) or above vapor semi-permeable or permeable sheathing which is outboard of vapor permeable insulation, the following requirements shall be met:

Zones 0, 1, 2, 3A, 3B and 3C
No interior vapor control layer is required.

> **Process Tip:** Smart membranes such as Membrain & Intello are not recommended in hot/humid and mixed/humid climates.[63]

Zones 4, 5 and 6
Interior Class III vapor control is required.

Zones 7 and 8
Interior Class II vapor control is required.

Well-Vented Sloped Roof over Attic

The soffit and ridge vents must be connected by an open-air volume of at least 12” (300mm) average height, and no less than 1.5”/38mm anywhere and the following requirements shall be met:

Zones 0, 1, 2, 3, 4A, 4B and 4C
No interior vapor control layer is required.

Zones 5 and 6
Interior Class III vapor control is required.

Zones 7 and 8
Interior Class II vapor control is required.

b) Unvented, framed roof assemblies with vapor permeable cavity insulation and Class II vapor control insulation.

Roofs need not be vented if diffusion and air leakage related wetting can be strictly limited. To accomplish this, some Class II insulation can be located outside of vapor permeable insulation.

The ratio of the insulation value of the exterior air- and vapor-control insulation to the insulation value of the interior air- and vapor-permeable insulation increases as the climate becomes colder, and the interior more humid. The following criteria must be met:

[63] The climate zones noted here are defined by the Building America Zoning system.

Zones 0, 1, 2, 3A and 3B

- No interior vapor control layer required.
- Outer Class II vapor control insulation R-value >15% of total

Example: 2x10 with R-3.8/in cavity insulation + 1.5" XPS
9.25" x R-3.8/in = R-35.2
1.5" x R-5.0/in = R-7.5
R-7.5 ÷ (R-35.2 + R-7.5) = 17.6% > 15% limit

Zones 3C and 4C

- Interior Class II vapor control required.
- Outer Class II vapor control insulation R-value >25% of total

Example: 2x10 with R-3.8/in cavity insulation + 2" PolyIso
9.25" x R-3.8/in = R-35.2
2.0" x R-6.0/in = R-12.0
R-12.0 ÷ (R-35.2 + R-12.0) = 25.4% > 25% limit

Zones 4A and 4B

- No interior vapor control layer required.
- Outer Class II vapor control insulation R-value >35% of total

Zone 5

- Interior Class III vapor control required.
- Outer Class II vapor control insulation R-value >35% of total

Example: 2x10 with R-3.8/in cavity insulation + 3.5" PolyIso
9.25" x R-3.8/in = R-35.2
3.5" x R-6.0/in = R-21.0
R-21.0 ÷ (R-35.2 + R-21.0) = 37.4% > 35% limit

Zone 6

- Interior Class III vapor control required.
- Outer Class II vapor control insulation R-value >50% of total

Example: 2x10 with R-3.8/in cavity insulation + 5.5" PolyIso
9.25" x R-3.8/in = R-35.2
5.0" x R-6.0/in = R-36.0
R-36.0 ÷ (R-35.2 + R-36.0) = 50.6% > 50% limit

Zones 7 and 8

- Interior Class III vapor control required.
- Outer Class II vapor control insulation R-value >65% of total

Example: 2x10 with R-3.8/in cavity insulation + 11" PolyIso
9.25" x R-3.8/in = R-35.2
11.0" x R-6.0/in = R-66.0
R-66.0 ÷ (R-35.2 + R-66.0) = 65.2% > 65% limit

Process Tip: For roofs, a sheathing R-value as a percentage of the total assembly R-value is specified. This is different from walls which prescribe the sheathing-to-cavity R-value ratios.

c) Unvented roof assemblies with all Class II vapor control insulation outboard of the structure.

To control diffusion at joints in board foam, all board insulation should be installed in two layers or more, with offset joints.

d) Unvented roof assemblies composed only of air-impermeable and Class II vapor control insulation.

The EPS and urethane foam cores of wood or metal SIPS, board foams, and medium density closed cell spray foam, require no additional vapor diffusion control in any climate with normal residential and non-residential interior humidity conditions.

Process Tips:
Cracks between framing members and panels are significant for airflow control and must be addressed in all the systems described above. A very effective airflow control layer is required on the inside of the insulation and/or framing for all unvented roof assemblies.

Wood studs and cracks between steel or wood studs do not allow significant vapor to flow by diffusion and hence do not change the recommendations.

B-4 Floor Moisture Control Guidelines

Floors that are subject to "bulk water events"[64] (i.e. have plumbing fixtures or hot water tanks) from above have trouble drying out.

B-4.1 Floors with Vapor Permeable Insulation

Floors with vapor permeable insulation (or acoustical material) that are subject to bulk water events from above must meet both requirements outlined below:

- Provide a water resisting layer above the air permeable or water absorbing insulation (or acoustical material).

Examples: Vapor permeable weather resistive membrane or an impermeable waterproofing.

- Limit the thickness of vapor permeable (or acoustical material) to less than or equal to (≤) 2.5".
    - If more than (>) 2.5" of vapor permeable (or acoustical material) is provided, the assembly must pass the hygrothermal performance test according to the protocol in the Moisture Risk Analysis & Assessment using WUFI (v1.0 or later)

Suspended floors with vapor permeable insulation (or acoustical material) that are not at risk to bulk water events from above (i.e. do not have plumbing fixtures or hot water tanks in a room above) and that are accessible from below for repair should follow the vapor control requirements for walls outlined in Appendix B-2.

Process tips:
For floors with vapor permeable insulation, over a crawl space or garage, or cantilevered over outdoor ambient conditions, hydrophobic insulation such as fiberglass or mineral wool, is preferable to cellulose. (drain-down strategy instead of buffering)

One situation that will usually fail the performance test is the case of vapor permeable insulation directly on a slab in a cold climate, or only a thin layer of rigid on the bottom and slab or ground directly below. These might pass in hot climates, but in cold climates there is a high risk that the floor would never dry out from a bulk water event, and repair could be expensive, requiring removal of interior walls.

Another situation of concern is the case of a crawlspace in a mixed climate with humid summers. In the summer these benefit from air-impermeable insulation on the bottom, as noted in (Lstiburek 2010). But with vapor permeable cavity insulation, this creates a tradeoff with moisture accumulation on the cold side of the cavity in the winter, and with the ability to dry from an indoor wetting event, unless the air-impermeable insulation is thick enough.

The use of vapor permeable insulation in floors is preferably limited to a thin layer near the inside for sound deadening purposes.

B-4.2 Below Grade Floor Assemblies

Locating all the insulation below the structure with a Class I vapor control layer between the structure and the insulation is the practical and economical manifestation of the perfect enclosure.

Process tips:
Some insulations provide the same level of vapor control (foil-faced polyiso or EPS, plastic-faced XPS) but many products will require a special low-permeance layer (polyethylene sheet is commonly used, inexpensive and effective).

If no impermeable floor finishes are likely to be used during the life of the structure, the vapor control class requirement can be relaxed to a Class II. See also BSI-003: Concrete Floor Problems and BSI-009: New Light in Crawl Spaces for more discussion of vapor control and flooring.

[64] Bulk water events include water heater failure, floods from dishwashers, clothes washers, sink/tub/toilet overflows, wet-pipe or dry-pipe sprinkler systems, but not incidental beverage spills or water lines to residential freezer ice-makers.

Appendix C - Additional Information for Raters & Verifiers

C-1 Phius Certified Rater and Verifier General Information

C-1.1 Definitions

Phius Certified Raters and Phius Certified Verifiers are certified professionals eligible to perform the on-site inspections and performance testing requirements for verification of all aspects of Phius Certification. The eligibility of each professional to inspect and verify a given project type depends on the designation: Rater or Verifier. Please visit our website through the links below to learn more about becoming a rater or verifier.

Phius Certified Rater or Phius Certified Verifier

For projects where no Phius Certified Verifier is within 200 miles of project, but a Phius Certified Rater is within 200 miles of the project, a Phius Certified Rater may serve as the Phius Certified Verifier on the project so long as they are approved by Phius for the project in question.

Non-Certified Inspectors:

Where no Phius certified professional is within 200 miles of a project, a project may elect to use a non-Phius certified professional to perform site inspections and testing if approved in advance of construction by Phius Staff.

Phius Certified Rater or Verifier Mentorship Letter of Attestation

C-1.2 Third Party Status

Phius Certified Raters and Phius Certified Verifiers cannot serve as the Phius Certified Consultant (CPHC) or builder on a project in which they are performing verification. However, another member of the Rater/Verifier's company may perform this scope with prior written approval, in advance of construction, from Phius certification staff.

C-1.3 How to Extend Your Credentials

Phius Certified Rater and Verifier credentials expire 3 years after their original certification date. For more information, please visit our website to Maintain Credentials.

C-2 Procedure to Prepare the Building for Airtightness Testing

C-2.1 Whole-Building Airtightness Testing

Whole-building infiltration testing shall be performed by the Phius Certified Rater/Verifier for each detached building in certification project. Testing shall be conducted using multi-point infiltration procedures as specified in Appendix C-2, as well as additional guidance specific to multifamily building testing included in the RESNET Guidelines for Multifamily Energy Ratings document.

If a single blower door fan is utilized for testing, the Rater/MF Verifier shall use an automated multi-point testing software such as The Energy Conservatory TECTITE or Retrotec Fantestic software. If multiple fans are used, it is recommended that the test be performed using a multi-fan control testing software such as The Energy Conservatory TECLOG software. Alternative testing methodologies proposed by the Rater/MF Verifier must be presented in writing to the Phius QA/QC Manager and will be considered on a case-by-case basis.

For attached multifamily housing developments without a common access point to perform testing of all building common spaces and dwelling units, achieving uniform test pressure from a single testing location will likely be impossible. This will often be the case for attached townhouse developments, or apartment buildings without common enclosed hallways with doorways connecting the dwelling units to the common space. In such cases, multi-zone whole building testing shall be required, which will necessitate the use of multiple fans set up in multiple testing locations to achieve uniform testing pressure throughout all building zones, and either a multi-fan control testing software must be utilized, or sufficient fan operators must be employed to achieve accurate testing results.

If the nature of the development is such that the number of fans and/or fan operators needed to achieve uniform multi-zone testing conditions to assess whole-building infiltration result is beyond the ability of the project to reasonably coordinate (example: a 20-unit attached townhouse development, which would require 20 simultaneously running blower door tests to create a uniform result), the project shall use the following testing protocol:

C-2.1.1 Individual zone, “unguarded” testing

Each unique building zone shall be tested individually, without adjusting the pressure of adjacent zones.

The test results shall be adjusted using the coefficients provided in the Guidance for modeling infiltration results for dwelling units in multifamily residential buildings section of the RESNET Guidelines for Multifamily Energy Ratings document.

All coefficient-adjusted test results for each individual zone shall be added together. The total sum of all project zone test results shall comply with the whole-building infiltration threshold.

C-2.1.2 Individual zone, “guarded” testing

In general, “guarded” blower door testing of individual dwelling units is undesirable due to a lack of confidence in the isolation of individual dwelling unit infiltration to outdoor results. However, certain cases may require implementation of such a strategy to isolate the infiltration to outdoors of an individual dwelling unit.

The strategy below shall only be allowed if an appropriate whole-building test is unable to be performed, and where dwelling units achieve the following prescriptive measures:

- All penetrations in dwelling unit enclosure shell shall be sealed, including pipes, wires, light fixtures, vent fans, duct/ventilation boots, light switches, electrical outlets, etc. so as to prevent leakage between the dwelling unit and other adjacent spaces.
- If electrical conduit is used to connect electrical fixtures or junction boxes, the conduit shall be sealed at each fixture or junction box to prevent air leakage within the conduit. Additionally, if each dwelling-unit contains an electrical service panel, the conduit leading from the service panel to outside of the dwelling unit shall be sealed.
- Dwelling unit bottom and top plates shall be sealed using appropriate sealing products, such as high-quality caulk, air sealing tape, foam gasket product, etc.
- Partition walls between dwelling units shall be capped at the top of the wall so as to prevent air leakage into the

interstitial ceiling cavity space. In addition, solid blocking material shall be installed above partition walls for the entire perimeter of the dwelling unit so as to create a sealed ceiling cavity space directly above the dwelling unit. Any wires, pipes, ducts or other penetrations running through this blocking shall be sealed so as to prevent leakage into adjacent building chase spaces.

- For dwelling units with attic space above, ideally a fully sealed partition wall would extend from the attic floor to the roofline so as to isolate the attic space of each dwelling unit. Where this is not possible or practical, Rater/MF Verifier measured zonal pressure testing shall be conducted while performing individual unit blower door tests to determine unit pressure connection to the attic space. The attic zonal pressure reading shall be 49 Pa or higher (more isolated) in comparison to the pressure within the dwelling unit while the dwelling unit is depressurized to -50 Pa.
- If the above criterion is met, the "guarded" testing strategy described below shall be accepted.
- Blower doors are installed in individual dwelling units to be tested. Blower door is also installed in each directly adjacent building zone surrounding the dwelling unit. (Example 1: A middle floor, interior apartment has 4 directly adjacent building zones – the unit above, the unit below, and the units on either side of the tested dwelling unit. Example 2: a townhouse end-unit has one directly adjacent building zone.)
- All fans are set to depressurize their respective zones to uniform test pressures. Multi-point testing shall be required and repeated for pressurization. The pressurization and depressurization results shall be averaged.
- This testing protocol shall be completed for all individual zones of the building. The averaged zone leakage rate for each individual zone shall be added together. The total sum of all project zone test results shall comply with the whole-building infiltration threshold.

C-2.1.3 Zone Linking Method

An additional alternative may be employed whereby attached multifamily dwellings without common corridors to link them together may be linked through an approved "zone linking" method.

Zone linking refers to connecting attached dwelling units together from a pressure perspective with some form of conduit connecting the zone of the building where the testing fan is installed and adjacent zones that will not have a testing fan installed.

Examples of zone linking methods include using well sealed flex duct and taped transitions into windows of adjacent spaces, or using duct work of central ventilation systems. Using these methods, several zones can be linked together from a pressure perspective, allowing whole-building testing to be performed.

Any method of zone linking used will be required to be documented with Phius prior to field execution. Once approved, the method may be used, but care must be taken during the test to ensure that all linked zones achieve the minimum testing pressure (i.e., a linked zone is depressurized to -50 Pa the same as the location of the testing fan). If consistent pressure cannot be maintained between zones (5 Pa) then either the conduit size must be increased in size, or additional fans may be required for testing to achieve consistent pressure.

C-2.2 Large Building Infiltration Testing

Verifiers are required to conduct a whole building airtightness test. For projects requiring multiple fans or complicated preparation, a testing plan must be submitted to Phius in advance for review.

Verifiers can use experienced testing professionals provided they supervise and witness the building preparation and testing. Phius is open to alternative methods of testing as long as a proposed Testing Plan is provided by the Verifier and in advance of testing Contact Us.

The building is to be prepared for testing in accordance with F-1 ANSI/RESNET/ICC Standard 380-2022 (or later versions) or The ABAA Standard Method for Building Enclosure Airtightness Compliance Testing.

C-2.3 Non-Threatening Air Leakage

Exception, for non-threatening air leakage:

If the airtightness criterion is missed, and the extra leakage can be proven to be due to a non-assembly-threatening leakage element, certification staff may allow that element to be taped off for the purpose of passing the airtightness criterion.

Projects with openings not listed below may request approval by Contacting Us to tape such items off prior to the airtightness test.

The un-taped test result must be used for the energy model.

Further details are subject to staff interpretation as detailed below.

Non-threatening leakage elements that may be taped upon Phius approval:

- Fire rated entry doors - leakage through operable components
- Entry doors with panic hardware requirements - leakage through operable components
- Entry door thresholds with universal accessibility requirements - leakage at threshold/sweep
- Elevator doors - leakage through operable components into shaft
- Dampers - leakage at seal
- Trash chutes and compactor systems, code required dampened openings like elevator shaft vents, gas meter room vents, coiling doors
- Direct vent gas fireplace – leakage through firebox
- Window mounted space conditioning unit – leakage through unit itself or through gasket inset in window glazing or window frame (some frames present durability risk and certifier has discretion to decline request for taping)

Non-threatening leakage elements already accounted for in the cfm/ft^2 gross envelope limit. May not be taped:

- Standard casement/TT/awning windows - leakage through operable components
- Standard lift and slide doors - leakage through operable components
- Standard Balcony/French doors – leakage through operable components
- Duct/vent leakage if fully exposed and in conditioned space

Threatening leakage sources. May not be taped.

- Window or door installation - leakage at rough opening
- Duct/vent/wiring - leakage at penetration of exterior wall
- Duct or vent - leakage inside assembly
- Exterior wall mounted space conditioning unit installation–leakage through rough opening

Phius Variance:

Barometric/spring loaded dampers on air moving equipment that operates continuously (more than 8000 hours per year) may be sealed for the direction of the test that they will be force-failed open by the test. Thus, fresh air intake dampers could be sealed during depressurization, while exhaust dampers could be sealed during pressurization. Review ANSI/RESNET/ICC Standard 380-2022 or ABAA Standard Method for Building Enclosure Airtightness Compliance Testing for further guidance.

Related Documents

Acceptable Airtightness of Walls in Passive Houses – Salonvaara and Karagiozis 2015

Background: Use of CFM_{50}/ft^2 Instead of ACH_{50}

The Phius Technical Committee goal was a clear standardized building enclosure metric for all buildings, large and small. ACH_{50} is not an equitable metric since the volume of a building does not scale at the same rate as surface area. Phius views the primary purpose of the airtightness threshold as the reduction of the risk of building assembly damage due to air-leakage driven moisture in super insulated assemblies with minimized mechanical systems, and energy efficiency as the secondary purpose.

Testing at 75 Pa aligns with commercial code (IBC, IECC) and U.S. Army Corps of Engineers (as well as U.S. General Services Administration Facilities Standards, ASTM E779, ASHRAE 90.1, and the National Building Code of Canada.)

C-2.4 On-Site Requirement Failures

Phius' Building Certification Programs are appealing for many reasons:

- They are built on best practices, and building science.
- They push the construction industry forward to provide energy efficient, healthy, resilient and comfortable buildings.
- The requirements have been designed to make passive building cost effective and achievable while granting relative flexibility in design.
- They provide guidance for the design, construction and on-site verification.

Phius' goal is to certify high-quality buildings that perform as designed. The review and certification process is built on a platform of accountability and the integrity of the standard is paramount.

The construction industry is not an exact science and on-site shortcomings and failures can happen. The following sections outline the process Phius requires project teams to follow if on-site failures are identified and cannot be rectified.

C-2.4.1 Phius Requirements

In the event of a Phius-specific requirement not being met, the project team shall reach out to Phius using the Contact Us form. The submission should include the Phius project number, identify the team members involved in the project (CPHC, CPHB, Rater, Verifier etc...), details on the nature of the requirement failure and outline the actions (if any) taken by the team to rectify the failure. Phius will communicate with the project team in an effort to rectify the failure without compromising the integrity of the certification.

C-2.4.2 Co-requisite Programs

Phius does not represent the government-run co-requisite programs and requires project teams working through the requirements of those programs to apply for waivers or allowances through those programs. Any waivers or allowances granted by the co-requisite programs must be communicated to Phius using the Contact Us form. The submission should include the Phius project number, identify the team members involved in the project (CPHC, CPHB, Rater, Verifier etc..), details on the nature of the waiver or allowance and relevant correspondence with the co-requisite program.

C-3 Sampling Protocol for Multifamily Projects

Phius accepts Sampling as a method for streamlining on-site verification by Phius Certified Verifier. If the project is being verified by a Phius Certified Verifier who is in good standing with a RESNET Sampling Provider, they shall have their plan for implementing Sampling approved by their Provider prior to Sampling being implemented. Where the Verifier is not a RESNET Rater working with a Sampling Provider, project Sampling plan must be submitted to Phius' QA/QC Manager for approval prior to implementation of Sampling.

For ventilation testing for Multifamily projects, Phius employs a sampling protocol to determine the type and number of dwelling units that need to be tested. Please visit the Phius Quality Assurance Workbook, specifically the ventilation tab, for the step by step protocol. The approved sampling plan shall be no less stringent than the protocol outlined in the Phius QA Workbook.

The following dwelling unit-level on-site verification measures are likely candidates for implementation of Sampling controls:

Compartmentalization testing

Duct system tightness testing

Ducted heating, cooling and ventilation air volume measurement and balancing

- If project has hired third-party air volume measurement and balancing professional other than the Rater/MF Verifier to conduct air volume measurement and balancing, Rater/MF Verifier shall be responsible for repeating the air volume measurement testing on 10% of dwelling units (maximum of 10, minimum of 3), whichever is greater. Any failures identified by the Rater/MF Verifier shall be corrected, and an additional unit shall be added to Rater/MF Verifier verified tally to ensure project failures are either isolated occurrences or are appropriately fixed.
- If a project has hired third-party professionals as described above, Rater/MF Verifier shall not be responsible for repeating common space ducted HVAC system air volume measurements. However, testing professionals shall submit documentation of this test to Rater/MF Verifier as described below.
- Please visit the Phius Quality Assurance Workbook, specifically the ventilation tab, for the step by step protocol or Contact Us for any specific questions.

ZERH hot water distribution efficiency test

Bedroom pressure balancing for units with ducted HVAC systems

- Per Phius standards, bedrooms shall also be pressure balanced to +/- 1 Pa for dwelling units with ducted ventilation systems

External static pressure testing of forced air heating and cooling systems.

Spot ventilation air volume measurements to comply with ES MFNC standards.

Verification of insulated assemblies, mechanical systems, lighting and appliances.

In addition to dwelling-unit-level measures, the Rater or Verifier may also implement a customized sampling plan for common space building envelope and mechanical system verification. A written plan for sampling of these additional measures must be submitted to qa@phius.org for review prior to execution.

Appendix D - Definitions & Glossary of Terms

D-1.1 Phius Glossary of Terms

Phius Glossary of Terms (coming soon!)

Common Spaces: The term ‘common space’ refers to any spaces that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration, or maintenance in support of the residents.

Process loads: Services being provided to a customer or client in the building. Whether it is the customer or client using the energy (eg. arcade, training center) or if the energy is used on their behalf (eg. commercial kitchen in a restaurant), both situations may qualify as process loads.

Space Conditioning: Each individual enclosure must be modeled separately, allocating the correct internal loads to each enclosure for accuracy of the internal heat calculation (ex: if all of the laundry is done in one building, the gains from this laundry should only be counted in that enclosure). The space conditioning targets (heating demand, heating load, cooling demand, cooling load) must be met for each enclosure in the separate energy models, and the airtightness requirements also apply for each enclosure individually.

Net Source Energy Allowance: If the campus/community is strongly/mainly residential in character the source energy allowance is proportional to the design occupancy. For non-residential day schools, commuter campuses and the like, the source energy allowance is per square foot of interior conditioned floor area (iCFA). See Table 1.3.4.1.1 for specific target values

Appendix E - Electrification Readiness for Combustion Equipment

Combustion equipment shall comply with the section below.

Combustion water heating:

(with a capacity less than or equal to 300 kBtu/h) shall be installed in accordance with the following:

1. A dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 3 feet from the water heater and be accessible to the water heater with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Heat Pump Water Heater" and be electrically isolated.
2. A condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet of the water heater.
3. The water heater shall be installed in a space with minimum dimensions of 3 feet by 3 feet by 7 feet high.
4. The water heater shall be installed in a space with a minimum volume of 700 cubic feet or the equivalent of one 16-inch by 24-inch grill to a heated space and one 8-inch duct of no more than 10 feet in length for cool exhaust air.

For systems with capacity greater than 300 kBtu/h, see 'Other combustion equipment' requirements at the end of this section.

Combustion space heating:

The building shall be provided with a designated exterior location(s) in accordance with the following:

1. Natural drainage for condensate from cooling equipment operation or a condensate drain located within 3 feet, and
2. A dedicated branch circuit in compliance with IRC Section E3702.11 based on heat pump space heating equipment sized in accordance with R403.7 and terminating within 3 feet of the location with no obstructions. Both ends of the branch circuit shall be labeled "For Future Heat Pump Space Heater."

Exception: Where an electrical circuit in compliance with IRC Section E3702.11 exists for space cooling equipment.

Combustion clothes drying:

A dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 6 feet of natural gas clothes dryers and shall be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Clothes Drying" and be electrically isolated.

Combustion cooking:

A dedicated 240-Volt, 40A branch circuit shall terminate within 6 feet of natural gas ranges, cooktops and ovens and be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Electric Range'' and be electrically isolated.

Other combustion equipment

Combustion equipment and end-uses not covered by sections above shall be provided with a branch circuit sized for an electric appliance, equipment or end use with an equivalent capacity that terminates within 6 feet of the appliance or equipment.

Appendix I - Informative

I-1 Process

I-1.1 Dropbox Basics

The following is a general list of tips created by the Phius certification team that aim to assist project teams in having an efficient and successful review and a well-documented project submission.

- The folder structure within the Dropbox is organized for consistency between projects and allows the Phius Building Certification Team to locate documentation quickly. Using the existing folder structure is strongly recommended.
- Uploading documents to the DropBox folder is not an indication to Phius that the project is ready for review. Project teams must submit the project into Phius' Review Queue as indicated in Phase 2.
- Track everything. The Phius Certification Feedback Form is the primary communication channel and is meant to act as a checklist for certification compliance. Any time anything has been changed in the model, it must be recorded. If the Phius reviewer identifies changed inputs with no justification, more questions may arise and the review process may become extended as a result.
- Likewise, when uploading new feedback, please give it a final run through to make sure that if you refer to new information, that those documents are in fact uploaded to the Dropbox - and that the noted adjustments to the energy model were implemented.
- Communication by phone or email can be used from time to time, but these outside discussions should be captured in the feedback form. Email correspondence should be documented via PDF and uploaded to the appropriate Dropbox subfolder.
- Include dates in the file naming conventions and archive old files (rather than deleting them) using the appropriate subfolders.
    - Files should be named in a logical manner (i.e. v1, v2, etc.). Avoid uploading files with filenames non-descriptive of the file content. Rename files when necessary, before uploading.

Example: Original file downloaded from online, file name 'k35fd8463yfh.pdf. Rename to 'Dishwasher ES Rating.pdf'

- Phius may ask for changes to the energy model even if it looks like the change will have a small impact, or in cases where there are two mistakes, but the net result is a wash. There are two reasons for this:
    1. Educational—on the next project it may make more of a difference and repeat mistakes should be avoided.
    2. Accuracy—improve the chances that the model will match actual energy use if the comparison is ever made.

I-1.2 Phius Portal Access & Submitting a Project

All Phius trained professionals, certified professionals and Phius Alliance members will automatically have access to the Phius Portal.

Projects should be submitted through the 'My Projects & Products' page using the 'Submit a Project' button. A six-digit Phius ID is required to submit a project.

- For individuals, who are not trainees, certified professionals or Alliance members that would like to submit a project for certification, a Project Submitter Profile must be created.
- Use this form to create a Submitter profile. A Phius ID will be assigned to you and sent to you via email, and you will be granted access to the Phius Portal to submit a project.

Any questions regarding Phius Portal access should be directed here.

I-1.3 Editing Project Public Listing

Project editing can be done through the Phius Portal under the 'My Projects & Products' tab.

- Phius is responsible for filling in all data shown on the 'Phius Project Data' tab of the portal.
- The project team is responsible for entering the data for all of the remaining tabs that appear in the project listing.

Please review this blog post for additional information.

I-2 Tips for Passive Building Design

I-2.1 Tips to Design a Low-Cost Passive Building

- Keep the thermal envelope simple (add "architectural interest" outside of it).
- Keep window area down (10-15% of wall area for single-family houses).
- For small buildings, design a compact shape.
- For large buildings, bump-ins for daylighting may be more important.
- Limit "open to below" areas on the floor.
- Not too "tiny" and detached – design attached housing with small units instead.
- Use details that do not require excessive labor to air-seal (avoid "conceptual retrofitting").

I-2.2 Tips on Assemblies

Air Barrier

Mid-wall is the best place for the air barrier. Exterior/interior placement is more vulnerable.

Perfect Wall

Keep in mind the "perfect wall" concept - structure to the inside, insulation to the outside. Diffusion open or exterior rigid foam, both versions can work moisture-wise and super-insulated.[65],[66]

Slab Construction

Moisture barrier and air barrier are typically placed between the foam layer and slab.

Polyisocyanurate (PolyIso) insulation is typically not to be used below grade.[67] Thoroughly follow the application guidance of the manufacturer's warranty and any ICC Evaluation Service report that pertains.

---

[65] Lstiburek, Joseph. BSI-001: The Perfect Wall. Building Science Corporation, 15 July 2010. Web. 16 May 2016.

[66] BSI-091: Flow-Through Assemblies. Building Science Corporation, 13 Jan. 2016. Web. 16 May 2016.

[67] Home » Green Basics: Encyclopedia » Envelope and Structure » Insulation Choices » Rigid Foam Insulation. Green Building Advisor. The Taunton Press, 9 Aug. 2012. Web. 16 May 2016.

I-2.3 Tips on Windows

Window Certification Program

It is generally recommended to follow the zone-by-zone guidelines on the Phius Certified Data for Window Performance Program page and to review Phius' requirements for window comfort and to avoid condensation risk.

Window Condensation

Regarding Exception 3 of N-3: Supplying heat at the room edge would not necessarily solve condensation problems - if there is a significant window niche the warm convection flow would tend to bypass it and leave the corners cold and stagnant. The condensation risk requirements cannot be met through supplemental heating. Windows should not need additional heating to prevent condensation.

Window Comfort

Regarding Exception 3 of N-3: Supplying heat at the room edge is a non-passive approach; it may not work, and this is harder to calculate. This tactic should help from a comfort point of view. but it is less clear that it would solve a condensation problem - if there is a significant window niche the warm convection flow would tend to bypass it and leave the corners cold and stagnant. The condensation risk requirements cannot be met through supplemental heating. Windows should not need additional heating to prevent condensation.

I-2.4 Tips on Ventilation

Exhaust Ventilation Devices

Consider moving an exhaust dryer to the mudroom or outside the thermal envelope.

Make-up air for a directly vented range hood is acceptable as long as the total meets the source energy requirements. If a make-up air system is planned then it can be tied directly to a vented dryer as well, i.e. it comes on when the dryer is running and venting. Refer to the Intermittent Exhaust Allowance Calculator.

Ventilation Fresh Air Supply

Dedicated ventilation ductwork is best practice.

Taking the supply air from above the roof is generally not recommended, because of the possibility of excessive heat and hot-roof odor.

MERV 12 or higher is recommended for filtration of the ventilation air.

When outdoor PM2.5 is >40, it is recommended to use a MERV 16 or HEPA filter on outdoor air duct to yield an indoor PM2.5 <12[68]

Ventilation System Capacity

It is recommended that the ventilation system be capable of at least 0.3 ACH based on the net volume at its maximum setting.

I-2.5 Fireplaces

In an airtight house there is great danger of back drafting or for the fireplace/stove using the interior air for combustion. The combustion intake air must be directly from the outdoors and independent of the interior air supply. Warning systems should be considered such as carbon monoxide detectors or depressurization sensors. If the building gets depressurized for some reason (one of the ventilator fans fails and the defect goes

[68] Selecting Ventilation Air Filters to Reduce PM2.5 Of Outdoor Origin. ASHRAE Journal. September 2016.

unnoticed) then, despite of all the precaution of airtight fire box and dedicated combustion air, back drafting could still occur and draw potentially life-threatening gasses into the interior of the building.

I-3 Modeling Protocol

I-3.1 Default Fastener Deration Values

Table I-3.1.0 Fastener Correction Derations		
Fastener Material	**Continuous Insulation Thickness**	**Deration Requirement**
Stainless Steel	<4"	Derate R/in by 10%
	≥4"	Derate R/in by 15%
Mild Steel	<4"	Derate R/in by 25%
	≥4"	Derate R/in by 35%
Plastic or Thermally Broken	No fastener correction required	
Aluminum	Fastener Correction Calculator required.	

Process Tips:

- Project teams may submit a project-specific Fastener Correction Calculator for certification compliance.
- The % deration should be applied to the R/in of the exterior rigid continuous insulation layer in the WUFI assembly.

I-3.2 Source Energy

The metric used for this criterion is net source energy use. The overall energy limit is based on source energy because that is a good measure of the impact the building's operation has on society. That impact consists mostly of CO_2 emissions, but the source energy metric differs from carbon-scoring in that it includes the impact of nuclear power as well.

Source Energy Factors for Grid Electricity

In past versions of the Phius certification program, the source-site ratio for grid electricity was defined by the Energy Star Portfolio Manager and was determined based on past generation and consumption data from the Energy Star Portfolio Manager.

Phius uses a source energy factor for grid electricity that reflects a future outlook. The intent is to reflect future conditions more appropriately and to better weigh the impact of using electricity versus natural gas on-site. For projects in the US, Phius 2024 uses a source energy factor based on a projected 2050 electricity generation mix. This future source energy factor was calculated from NREL's MidCase scenario in 2050, as reported in their 2020 Standard Scenario Report. This report details the future grid generation resource mix based on policies that were in place as of June 30, 2020. A full calculation methodology report can be found in the Tech Corner Article: Phius 2021 Future Electricity Source Energy Factors.

2050 is the furthest year out that the data is projected to and is roughly a midpoint on the anticipated life of a building built today.

Net Zero Source Energy

For an all- electric building, the same on-site PV array (or PPA, etc) that gives site zero also gives source zero. It is different if the building uses other fuels - for example if the building made heavy use of biomass for heating, the overall source/site ratio of its usage might be only 1.5, while the source/site ratio of the PV is 1.8. Therefore, on that building the PV array size for source zero would be smaller than the array size for site zero, because of the additional source-reduction strategy.

In setting the source energy limit to zero, it is unproductive to put the entire burden on the building and its on-site production potential. Doing so may push past the point of diminishing returns in energy conservation or prohibit projects with constrained sites from ever achieving this goal. At some point, the building has conserved and generated all it can, and the focus will shift to cleaning up the energy supply.

I-3.3 Airtightness Conversion

The example below demonstrates a conversion from cfm50/ft^2 to ACH50.

Example:
Total envelope area = 6,958 ft^2
Net volume = 19,387 ft^3
6,958 ft2 * (0.05 ft^3/min)/ft^2) * (60 min/hr.) * (1/19,387 ft^3) = 1.08 ACH50

I-3.4 Maximum Humidity Ratio

It is the upper limit for humidity levels according to the comfort standard ASHRAE 55-2004. This is essentially a humidity set-point. At 77 F this value corresponds to approximately 60% relative humidity.

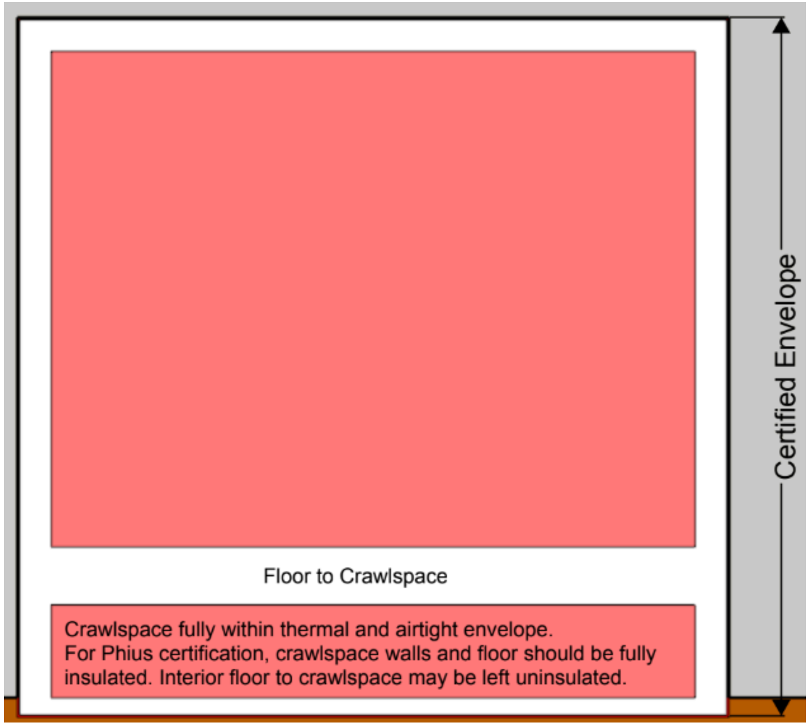
I-3.5 Domestic Hot Water Use Per Person

Remember, these are "hot gallons" (140 F). It calculates the energy to raise the water from the incoming water temperature (default 50 F) to 140 F, a 90 F rise. When mixed down to a temperature a person would want to shower under, it goes almost twice as far in terms of volume.

I-3.6 Foundation Interface

Per Indoor airPLUS Construction Specifications Version 1 (rev. 04), *Section 1.4: Basement and Crawlspace Insulation and Conditioned Air*, there are limited options for how to treat crawlspaces. The following graphics for modeling crawlspaces via the foundation interface, and their corresponding IAP excerpts below demonstrate the exhaustive list of options available for crawlspaces in Phius projects:

Crawlspace Option 1 (IAP Requirements):



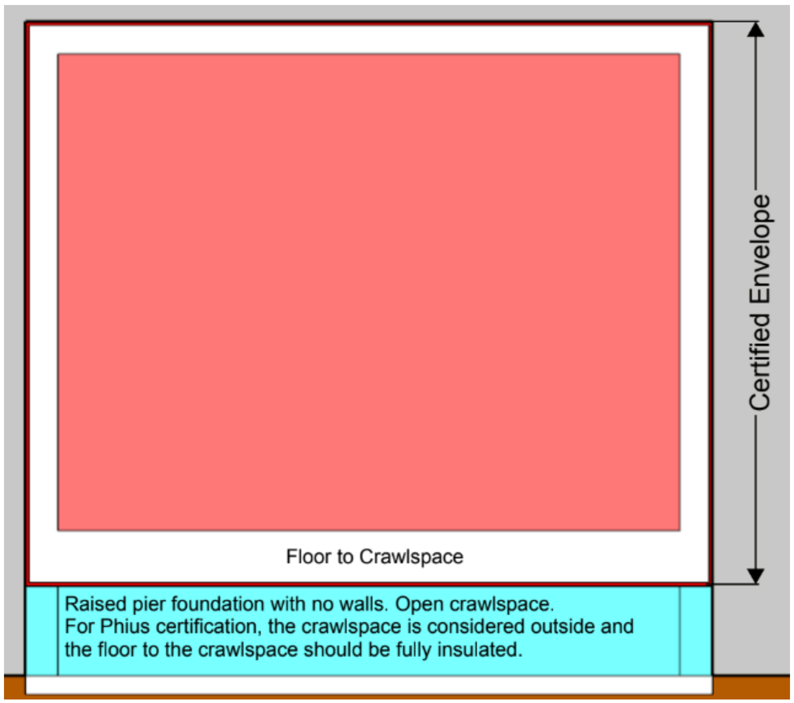
Foundation Interface Options (for WUFI:

- Slab on grade OR
- Heated basement (only if crawlspace walls are below grade)

Indoor airPlus Version 1 (rev. 04):

- *Seal crawlspace and basement perimeter walls to prevent outside air infiltration*
- *Insulate crawlspace and basement perimeter walls according to the prescriptive values determined by local code, or R-5, whichever is greater*
- *Provide conditioned air at a rate of not less than 1 cfm per 50 sf of horizontal floor area. This can be achieved by a dedicated supply (2015 IRC section R408.3.2.2) or through crawl-space exhaust (2015 IRC section R408.3.2.1). However, if radon resistant features are required (see Specification 2.1), do not use the crawlspace exhaust method.*

Crawlspace Option 2 (IAP Exceptions):



Foundation Interface (for WUFI):

- None
- The 'Outer side' attachment for the floor component in WUFI should be 'Outer air'

Indoor airPlus Version 1 (rev. 04):

- *Homes built in areas designated as 100-year flood zones. (Conditioned crawlspaces are not recommended for use in flood zones. For more information on designated 100-year flood zones, see FEMA's definition of Special Flood Hazard Areas: https://www.fema.gov/flood-zones).*
- *Raised pier foundations with no walls*
- *Dry climates, as defined by 2015 IECC Figure 301.1.*
- *Marine climates, as defined by 2015 IECC Figure 301.1, if no air handler or return ducts are installed in the crawlspace*

I-3.7 Net Volume

The net volume can be used as an indicator of how many mechanical air changes are provided for the building and can be a useful metric. If a calculation is done, determine the building's interior volume (drywall to drywall floor to ceiling, wall to wall) minus volume taken up by interior walls and floor systems.

I-3.8 Specific Heat Capacity/Thermal Mass

Guidelines for Accounting Heavy Surfaces

- ½" Drywall = 0 heavy surfaces
- ⅝" drywall = 0.34 heavy surfaces
- Double or high-density drywall = 0.5 heavy surfaces
- Flagstone/tile = 0.5 heavy surfaces
- ≥2" concrete or phase-change materials = 1 heavy surface

Example:
Concrete floor = 1 heavy surface
Other 5 surfaces = 0.34 each = 1.7 heavy surfaces
Total n (heavy surfaces) = 2.7
Specific capacity = (60+2.7*24) *0.176 = 21.96 BTU/ft2F

I-3.9 Default Materials Database

Table I-3.8.1 Construction Materials

Construction Material Type	R-Value/inch	THERM input [BTU-in/hr.ft^2.F]
Aerated Concrete (AAC)	1.15	0.87
Brick	0.360	2.778
Concrete	0.085	11.765
Concrete Masonry Unit (CMU)	0.197	5.076
Wood Framing	1.60	0.625
Gypsum Wall Board	0.88	1.136
Oriented Strand Board (OSB)	1.11	0.901
Plywood	1.11	0.901

Table I-3.8.0 Insulation Materials

Insulation Type	R-Value/inch	THERM input [BTU-in/hr.ft^2.F]
Expanded Polystyrene (EPS)	4.0	0.250
Extruded Polystyrene (XPS)	5.0	0.200
Fiberboard (FB)	3.0	0.333
Graphite Polystyrene (GPS)	5.0	0.200
Mineral Wool Board (MWB)	4.0	0.250
Cellulose (Dense-Pack)	3.6	0.278
Closed-Cell Spray Polyurethane Foam (CCSPF)	5.8	0.172
Fiberglass (High-Density)	3.6	0.278
Mineral Wool Batt	3.6	0.278
Polyisocyanurate (PolyIso)	6.0	0.167
Wood Fiber	3.6	0.278
Cellulose (Loose-Fill)	3.3	0.303
Fiberglass Batt (Low-Density)	3.3	0.303
Open-Cell Spray Polyurethane Foam (OCSPF)	3.6	0.278

Process Tip: Under Options >Preferences > Conductivity Units and ensure 'BTU-in/hr.ft2.F' is selected.

I-3.10 Blinds

Insulated Interior Blinds

Unless the blind is air sealed to the window opening and is airtight, much of the insulating value of the blind can be bypassed. Because of this, we are giving credit for essentially, the R-value of the two air films on either side of the blind and not the blind itself. We generally round this to R-2 in IP units. We also assume that user behavior impacts the use of the blinds and that somewhere around half the time, the blinds are not in the right spot, or are removed. Therefore, we currently allow an R-1 adjustment to be made directly to the glass R-value and the Frame R-value. One word of caution is that if they do work as intended/advertised, there is a significant risk of condensation on the window in cold climates, which over time could lead to problems and durability issues. This must be checked and managed.

I-3.11 ASHRAE Fundamentals 2017 Non-Residential Equipment Tables

Table 8A: Recommended Heat Gain for Typical Desktop Computers

Table 8B: Recommended Heat Gain for Typical Laptops and Laptop Docking Stations

Table 8C: Recommended Heat Gain for Typical Tablet PC

Table 8D: Recommended Heat Gain for Typical Monitors

Table 9: Recommended Heat Gain for Typical Printers

Table 10: Recommended Heat Gain for Miscellaneous Equipment

Table 11: Recommended Load Factors for Various Types of Offices

Table 12: Diversity Factor for Different Equipment

Table 8A Recommended Heat Gain for Typical Desktop Computers

Description	Nameplate Power,[a] W	Peak Heat Gain,[b,d] W
Manufacturer 1		
3.0 GHz processor, 4 GB RAM, n=1	NA	83
3.3 GHz processor, 8 GB RAM, n=8	NA	50
3.5 GHz processor, 8 GB RAM, n=2	NA	42
3.6 GHz processor, 16 GB RAM, n=2	NA	66
3.3 GHz processor, 16 GB RAM, n=2	NA	52
4.0 GHz processor, 16 GB RAM, n=1	NA	83
3.3 GHz processor, 8 GB RAM, n=1	NA	84
3.7 GHz processor, 32 GB RAM, n=1	750	116
	NA	102
3.5 GHz processor, 16 GB RAM, n=3[c]	550	144
	NA	93
Manufacturer 2		
3.6 GHz processor, 32 GB RAM, n=8	NA	80
3.2 GHz processor, 16 GB RAM, n=1	NA	78
3.4 GHz processor, 32 GB RAM, n=1	NA	72
3.4 GHz processor, 24 GB RAM, n=1	NA	86
3.5 GHz processor, 4 GB RAM, n=1	NA	26
3.3 GHz processor, 8 GB RAM, n=1	NA	78
3.2 GHz processor, 8 GB RAM, n=1	NA	61
3.7 GHz processor, 4 GB RAM, n=1	NA	44
2.93 GHz processor, 16 GB RAM, n=1	NA	151
2.67 GHz processor, 8 GB RAM, n=1	NA	137
Average 15-min peak power consumption (range)	82 (26-151)	

Source: Bach and Sarfraz (2017)

n= number of tested equipment of same configuration.

[a] Nameplate for desktop computer is present on its power supply, which is mounted inside desktop, hence not assesible for most computers, where NA = not available.

[b] For equipment peak heat gain value, highest 15-min interval of recorded data is listed in tables.

[c] For tested equipment with same configuration, increasing power supply size does not increase average power consumption.

[d] Approximately 90% convective heat gain and 10% radiative heat gain.

Table 8B Recommended Heat Gain for Typical Laptops and Laptop Docking System			
Equipment	Description	Nameplate Power, [a] W	Peak Heat Gain, [b,c] W
Laptop computer	Manufacturer 1,		
	2.6 GHz processor, 8 GB RAM, n=1	NA	46
	Manufacturer 2,		
	2.4 GHz processor, 4 GB RAM, n=1	NA	59
Average 15-min peak power consumption (range)		61 (26-151)	
Laptop with docking station	Manufacturer 1,		
	2.7 GHz processor,8 GB RAM, n=1	NA	38
	1.6 GHz processor, 8 GB RAM, n=2	NA	45
	2 GHz processor, 8 GB RAM, n=1	NA	50
	2.6 GHz processor, 4 GB RAM, n=1	NA	51
	2.4 GHz processor, 8 GB RAM, n=1	NA	40
	2.6 GHz processor, 8 GB RAM, n=1	NA	35
	2.7 GHz processor, 8 GB RAM, n=1	NA	59
	3.0 GHz processor, 8 GB RAM, n=3	NA	70
	2.9 GHz processor, 32 GB RAM, n=3	NA	58
	3.0 GHz processor, 32 GB RAM, n=1	NA	128
	3.7 GHz processor, 32 GB RAM, n=1	NA	63
	3.1 GHz processor, 32 GB RAM, n=1	NA	89
Average 15-min peak power consumption (range)		61 (26-151)	

Source: Bach and Sarfraz (2017)
n= number of tested equipment of same configuration.
[a]Voltage and amperage information for laptop computer and laptop docking station is available on power supply nameplates; however, nameplate does not provide information on power consumption, where NA = not available.
[b]For equipment peak heat gain value, highest 15-min interval of recorded data is listed in tables.
[c]Approximately 75% convective heat gain and 25% radiative heat gain.

Table 8C Recommended Heat Gain for Typical Tablet PC		
Description	**Nameplate Power, [a] W**	**Peak Heat Gain, [b] W**
1.7 GHz processor, 4 GB RAM, n=1	NA	42
2.2 GHz processor, 16 GB RAM, n=1	NA	40
2.3 GHz processor, 8 GB RAM, n=1	NA	30
2.5 GHz processor, 8 GB RAM, n=1	NA	31
Average 15-min peak power consumption (range)	36 (31-42)	

Source: Bach and Sarfraz (2017)
n= number of tested equipment of same configuration
[a]Voltage and amperage information for tablet PC is available on power supply nameplates; however, nameplate does not provide information on power consumption, where NA = not available.
[b]For equipment peak heat gain value, highest 15-min interval of recorded data is listed in tables.

Table 8D Recommended Heat Gain for Typical Monitors

Description[a]	Nameplate Power, W	Peak Heat Gain,[b,c] W
Manufacturer 1		
1397 mm LED falt screen, n=1 (excluded from average because atypical size)	240	50
686 mm LED flat screen, n=2	40	26
546 mm LED flat screen, n=2	29	25
Manufacturer 2		
1270 mm 3D LED flat screen, n=1 (excluded from average because atypical size)	94	49
Manufacturer 3		
864 mm LCD curved screen, n=1 (excluded from average vecause atypical size and curved)	130	48
584 mmLED flat screen, n=3	50	17
584 mm LED flat screen, n=1	38	21
584 mm LED flat screen, n=1	38	14
Manufacturer 4		
610 mm LED flat screen, n=1	42	25
Manufacturer 5		
600 mm LED flat screen, n=1	26	17
546 mm LED flat screen, n=1	29	22
Manufacturer 6		
546 mm LED flat screen, n=1	28	24
Average 15-min peak power consumption (range)	21 (14-26)	

Source: Bach and Sarfraz (2017)
n= number of tested equipment of same configuration.
[a]Screens with atypical size and shape are excluded for calculating average 15-min peak power consumption.
[b]For equipment peak heat gain value, highest 15-min interval of recorded data is listed in tables.
[c]Approximately 60% convective heat gain and 40% radiative heat gain.

Table 9 Recommended Heat Gain for Typical Printers

Equipment	Description	Max. Printing Speed, Pages per Minute	Nameplate Power, W	Peak Heat Gain,[a] W
Multifunction printer (copy, print, scan)	Large, multiuser, office type	40	1010	540 (Idle 29 W)
		30	1300	303 (Idle 116 W)
		28	1500	433 (Idle 28 W)
Average 15-min peak power consumption			425 (303-540)	
	Multiuser, medium-office	35	900	732 (Idle 18 W)
	Desktop, small-office type	25	470	56 (Idle 3 W)
Monochrome printer	Desktop, medium-office type	55	1000	222
		45	680	61
Average 15-min peak power consumption			142 (61-222)	
Color printer	Desktop, medium-office type	40	620	120
Laser printer	Desktop, small-office type	14	310	89
		24	495	67
		26	1090	65
Average 15-min peak power consumption			74 (65-89)	
Plotter	Manufacturer 1		1600	571
	Manufacturer 2		270	173
Average 15-min peak power consumption			372 (173-571)	
Fax machine	Medium		1090	92
	Small		600	46
Average 15-min peak power consumption			69 (46-92)	

Source: Bach and Sarfraz (2017)
[a]Approximately 70% convective heat gain and 30% radiative heat gain.

Table 10 Recommended Heat Gain for Miscellaneous Equipment

Equipment	Nameplate Power,[a] W	Peak Heat Gain,[b] W
Vending machine		
Drinks, 280 to 400 items	NA	940
Snakcs	NA	54
Food (e.g., for sandwiches)	NA	465
Thermal building machine, 2 single documents up to 340 pages	350	28.5
Projector, resolution 1024 x 768	340	308
Paper shredder, up to 28 sheets	1415	265
Electric stapler, up to 45 sheets	NA	1.5
Speakers	220	15
Temperature-controlled electronics soldering station	95	16
Cell phone station	NA	5
Battery charger		
40 V	NA	19
AA	NA	5.5
Microwave oven, 7 to 9 gal	1000 to 1550	713 to 822
Coffee maker		
Single cup	1400	385
Up to 12 cups	950	780
With grinder	1350	376
Coffee grinder, up to 12 cups	NA	73
Tea kettle, up to 6 cups	1200	1200
Dorm fridge, 3.1 ft^3	NA	57
Freezer, 18 ft^3	130	125
Fridge, 18 to 28 ft^3	NA	387 to 430
Ice maker and dispenser, 20 lb. bin capacity	NA	658
Top mounted bottled water cooler	NA	114 to 350
Cash register	25	9
Touch screen computer, 15 in. standard LCD and 2.2 GHz processor	NA	58
Self-checkout machine	NA	15

Source: Bach and Sarfraz (2017)

[a] For some equipment, nameplate power consumption is not availbale, where NA= not available.

[b] For equipment peak heat gain value, highest 15-min interval of recorded data is listed in tables.

Table 11 Recommended Load Factors for Various Types of Offices

Type of Use	Load Factor*, W/ft^2	Description
100% laptop, docking station		
light	0.34	167 ft^2/workstation, all laptop docking station use, 1 printer per 10
medium	0.46	125 ft^2/workstation, all laptop docking station use, 1 printer per 10
50% laptop, docking station		
light	0.44	167 ft^2/workstation, 50% laptop docking station use/50% desktop, 1 printer per 10
medium	0.59	125 ft^2/workstation, 50% laptop docking station use/50% desktop, 1 printer per 10
100% desktop		
light	0.54	167 ft^2/workstation, all desktop use, 1 printer per 10
medium	0.72	125 ft^2/workstation, all desktop use, 1 printer per 10
100% laptop, docking station		
2 screens	0.69	125 ft^2/workstation, all laptop docking station use, 2 screens, 1 printer per 10
100% desktop		
2 screens	0.84	125 ft^2/workstation, all desktop use, 2 screens, 1 printer per 10
3 screens	0.96	125 ft^2/workstation, all desktop use, 3 screens, 1 printer per 10
100% desktop		
heavy, 2 screens	1.02	85 ft^2/workstation, all desktop use, 2 screens, 1 printer per 8
heavy, 3 screens	1.16	85 ft^2/workstation, all desktop use, 3 screens, 1 printer per 8
100% laptop, docking station		
full on, 2 screens	1.14	85 ft^2/workstation, all laptop docking use, 2 screens, 1 printer per 8, no diversity
100% desktop		
full on, 2 screens	1.33	85 ft^2/workstation, all desktop use, 2 screens, 1 printer per 8, no diversity
full on, 3 screens	1.53	85 ft^2/workstation, all desktop use, 3 screens, 1 printer per 8, no diversity

Source: Bach and Sarfraz (2017)

*Medium-office type monochrome printer is used for load factor calculator with 15-min peak power consumption of 142 W.

Table 12 Diversity Factor for Different Equipment		
Equipment	Diversity Factor, %	Diversity Factor,[a] %
Desktop PC	75	75
Laptop docking station	70	NA
Notebook computer	75[b]	75
Screen	70	60
Printer	45	NA

Source: Bach and Sarfraz (2017)

[a] 2013 *ASHRAE Handbook-Fundamentals*

[b] Insufficient data from RP-1742; values based on previous data from 2013 *ASHRAE Handbook-Fundamentals* and judgement of Bach and Sarfraz (2017).

I-3.12 Method for Evaluating when a Cooling System is Recommended

Some designers are against the use of cooling systems, and indeed, in regard to the building code, the "cooling-is-a-luxury" perspective survived the introduction of air-conditioning. North American building codes do not require a cooling system in any climate, nor do the U.S. Energy Star requirements which are part of the Phius certification program.

Process Tip: The question of when to design in a cooling system could be decided with reference to ASHRAE 55. Clause 5.4 lays out the procedure for determining Acceptable Thermal Conditions in Occupant-Controlled Naturally Conditioned Spaces, based on the climate.

Reviewing the daily mean outside temperatures in the hottest part of the year, calculates a running average, and then from a graph/formulas determines the acceptable range of indoor operative temperature, which cannot be any higher than 89 F regardless of climate. The formula for the upper limit is:

0.31 * Tpma-out + 60.5 F

Tpma-out: The "prevailing mean outdoor temperature". This value must be less than 92.3 F. (There is also a lower limit which is 12.6 F cooler.)

- Up to another 4.0 F can be added to the upper limit if increased air speed of 236 fpm can be provided (with fans).

For the Tpma-out calculation the language of ASHRAE 55 prefers TMY3 or actual daily weather data, but monthlies are allowed if those are not available. Seven to thirty days of averaging is acceptable.

Example: In Dubuque, Iowa, picking in the middle at 18 days (432 hours) and running the average, Tpma-out tops out at 73.9 F which is a little warmer than the 70.2 maximum in the monthly file.

This makes the upper operative temperature limit (Top):

- Top = 0.31 * 70.2 + 60.5 = 82.2 F, by monthly data maximum
- Top = 0.31 * 73.9 + 60.5 = 83.4 F, by TMY3 18-day running average

Going by the monthly, then with the air speed adjustment the limits are

- Top = 82.2 + 2.2 = 84.4 F, for air speed 118 fpm
- Top = 82.2 + 3.2 = 85.4 F, for air speed 177 fpm
- Top = 82.2 + 4.0 = 86.2 F, for air speed 236 fpm

Process Tip: It may be fair to credit the 118 fpm if there are any ceiling fans. U.S. Energy Star ratings for ceiling fans report air flow in cubic feet per minute, which can be converted to fpm directly under the fan using the fact that the test duct is a cylinder eight inches larger in diameter than the fan. Air speed in the room could be then estimated from consideration of the room cross section compared to the fan.

I-3.12.1 Protocol to decide on providing a cooling system

A cooling system may reasonably be foregone if all of the following conditions are met:

- Representative occupants have metabolic rates ranging from 1.0 to 1.3 met.
- Representative occupants are free to adapt their clothing to the indoor and/or outdoor conditions within a range at least as wide as 0.5 to 1.0 Clo.
- The prevailing mean outdoor temperature Tpma-out (monthly max) is greater than 50 F and less than 92.3 F.
- WUFI Passive model calculates no cooling load with a cooling set point of 0.31 * Tpma-out + 60.5 F (plus 2.2 F if there are ceiling fans).
    - Input the upper-limit temperature into the building's WUFI Passive energy model as a cooling set-point.
    - Natural ventilation for day/night may be modeled, but no higher than B.A. protocol allows as outlined in Section 1.4.4.10 Summer Ventilation.

The conditions on the representative occupants might always be assumed true for residential but might not be for nonresidential. However, as noted above, residential occupancies are demographically more likely to be occupied by sensitive people than workplaces, so a cooling system is more strongly advisable for residential.

I-3.12.2 Passive Cooling Protocol when no Active Cooling System is Provided

ACH via natural ventilation (day):

For Phius Certification:

0.1 ACH default may be used for daytime ventilation.

Exception: A project-specific calculation may be run.

Click the [...] in the far right of the cell in WUFI to expand the built-in calculator required to complete this section. Enter the relevant groups of operable windows in one column. A second window group is allowed for stack effect and cross ventilation for daytime ventilation.

Default settings noted below should be used:
Fraction of opening duration: 0.43 (or less)
Temperature Difference Interior-Exterior [F]: 7.2 (or less)
Wind Velocity [ft/s]: 6.5

ACH via natural ventilation (night):

Be cautious and realistic with the amount of natural ventilation being accounted for towards cooling. There are two main concerns with the amount of cooling:

1. Humidity - look for dew point temperature in the Climate Data. In many climates in the United States, there are high levels of humidity in the cooling situations.
2. The built-in summer ventilation calculator can generate quite high air change rates, but during the night usually interior doors are closed so that cross ventilation is cut off.

For Phius Certification:

0.3 ACH default may be used for nighttime ventilation.

Exception: A project-specific calculation may be run following Building America House Simulation Protocol, which states: 33% of the open-able windows are opened. This can happen 3 days a week (M, W, F), which would translate to a fraction of opening duration of 43%, Or 10.3 hrs/day.

Click the [...] in the far right of the cell in WUFI to expand the built-in calculator required to complete this section. Enter the relevant groups of operable windows in one column. A second window group is allowed for night ventilation only if there are no intervening doors.

Default settings noted below should be used:
Fraction of opening duration: 0.43 (or less)
Temperature Difference Interior-Exterior [F]: 1.8 (or less)
Wind Velocity [ft/s]: 0

I-3.13 DHW Distribution Calculation Methods

Simplified hot water piping calculator:

This setting may be used early in design, but is not accepted for design nor final certification. For early design, update values noted below on the 'Hot water piping' tab.

- Pipe material: Select the pipe material used. More information can be found in Appendix N-10.
- Pipe diameter: Nominal pipe diameter in inches.
- Number of bathrooms: Sum of all bathrooms in a building covered by the DHW device in this 'System'.

I-4 - Data Monitoring

I-4.1 Monitoring

Post occupancy energy monitoring is highly recommended, however, Phius does not require it for certification. A main reason for this is because it is highly dependent on occupant behavior. Phius certifies projects based on values that assume how occupants would behave, but most times occupant behavior cannot be controlled by the designer.

By gathering actual performance data – in the form of utility bills or from monitoring systems – Phius can improve modeling protocols and refine the practices used by all parties involved in the certified project, including component manufacturers. This may also provide insight into the intricacies of climate specific design and its financial implications for the passive building owner.

I-4.1.1 Monitoring Protocol

Phius has released draft monitoring protocol which defines background information on:

- The purpose of monitoring
- Research questions that guide selection of data points to monitor
- Various tiers of equipment to use based on project budget
- Roles and responsibilities of planning and executing a successful monitoring plan from design through construction to post occupancy.

The monitoring protocol will continue to develop as Phius gains more insight and experience on collecting data from certified projects.

I-4.1.2 Monitoring Your Project

Contact Us if:

- You have a project in design-phase that is interested in participating in Phius' monitoring program.
- You are willing to share monitored data for a Phius Certified project.

Appendix N - Normative

N-1 Mixed-Use Project Calculations

N-1.1 Source Energy Compliance

The following equation shall be used to demonstrate compliance with the source energy limit for mixed-use projects that include finished non-residential spaces following A) Whole Building Certification - One combined certification for Residential and Non-Residential.

$$\left(SE\ Use_{res} * Occ_{res} * 3.412\frac{kBTU}{kWh}\right) + \left(SE\ Use_{non-res} * iCFA_{non-res}\right) \leq$$
$$\left(SE\ Limit_{res} * Occ_{res} * 3.412\frac{kBTU}{kWh}\right) + \left(SE\ Limit_{non-res} * iCFA_{non-res}\right) + PLA$$

Table N-1.1.1 Factor Nomenclature	
$SE\ Use_{res}$	Residential Source Energy use in kWh/person.yr
Occ_{res}	Residential occupant quantity
$SE\ Use_{non-res}$	Non-Residential Source Energy use in kBTU/ft^2.yr
$iCFA_{non-res}$	Non-residential iCFA
$SE\ Limit_{res}$	Residential Source Energy limit in kWh/person.yr
$SE\ Limit_{non-res}$	Non-Residential Source Energy limit in kBTU/ft^2.yr
PLA	Process Load Allowance (case by case basis)

Process Tip: Projects with unfinished spaces following the UF protocol do not have a source energy limit and therefore mixed-use projects that include unfinished spaces do not have an additional allowance or target outlined in the calculation above.

ASHRAE 90.1-2010 Process Energy Definition:
Energy consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for the occupants of a building.

Process load allowances only apply to the source energy limit. They do not influence the space conditioning limits.

The source energy allowance may include the energy use from an increased space conditioning load caused by that process load.

Example: A commercial kitchen requiring direct exhaust range hoods. The source energy allowance is calculated as a combination of the increased heating energy consumption caused by the exhaust and makeup air and the fan energy associated with operating the range hoods.

For unique non-residential/commercial buildings with significant process loads, very high internal loads, or highly variable occupancy, custom optimization may need to be completed to determine the appropriate targets for Heating Demand, Cooling Demand, Heating Load & Cooling Load. Contact Us to coordinate the creation of custom Phius targets on a case-by-case basis using BEopt for an additional fee.

N-1.2 Space Conditioning Compliance

The following equation shall be used to demonstrate compliance with the space conditioning limits for **all** mixed-use projects following A) Whole Building Certification - One combined certification for Residential and Non-Residential.

$$\left(Use_{res} * iCFA_{res}\right) + \left(Use_{non-res} * iCFA_{non-res}\right) \leq$$
$$\left(Limit_{res} * iCFA_{res}\right) + \left(Limit_{non-res} * iCFA_{non-res}\right)$$

Table N-1.2.1 Factor Nomenclature	
Use_{res}	Calculated Residential Heating or Cooling Demand [kBTU/ft^2.yr], Heating or Cooling Load [BTU/ft^2.hr]
$iCFA_{res}$	Residential iCFA
$Use_{non-res}$	Calculated Non-residential Heating or Cooling Demand [kBTU/ft^2.yr], Heating or Cooling Load [BTU/ft^2.hr]
$iCFA_{non-res}$	Non-residential iCFA
$Limit_{res}$	Targeted Residential Heating or Cooling Demand [kBTU/ft^2.yr], Heating or Cooling Load [BTU/ft^2.hr]
$Limit_{non-res}$	Targeted Non-residential Heating or Cooling Demand [kBTU/ft^2.yr], Heating or Cooling Load [BTU/ft^2.hr]

N-2 Minimum Interior Surface Temperature for Thermally Bridged Construction Details

One requirement for certification pertains to avoiding mold growth on interior surfaces caused by thermal bridges. Even if a thermal bridge is tolerable in terms of its impact on the space conditioning loads and demands, it is not tolerable if it can lead to mold growth on the inside.

If a thermal bridge is significant enough, Phius may ask that an interior surface mold risk analysis be completed according to ISO 13788. The calculator can be downloaded from the Resource Library page on the Phius website.

The detail is modeled in THERM, the same tool we use to calculate the energy impact of a thermal bridge. Instead of calculating the extra energy loss, the critical result is the point of lowest temperature on the inside surface, and the criterion is that at that point, the interior air, when chilled down to that temperature, should be at less than 80% relative humidity.

In addition to surfaces directly exposed to interior air, the requirement applies to interstitial surfaces that are a) inboard of the water control layer and b) adjacent to air gaps or air-permeable insulation (e.g. rim joist.) The requirement applies regardless of whether such a surface is inboard or outboard of the air barrier control layer.

Exception: The requirement does not apply if such an interstitial surface is separated/isolated from the interior air by a class I vapor retarder (e.g., air-permeable insulation fully encapsulated.)

The calculator, based on ISO 13788, outlines the appropriate boundary conditions to use in the THERM model – the outside temperature and the indoor relative humidity. This is based on consideration of the monthly average outside temperature and humidity for the climate. The outdoor humidity is added to an indoor source that depends on one of five building humidity classes from low to high.

For each month, a psychrometric calculation is then done to determine a minimum inside surface temperature needed to keep the RH at the surface below 80%.

The critical month is the one in which that minimum surface temperature is farthest from the outside temperature and closest to the inside temperature, because that requires the detail to be the most “insulating.” This “surface temperature factor” (fRsi) of the building element is defined mathematically as:

$$\text{fRsi} = \frac{(Inside\ surface\ temp - Outside\ temp)}{(Inside\ temp - Outside\ temp)}$$

with a surface resistance at the inside surface of Rsi.

Example: Usually, the critical month is also the coldest month - but not always. Depending on the climate it might be in October.

N-3 Window Comfort

The optimization used to set space conditioning targets allowed for code-minimum windows in the mid-rise and high-rise buildings. While the relaxed window performance may be most cost effective from an up-front cost and energy savings payback, it does not provide an adequate guardrail on ensuring comfort.

The whole-window U-value must be low enough such that the window surface inside is no more than a certain temperature difference (ΔT) lower than the inside air temperature when the outside air temp T_d is at the ASHRAE 99% design temperature. Window U-value as a design decision is more impactful to prevent discomfort during the heating season while shading devices, low-e coatings and solar heat gain coefficient (SHGC) are more impactful to prevent discomfort during the cooling season.[69]

Maximum temperature difference (ΔT) =

$6.0\ °F$ for double-height spaces (≥16');

$14.7°F - (0.742\ x\ HHS(ft))$ for window head-height-from-sill HHS of 10 feet or less,

or $13.3°F$, whichever is less;

where the whole-window U is calculated as:

$$U = \frac{\Delta T}{\left[R_{si}\left(T_{air,inside} - T_d\right)\right]}$$

$$R_{si} = 0.74\ \frac{hrft^2°F}{BTU}$$

$$T_{air,\ inside} = 68°F$$

$$T_d = ASHRAE\ 99\%\ Design\ Temperature\ °F$$

Exceptions:

- Windows and doors in non 'regularly occupied' areas.

  Example: A college dormitory with an entry lobby and no seating, exterior doors and windows to a vestibule, or a hallway in a school with only transient occupants.

- ADA doors.
- For windows and non-ADA doors greater than 6' in height review rules below and review Appendix I-2.3.

1. Where window comfort cannot be met through the performance U-value, providing active heat at the perimeter may be used to meet the comfort criteria.
2. The location of the perimeter heating is an important consideration and must be located within 3' in plan (1 meter) of the window.
3. Perimeter heating may be provided from two distinct sources:
   1. Primary heat source
   2. Supplementary heat source
      - Using supplementary perimeter heating will impact the source energy and may be calculated as follows.
      - Calculate a heat demand (Btu): (U-proposed - U-criterion) x Window Area (sf) x HDD65 x 24h/day = Heating Demand Comfort (Btu)

[69] The Efficient Windows Collaborative provides an easy-to-understand explanation of this concept here: Control Comfort - Efficient Windows Collaborative

- Heating Demand Comfort divided by site efficiency of the supplemental heating system e.g. 100% for electric resistance or 80% for gas/hydronic.
- Apply the correct source energy factor based on the fuel type.
- Account for the additional energy use under System > Distribution > Supportive device / auxiliary energy. The device type should be set to 'Other' and the Energy demand should be input in watts with the Period of operation set to 1 khr/yr.

N-4 Renewable Energy

From ASHRAE 189.1-2017 Addendum J, Phius markup

N-4.1 Renewable Energy Systems

For **Phius CORE**: part of the production from an on-site renewable energy system may be used to offset the source energy use and meet the source energy performance limit. Reduction factors outlined in Appendix N-4.2 are used.

For **Phius ZERO**: an on-site renewable energy system, an off-site renewable energy system or a combination of the two shall be provided to equal or exceed the modeled energy use. Reduction factors outlined in Appendix N-4.2 are used.

Qualifying Renewable Energy Systems are as follows:

1. **On-site** renewable energy system
2. **Off-site** renewable energy system
   a. Self generation (an off-site renewable energy system owned by the building project owner). The system shall comply with Appendix N-4.3.
   b. Community Renewable Energy Facility - The system shall comply with Appendix N-4.3.
   c. Purchase Contract - The system shall comply with Appendix N-4.3.
   d. Contract for renewable electricity products complying with the Green-e Energy National Standard for Renewable Electricity products of no less than 20 years. A combination of renewable electricity products and renewable energy systems shall be permitted to demonstrate compliance. RECs shall be tracked per Appendix N-4.4

N-4.2 Adjusted Renewable Energy

Each source of renewable energy delivered to or credited to the building project shall be multiplied by the factors in Table N-4.2.0 when determining compliance with Appendix N-4.1.

Table N-4.2.0: Multipliers for Renewable Energy Procurement Methods

Location	Renewable Energy Source	Renewable Energy Adjustment Factor	
		CORE	ZERO
On-Site	On-Site Renewable Energy System	Varies[70]	1.00
Off-Site	Directly Owned Off-Site Renewable Energy System	N/A	0.75
	Community Renewable Energy System	N/A	0.75
	Virtual PPA	N/A	0.75
	Green-e RECs	N/A	0.20

[70] Between 0-1, based on an estimate of coincident production-and-use of the predicted annual onsite-renewable electricity generation. For rooftop PV, Phius has pre-defined utilization curves that are used to determine this value. On-site energy storage may be used to increase this utilization factor and requires a custom calculation.

N-4.2.1 Accounting Table for Source Energy Offset by Adjusted Renewable Energy

The annual net source energy for a building is calculated by multiplying the site energy by the fuel-dependent source energy factor, and then subtracting the adjusted renewable energy production multiplied by the fuel-dependent source energy factor of the fuel type it is offsetting.

Phius CORE	Annual Renewable Energy Production (kWh/yr)	Adjustment Factor	Grid-Electricity Source Energy Factor	Offset to Source Energy
On-Site Renewable Energy System	×	Varies	=	
TOTAL	-	-	-	

Phius ZERO	Annual Renewable Energy Production (kWh/yr)	Adjustment Factor	Grid-Electricity Source Energy Factor	Offset to Source Energy
On-Site Renewable Energy System	×	1	=	
Directly Owned Off-Site Renewable Energy system	×	0.75	=	
Community Renewable Energy System	×	0.75	=	
Virtual Power Purchase Agreement	×	0.75	=	
Green-E Certified RECs	×	0.2	=	
TOTAL	-	-	-	

N-4.3 Off-Site Renewable Energy Requirements

Off-site renewable energy delivered or credited to the building project to comply with Appendix N-4.1 shall be subject to a legally binding contract to procure qualifying off-site renewable energy.

Qualifying off-site renewable energy shall meet the following requirements:

1. Documentation of off-site renewable energy procurement shall be submitted to Phius.
    a. Procurement plan is required for review and approval during Phius' Design Certification phase.
    b. Contract as described below is required for review and approval during Phius' Final Certification phase.
2. The purchase contract shall have a duration of not less than 15 years. The contract shall be structured to survive a partial or full transfer of ownership of the building property.
3. RECs associated with the purchase contract from an off-site renewable energy shall be assigned exclusively to the building owner for a period of not less than 15 years and tracked in accordance with Section A-4.
4. The energy source shall produce electricity from solar, wind, or geothermal energy.

Exceptions:

a. Captured methane from feed-lots and landfills are permitted to be used to generate electricity for the purposes of this section.
b. Hydropower from new generation capacity on a non-impoundment or new generation capacity on an existing impoundment that meets one of the following conditions:
    i. The hydropower facility complies with the Low Impact Hydropower Certification Handbook and is certified by a nationally recognized accreditation organization.
    ii. The hydropower facility complies with UL 2854 and is certified by an organization that has the standard in its ISO 17065 scope of accreditation.
    iii. The hydropower facility consists of a turbine in a pipeline or a turbine in an irrigation canal. For facilities falling under either Exception, only output generated during the period of certification is eligible for RECs sale in accordance with the provisions of this section. Renewables from new impoundments of water are not eligible.

5. The generation source shall be located where the energy can be delivered to the building site by any of the following:
    a. By direct connection to the off-site renewable energy facility
    b. By the local utility or distribution entity
    c. By an interconnected electrical network where energy delivery capacity between the generator and the building site is available (Informative Note: Examples of interconnected electrical networks include regional power pools and regions served by Independent System Operators or Regional Transmission Organizations.)
6. Records on renewable power purchased by the building owner from the off-site renewable energy generator that specifically assign the RECs to the building owner shall be retained or retired by the building owner on behalf of the entity demonstrating financial or operational control over the building seeking compliance to this standard and made available for

inspection by Phius upon request. (Informative Note: Refer to Appendices N-4.4 and N-4.5 for tracking and allocation requirements.)

7. Where multiple buildings in a building project are allocated energy procured by a contract subject to this section, the owner shall allocate for not less than 15 years the energy procured by the contract to the buildings in the building project.
   a. (Informative Note: Refer to Section A-5 for allocation requirements.)

N-4.4 Renewable Energy Certificate Tracking

The plan shall include provisions to use a REC tracking system that meets the requirements of Section V.B of the Green-e Framework for Renewable Energy Certification. The plan shall describe how the building owner will procure alternative qualifying renewable energy in the case that the renewable energy producer ceases operation.

N-4.5 Renewable Energy Allocation to Multiple Buildings

Where renewable energy is allocated to multiple buildings in compliance with Appendix N-4.3 (7), the plan shall indicate how renewable energy produced from on-site or off-site systems that is not allocated before issuance of the certificate of occupancy will be allocated to new or existing buildings included in the building project. The plan shall indicate who will be responsible for retaining the documentation for allocations and where it will be stored so that it can be made available for inspection by Phius upon request.

Where multiple buildings in a building project share a common utility interconnection and are served by the same on-site renewable energy system, the building owner shall allocate for not less than 15 years the annual REC generation of the on-site renewable energy system to the buildings served by the system. The annual generation vintage date of delivered RECs shall be allocated to the same 12-month reporting year, up to six months prior, or up to three months after the calendar year in which the electricity is used in the building. The annual allocation of RECs shall be documented as part of the plan. The plan shall indicate who will be responsible for retaining the documentation and where it will be stored so that it can be made available for inspection by Phius upon request.

N-5 Recirculation Defrost

For ventilation units that can maintain the required fresh air ventilation rates on average with the unit intermittently in recirculation mode, then re-circulation defrost is acceptable. The unit needs to have enough boost to maintain the same time-average fresh air ventilation rate as it would at higher temperatures.

In the case that the cycle time is more than 3 hours. The ASHRAE 62.2-2010 Table 4.2 effectiveness factor calculation should be used to determine the required boost intermittent rate.

$$\text{Intermittent fan flow rate} = \frac{continuous\ fan\ flow\ rate}{(effectiveness\ factor\ \varepsilon)\ x\ \ (fractional\ on{-}time\ f)}$$

where:

continuous fan flow rate = **Required whole-building ventilation rate** for the house or apartment if the system was operated continuously

f = **Fractional on-time** for whole-building ventilation, or the percentage of time the whole-building ventilation equipment will operate in one duty cycle (the length of one complete on/off cycle).
ε = [Ventilation Effectiveness for Intermittent Fans]() from Table 4.2 in ASHRAE Standard 62.2. **Note**: Table 4.2 is different in ASHRAE 62.2-2007 and ASHRAE 62.2-2010.

N-6 Blinds

If the shading reduction factor for a blind in the closed position is "z", and "Z effective" is in the input in WUFI Passive then:

For exterior blinds:

Z effective = 0.3 + 0.7 * z

> Example: If blinds allow 46% solar access (solar transmittance, Ts) when closed, use that for z, and z effective turns out to be 62%.
> Z effective = 0.3 + (0.7*0.46) = 0.622

For interior blinds:

Z effective = 1- (1-z) * (1-0.6)

> Example: If blinds allow 46% solar access (solar transmittance, Ts) when closed, use that for z, and z effective turns out to be 78%.
> Z effective = 1 – (1-0.46) * (1-0.6) = 0.784

N-7 Multi-unit Lighting & MEL calculations

The basic protocol for lighting and miscellaneous electric loads is that they are calculated at 80% of RESNET (2013) levels for the "Rated Home". [71] RESNET's formulas are intended to apply to living/dwelling units, whether detached or attached, and strictly speaking to buildings of three stories or less. RESNET does not yet have protocol for multifamily common spaces. For Phius certification, the scope of the RESNET formulas is expanded to include multifamily buildings four stories or more in height but applies only to the dwelling units. Supplemental protocol for multifamily common spaces and certain outdoor loads follows Building America House Simulation Protocols (2014). [72] In the formulas, iCFA is used in place of RESNET's CFA and Building America's FFA. The RESNET lighting formulas have been expressed more compactly here but are algebraically equivalent to the published versions. There are additional options for calculating the energy use of pools and elevators.

Miscellaneous Electric Loads (MELs)

For whole-building certification:

$$MEL = MEL_{DWELL} + MEL_{COMM} + MEL_{YARD} \text{ (kWh/yr)}$$

MEL_{DWELL} accounts for the living units.
MEL_{COMM} accounts for the common spaces (if the design includes any).
MEL_{YARD} accounts for Large / Uncommon Electric and Gas loads (if the design includes any).
To facilitate verification, the MEL_{DWELL} calculation must be itemized. This may be done by unit type or floor-by-floor.

For itemization by unit type *k*:

$$MEL_{DWELL} = \sum_k units_k * \left(413 + 69 * Nbr_k + 0.91 * iCFA_k\right) * 0.8$$

k are the unit types.

[71] RESNET, op.cit., Section 303.4.

[72] Wilson, E. et al. *2014 Building America House Simulation Protocols* (BAHSP). Golden, CO: National Renewable Energy Laboratory, 2014. Print..

http://energy.gov/eere/buildings/house-simulation-protocols-report

$units_k$ is the number of units of type *k* in the building.

Nbr_k is the number of bedrooms in a unit of type *k*.

$iCFA_k$ is the interior conditioned floor area of a unit of type *k*. [73]

For purposes of this calculation, $iCFA_k$ may include or exclude the projected floor area of interior partition walls within or between units, whichever approach is simpler to document.

<u>For itemization by floor *n*:</u>

$MEL_{DWELL} =$

$$\sum_n \left(units_n * 413 + 69 * Nbr_n + 0.91 * iCFA_{DWELL,n}\right) * 0.8$$

n are the floors.

$units_n$ is the number of units on floor *n*.

Nbr_n is the number of bedrooms on floor *n*.

$iCFA_{DWELL,n}$ is the interior conditioned floor area of all the dwelling units on floor *n*, including the partition walls within and between units, but not including the floor area of the common spaces.

For purposes of this calculation, $iCFA_{DWELL,n}$ may include or exclude the projected floor area of interior partition walls to common spaces, whichever approach is simpler to document.

For MEL_{COMM} add the following, or submit a more detailed accounting.

[73] RESNET, op. cit., clause 303.4.1.7.2.1 "Residual MELs" and 303.4.1.7.2.6 "Televisions".

Multifamily Common Space MELs [74]

Room Type	Electricity (kWh/yr)
Office	3.2 x iCFA
Workout room	9.8 x iCFA
Corridor / Restroom / Mechanical	0
Elevator	*Varies

*Aligned with Energy Star Multifamily New Construction Simulation Guidelines Version 1 (Rev. 01) Section 3.11.3. This calculation is built into the Phius Multifamily Lighting & Misc Load Calculator.

Alternate for elevators: More detailed calculations may be made using the following resource. https://design.na.tkelevator.com/tools/energy-calculator

Although BAHSP has protocol for some "Multipurpose Room MELs", in a whole-building model any television, dishwasher, range, or microwave in a multipurpose room may be neglected – usage of these in the multipurpose room is assumed to displace usage in the units. However, any refrigerators or freezers in a multipurpose room should be added as additional appliances at their rated kWh/day.

For MEL_{YARD} use the table below or perform a more detailed calculation.

Large Uncommon Electric and Gas Loads [75]

[74] BAHSP, op. cit., Table 25. For Office and Workout room, footnote therein refers in turn to "Home Energy Usage Chart," Public Service of New Hampshire, 2013, and assumes 1h/wk usage.
[75] BAHSP, op. cit., Table 26.

Appliance	Electricity [kWh/yr]	Natural Gas [therms/yr]
Pool heater (gas)	-	3/0.014 × Fscale
Pool heater (electric)	10.1/0.0044 × Fscale	-
Pool pump	158.5/0.07 × Fscale	-
Hot tub/spa heater (gas)	-	0.87/0.011 × Fscale
Hot tub/spa heater (electric)	49/0.048 × Fscale	-
Hot tub/spa pump	59.5/0.059 × Fscale	-
Well pump	50.8/0.127 × Fscale	-
Gas fireplace	-	1.95/0.032 × Fscale
Gas grill	0.87/0.029 × Fscale	-
Gas lighting	0.22/0.012 × Fscale	-

Where the scaling factor, F_{scale} = (0.5 + 0.25 Nbr/3 + 0.25 iCFA/1920).

1 therm = 100 kBTU / [3.412 kBTU/kWh] = 29.3 kWh

IndoorPoolCalc, an online spreadsheet from the Washington State University Extension Energy Program, estimates the savings of several energy conservation measures for pools. Download the calculator and background information in the Resource Library.

Lighting

The lighting formulas below refer to "qualifying" light fixtures or locations, which means high-efficacy lighting. For residential projects fluorescent hard-wired (i.e. pin-based) lamps with ballast, screw-in compact fluorescent bulb(s), LEDs,

$LIGHTS_{INT,DWELL}$ accounts for the living units. [76]or light fixtures controlled by a photocell and motion sensor, are all considered high-efficacy.

Interior Lighting

For whole-building certification:

$$LIGHTS_{INT} = LIGHTS_{INT,DWELL} + LIGHTS_{INT,COMM} \text{ (kWh/yr)}$$

$LIGHTS_{INT,COMM}$ accounts for the common spaces (if the design includes any).

As with MELs, the $LIGHTS_{INT,DWELL}$ calculation must be itemized. This may be done by unit type or floor-by-floor.

For itemization by unit type *k*:

$$LIGHTS_{INT,DWELL} = \sum_k units_k * (0.2 + 0.8 * (4 - 3 * qFFIL)/3.7) * \left(455 + 0.8 * iCFA_k\right) * 0.8$$

qFFIL is the ratio of the qualifying interior light fixtures to all interior light fixtures in qualifying interior light fixture locations.

For itemization by floor *n*:

$$LIGHTS_{INT,DWELL} = \sum_n (0.2 + 0.8 * (4 - 3 * qFFIL)/3.7) * \left(units_n * 455 + 0.8 * iCFA_{DWELL,n}\right) * 0.8$$

[76] RESNET, op. cit., clause 303.4.1.7.2.2 Interior Lighting, and equation 5.

For $LIGHTS_{INT,COMM}$ use the table below for any of the listed Room Types that are included in the design, or submit a more detailed calculation.

Multifamily Common Space Lighting[77]

Room Type	Operating Hours [hrs/day]	W/ft^2
Central Restroom	1.6	0.9
Common Laundry	24	0.7
Common Mail	12	2.8
Common Office	9	1
Elevator	24	1.25
Equipment Room	0	1.5
Indoor Corridor	24	0.5
Multi-Purpose	12	1.1
Workout Room	16	0.9

$$LIGHTS_{INT,COMM} = (Operating\ hours\ *\ operating\ days\ *\ LPD\ *\ iCFA_{COMM})/1000$$

$Operating\ hours$ are per day.

$Operating\ days$ are per year.

LPD is the lighting power density of the space in W/ft^2.

$iCFA_{COMM}$ is the interior conditioned floor area of each unique common space, not including interior partition walls.

Occupancy Sensors: A 10% reduction in LPD is allowed for common spaces where occupancy sensors are documented in project submission (as in ASHRAE 90.1 Appendix G).

[77] Building America B10 Analysis – New Construction 2011-01-26 workbook, Detailed Lighting tab, C89:D101 and C120:L132

Projects may also complete a custom calculation for reduction in LPD in corridors based on occupancy sensors, using Phius MF Interior Corridor Lighting Occupancy Sensor Calculator, downloadable from the Resource Library.

When applying the reduction factor to stairwells in buildings that also have elevators, project teams may assume as low as a 50% of the traffic is by stairs in residential buildings.

Exterior Lighting

$$LIGHTS_{EXT} = LIGHTS_{EXT,DWELL} + LIGHTS_{EXT,COMM} + LIGHTS_{GAR}\ (kWh/yr)$$

$LIGHTS_{EXT,DWELL}$ pertains to exterior lighting for the dwelling units (balcony/porch or general building lights). [[78]]

$LIGHTS_{EXT,COMM}$ pertains to exterior lighting for the common spaces (exterior courtyards, exterior corridors/stairs, outdoor walkways, etc.)

$LIGHTS_{GAR}$ pertains only if the project includes a garage.*

For itemization by unit type *k*:

$$LIGHTS_{EXT,DWELL} = \sum_k units_k * (1 - 0.75 * FFEL) * \left(100 + 0.05 * iCFA_k\right) * 0.8$$

FFEL is the fraction of exterior fixtures that are qualifying light fixtures.

For itemization by floor *n*:

$$LIGHTS_{EXT,DWELL} = \sum_n (1 - 0.75 * FFEL) * (units_n * 100 + 0.05 * iCFA_n) * 0.8$$

[78] RESNET, op. cit., clause 303.4.1.7.2.3 Exterior Lighting, and equation 6.

For $LIGHTS_{EXT,COMM}$ use the table below for any of the listed Room Types that are included in the design, or submit a more detailed calculation.

Exterior Lighting[79]

Room Type	Operating Hours [hrs/day]	W/ft^2
Open Parking*	12	0.15
Outdoor Stairs	12	0.3
Outdoor Walkways	12	0.3

$LIGHTS_{EXT,COMM}$ =

$$(Operating\ hours\ *\ operating\ days\ \ *\ LPD\ *\ iCFA_{COMM})/1000$$

$Operating\ hours$ are per day. $Operating\ days$ are per year.

LPD is the lighting power density of the space in W/ft^2.

$iCFA_{COMM}$ is the interior conditioned floor area of each unique common space, not including interior partition walls.

Garage lighting may be calculated by the "80% RESNET" formula [[80]], BA default, or a more detailed calculation.

$$LIGHTS_{GAR} = Units * 100*(1-0.75*FFGL) * 0.8$$

Units is the total number of dwelling units in the building

FFGL is the fraction of garage fixtures that are Qualifying Light Fixtures.

Garage Lighting[81]

Room Type	Operating Hours [hrs/day]	W/ft^2
Parking Garage*	24	0.2

*Note: Phius does not require projects to include lighting energy for an open parking lot / parking garage, block heaters, or vehicle charging in the energy model for certification. For now, these are considered to be part of the "transportation sector" as opposed to the "building sector".

[79] B10 Analysis workbook, op. cit.
[80] RESNET, op. cit., clause 303.4.1.7.2.4 Garage lighting, and equation 7.
[81] B10 Analysis workbook, op. cit.

N-8 Non-Residential Utilization Patterns

Standard Default Patterns (per DIN V 18599-10:2007-02, Table 4) for Internal Loads and Occupancy Calculations for Non-Residential Buildings

Table N-8.0 Non-Residential Utilization Patterns									
Building Type	**Space Type**	**Notes**	**Start [time]**	**End [time]**	**Annual Utilization Days [d/a]**	**Maintained Illuminance [lux]**	**Height of the working plane [ft]**	**Relative Absence**	**Factor of lighting relative to building's operation time**
Library	magazine and stores	-	8	20	300	100	2.6	0.9	1
	open stacks areas	-	8	20	300	200	2.6	0	1
	reading rooms	-	8	20	300	500	2.6	0	1
Office	1 - 6 workstations	-	7	18	250	500	2.6	0.3	0.7
	7+ workstations	-	7	18	250	500	2.6	0	1
	Meeting, conference, and seminar room	-	7	18	250	500	2.6	0.5	1
Restaurant	Dining Area	-	10	24	300	200	2.6	0	1
	Kitchen	-	10	23	300	500	2.6	0	1
	Kitchen	preparation room or storeroom	7	23	300	300	2.6	0.5	1
School	Cafeteria	Canteen	8	15	250	200	2.6	0	1
	Classroom	school and nursery school	8	15	200	300	2.6	0.25	0.9
	Lecture Room, Auditorium	-	8	18	150	500	2.6	0.25	0.7

Table N-8.0 Non-Residential Utilization Patterns (continued)									
Building Type	**Space Type**	**Notes**	**Start [time]**	**End [time]**	**Annual Utilization Days [d/a]**	**Maintained Illuminance [lux]**	**Height of the working plane [ft]**	**Relative Absence**	**Factor of lighting relative to building's operation time**
Theaters & Event Locations	Foyer	-	19	23	250	300	2.6	0.5	1
	Audience area	-	19	23	250	200	2.6	0	1
	Stage	-	13	23	250	1000	2.6	0	0.6
Universal	Auxiliary Spaces	Non-habitable	7	18	250	100	2.6	0.9	1
		Habitable	7	18	250	300	2.6	0.5	1
	Server Room	-	0	24	365	500	2.6	0.5	0.5
	Restrooms / Toilets	-	7	18	250	200	2.6	0.9	1
	Corridors / Hallways	-	7	18	250	100	0	0.8	1
Specialty	Exhibition rooms and museums	with conservation requirements	10	18	250	200	2.6	0	1
	Hospital ward	-	0	24	365	300	2.6	0	0.5
	Hotel Bedroom	-	21	8	365	200	2.6	0.25	0.3
	Retail Space	-	8	20	300	300	2.6	0	1
	Sports Hall	without public viewing area	8	23	300	300	2.6	0.3	1
	Storeroom, technical equipment room, archive	-	7	18	250	100	2.6	0.98	1
	Workshop, assembly, manufacturing	-	7	16	250	500	2.6	0	1

N-9 Multiple Exhaust Dryer Protocol

If a community building (or similar) is serving multiple residential buildings, the multiple dryer exhaust protocol may be applicable. This protocol does not apply to centralized laundry rooms in multifamily buildings. When these buildings contain a laundry room with exhaust dryers, and the usage pattern is high, this increases the load on the space conditioning system (and increases the modeled annual demands and peak loads).

In these cases, the increase in space conditioning energy use due directly to the makeup air required for the dryers must be accounted for in the source energy calculation. However, it does not need to be accounted for in the same way as typical exhaust dryers, which would influence the modeled annual demands and peak loads of that building. Instead, see modeling protocol below to account for this additional energy.

- Duplicate the existing case, create a new ‘test’ case.
- Add the dryers to the Exhaust Appliances tab in WUFI Passive.
- Take the difference between the added heat demand and the added cooling demand. (On the theory that cold air makes the dryer work harder, warm air makes it work easier, than it does under its rated conditions.)
- Convert that to source energy using the COP and SE factor of the dryer. Divide by the source energy factor for electricity and enter the result as an auxiliary electric load outside the thermal envelope.
- Furthermore, it is recommended to install an electric heater in the makeup air duct (near the point of entry) capable of raising the air temperature to at least 49 F (dew point of 68 F air at 50% RH.)
- If the dryer is not electric resistance, the SE factor in the above energy calculation should be adjusted with a seasonal weighting based on the percentage of the year that the makeup air heater would be expected to operate. This would prevent the makeup air from causing a frost or condensation problem.

Notice that, if the space heating system is efficient or has a low source energy factor, a heated makeup air duct may use more energy overall in a site or source energy sense. Therefore, this is not necessarily the best strategy in all cases. The multiple exhaust dryer protocol is offered as an option that may help some smaller buildings meet the certification criteria for space conditioning.

N-10 DHW Distribution Pipe Materials and Sizes

Definitions from the 'Hot Water Piping' tab relevant to Section 1.4.4.13.

Demand Circulation: Checking this box resets the 'up-stream volume' for any branch connected to that trunk, i.e. it will assume the branch will always be served with hot water and the trunk length should not be considered when estimating the 'time to hot' for the EPA WasterSense Hot Water Delivery test.

> The on-demand recirculation pipes must still be entered to accurately account for DHW pipe distribution losses, even though it resets the volume in the trunk for the 'time to hot' calculation.

Pipe material: Update the pipe material as shown in the floor plans. The most common pipe types are Copper L and PEX-AL-PEX.

Pipe diameter: This should be verifiable from the floor plans and input in WUFI Passive to match.

Heat Capacity: This is calculated based on the type of piping chosen, piping diameter and piping length.

Volume [oz]: The calculated total volume of water stored in this pipe based on the pipe material, piping diameter and piping length.

Cumulative volume [oz]: This calculated volume is used to determine a project's compliance with the Watersense. If 'Demand recirculation' is checked for a trunk, the cumulative volume of that pipe will be zeroed out and not count towards the volume of water stored in the pipe.

Time to "hot" @ 1 gpm [s]: Calculates an estimate of how long it will take the water to rise 10F in seconds based on the cumulative volume of water in the pipes. 60 seconds coincides with failing the Watersense test.

Table N-10.0 Ounces of water per foot of hot water tubing [oz]								
Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜″	1.06	0.97	0.84	n/a	1.17	0.63	0.63	0.64
½″	1.69	1.55	1.45	1.25	1.89	1.31	1.31	1.18
⅝″	n/a	2.32	2.22	n/a	n/a	2.12	n/a	1.72
¾″	3.43	3.22	2.9	2.67	3.38	3.39	3.39	2.35
1″	5.81	5.49	5.17	4.43	5.53	5.56	5.56	3.91
1 ¼″	8.70	8.36	8.09	6.61	9.66	8.49	8.49	5.81
1 ½″	12.18	11.83	11.45	9.22	13.20	13.88	13.88	8.09
2″	21.08	20.58	20.04	15.79	21.88	21.48	21.48	13.86

Table N10.1 Outside Diameter [in]								
Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜″	0.50	0.50	0.50	n/a	0.68	0.47	0.47	0.50
½″	0.63	0.63	0.63	0.63	0.84	0.63	0.63	0.63
⅝″	n/a	0.75	0.75	n/a	n/a	0.79	n/a	0.75
¾″	0.88	0.88	0.88	0.88	1.05	0.98	0.98	0.88
1″	1.13	1.13	1.13	1.13	1.32	1.26	1.26	1.13
1 ¼″	1.38	1.38	1.38	1.38	1.66	1.58	1.58	1.38
1 ½″	1.63	1.63	1.63	1.63	1.90	1.97	1.97	1.63
2″	2.13	2.13	2.13	2.13	2.38	2.48	2.48	2.13

Table N-10.2 Inside Diameter [in]

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜″	0.45	0.43	0.40	n/a	0.49	0.35	0.35	0.36
½″	0.57	0.55	0.53	0.51	0.62	0.50	0.50	0.49
⅝″	n/a	0.67	0.65	n/a	n/a	0.64	n/a	0.58
¾″	0.81	0.79	0.75	0.72	0.82	0.81	0.81	0.68
1″	1.06	1.03	1.00	0.92	1.05	1.03	1.03	0.88
1 ¼″	1.29	1.27	1.25	1.13	1.38	1.28	1.28	1.07
1 ½″	1.53	1.51	1.48	1.33	1.61	1.63	1.63	1.26
2″	2.01	1.99	1.96	1.74	2.07	2.03	2.03	1.65

Table N-10.3 Weight Empty [lb/ft]

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜″	0.14	0.20	0.27	n/a	0.12	0.06	0.07	0.05
½″	0.20	0.29	0.34	0.08	0.18	0.07	0.10	0.06
⅝″	n/a	0.36	0.42	n/a	n/a	0.10	n/a	0.08
¾″	0.33	0.46	0.64	0.14	0.24	0.15	0.14	0.11
1″	0.47	0.66	0.84	0.23	0.35	0.23	0.23	0.17
1 ¼″	0.68	0.88	1.04	0.35	0.48	0.39	0.38	0.26
1 ½″	0.94	1.14	1.36	0.49	0.57	0.55	0.55	0.36
2″	1.46	1.75	2.06	0.83	0.76	0.92	0.91	0.61

Table N-10.4 Empty Pipe Heat Capacity [Btu/ft.F]								
Nominal Diameter	**Copper M**	**Copper L**	**Copper K**	**CPVC CTS SDR 11**	**CPVC SCH 40**	**PEX-AL-PEX**	**PE-AL-PE**	**PEX CTS SDR 9**
⅜”	0.01	0.02	0.02	n/a	0.02	0.04	0.04	0.02
½”	0.02	0.03	0.03	0.02	0.04	0.04	0.06	0.03
⅝”	n/a	0.03	0.04	n/a	n/a	0.06	n/a	0.05
¾”	0.03	0.04	0.06	0.03	0.05	0.08	0.08	0.06
1”	0.04	0.06	0.08	0.05	0.07	0.13	0.13	0.09
1 ¼”	0.06	0.08	0.09	0.07	0.10	0.21	0.21	0.14
1 ½”	0.08	0.10	0.12	0.10	0.11	0.30	0.30	0.20
2”	0.13	0.16	0.19	0.17	0.15	0.50	0.50	0.34

Table N-10.5 Pipe + Water Heat Capacity [Btu/ft.F]								
Nominal Diameter	**Copper M**	**Copper L**	**Copper K**	**CPVC CTS SDR 11**	**CPVC SCH 40**	**PEX-AL-PEX**	**PE-AL-PE**	**PEX CTS SDR 9**
⅜”	0.08	0.08	0.08	n/a	0.11	0.08	0.08	0.07
½”	0.13	0.13	0.13	0.10	0.17	0.12	0.14	0.11
⅝”	n/a	0.18	0.18	n/a	n/a	0.19	n/a	0.16
¾”	0.25	0.25	0.25	0.20	0.28	0.30	0.30	0.22
1”	0.42	0.42	0.41	0.33	0.44	0.49	0.49	0.35
1 ¼”	0.63	0.62	0.62	0.50	0.74	0.76	0.76	0.53
1 ½”	0.87	0.87	0.87	0.70	0.99	1.20	1.20	0.74
2”	1.50	1.49	1.49	1.19	1.60	1.90	1.89	1.26

N-11 Prescriptive Path

N-11.1 Compactness Criteria

The compactness requirement is intended not to force an ideal or optimal level of compactness, but rather to prevent particularly non-compact designs. The enclosure area AE must not exceed that of a notional rectangular building with the proposed interior conditioned floor area iCFA and number of walkable levels Ns, calculated as follows:

$$AE \leq AEmax \; = \; 2 * (w * d + d * h + w * h)$$

$$The\ height\ h \; = \; Hs * Ns$$

$$The\ depth\ d \; = \frac{\frac{iCFA}{Ns}}{w-0.6m} + 0.6m$$

$$The\ width\ w \; = \; sqrt\left(awd * \frac{iCFA}{Ns}\right) + 2\ feet\ (0.6m)$$

$$The\ width\ to\ depth\ aspect\ ratio\ awd \; = \; 3$$

$$The\ height\ per\ story\ Hs \; = \; 12\ feet\ (3.7m)$$

N-11.2 Solar Protection Criteria

Glazed fenestration solar heat gain coefficient:
Requirements vary by climate zone and align with DOE Zero Energy Ready Home.

Fixed overhangs:
Required for south windows in hot climate zones, with a depth that depends on the latitude and window height.

N-11.2.1 Fenestration Orientation (for detached houses only)

There are two rules pertaining to fenestration orientation, that is, the distribution of windows and glazed doors facing different directions.

1. Limit high peaks in cooling load in summer and shoulder seasons.
2. Limit net heat loss from the windows in winter.

These rules should not conflict because the “summer” rule concerns mostly east-west balance and the “winter” rule concerns mostly north-south balance, but it is possible to violate both, in some climate zones.

N-11.2.1.1 For Cooling

The fenestration orientation rule limiting cooling load peaks is based on the concept of adequate exposure diversity (AED) from ACCA Manual J. The idea is that the peak hour solar gain should not exceed the average over the daytime hours by more than a certain percentage. There are three compliance paths:

1. The most straightforward path is that, per Manual J Appendix 3, a dwelling is considered to have AED if “the total area of the windows, glass doors, and skylight assemblies does not exceed 15% of the associated floor area.”
2. The most involved path is to calculate AED, which requires software qualified for Manual J, and meet its criterion that the peak is no more than 30% over the average.
3. The middle path is to meet a simplified AED criterion developed for Phius CORE Prescriptive that varies by climate zone. The required inputs for simplified AED are

the glazed fenestration areas facing the cardinal directions (North, East, South, and West). All windows are to be assigned to the nearest cardinal direction. The checklist calculates a score and compares it to the zone's criterion.

The simplified AED score and criteria were derived from a computer experiment on a study building, using various fenestration orientation configurations in a representative city for each climate zone. The studied configurations comprised combinations of concentration and direction of concentration but with identical overall window area, e.g., 25% all around, 100% on one side, 50% on two sides, 33% on three sides. There are 15 such combinations x 19 zones, 0A to 8, for a total of 285 study cases. The study buildings were configured at the window SHGC limits and with south overhangs, as required for the climate zone by those other rules. Hourly simulations were done in EnergyPlus and the ratio of peak hour solar transmission to the day average (ST Pk/Av) was then averaged over 4 weeks around the summer solstice plus 4 weeks around the autumnal equinox.

The general patterns that emerged were:

1. A balance of east- and west-facing areas was good.
2. High concentration in one direction was bad, unless it was north, though all-south was not too bad.

Regression formulas were fitted, zone by zone, to the ST Pk/Av Jun+Sep data as functions of the orientation configuration variables (fraction facing each direction). The correlation coefficients of the fits fell between 0.85 and 0.95. The criteria thresholds were set relative to each zone, at the level of the mean over the 15 configurations. That was usually ST Pk/Av ~ 1.9, i.e., a peak hour about 90% over the day average. The score calculated in the checklist is the predicted ST Pk/Av from the regression function for the specified window configuration, rescaled to a percentage of the way towards the zone limit. This levels the passing criterion to ≤ 100% for all zones (lower is better). [82]

N-11.2.1.2 For Heating

The fenestration orientation rule for winter is based on the idea that the windows should preferably be oriented to have a net gain over the worst-case month (coldest/dimmest), or at least not too great a net loss. The same model buildings and representative cities were used as for the simplified AED cooling load study. The heat transmission loss from the windows was calculated with the windows at the U-value limit for the zone.

The results indicated that in zones 4C, 5C, and 8, net heat gain in the worst month was not possible with any window orientation, thus there is no orientation requirement for these zones. Also, in zones 0-3 the "winter" gain is either unavoidable, or again mostly unavailable due to the cooling season solar protection measures in place as required, thus there is no orientation requirement for zones 0-3.

For zones 4-7 except C, winter gain is desirable and fenestration orientation did make a big difference, so criteria were set: Regression functions of the orientation variables were fitted to the worst-month net heat gain data. The correlation coefficients of the fits were all over 0.98. The general pattern was that some North

[82] An attempt was made to find a correlation between this simplified AED and Manual J AED, by calculating both on a subset of 30 of the 285 study cases, but this did not work - the correlation coefficient was only 0.4. This may be due to differences in the Manual J design-day data compared to the TMY type weather data used to develop the simplified AED, or other Manual J AED calculation details we are not aware of as of this writing.

windows are tolerable if there are south-facing ones to compensate. The criteria thresholds were set relative to each zone, at the level of the median net gain over the 15 orientation configurations. The score calculated in the checklist is the difference between the predicted net gain from the regression function for the specified window orientation configuration, minus the zone target, then rescaled by the range of net gain over all the study cases. This makes for a levelized net gain score in the range of about ± 100, where zero is passing and higher is better.

The “summer” and “winter” orientation rules were tested together with the compactness rule on 33 certified projects and some randomly generated fenestration orientations and they appeared to give good guidance.[83]

N-11.3 Thermal Enclosure

The maximum U-value for fenestration is derived from the idea of maintaining the inside surface temperature high enough to prevent cold air from pooling under the window and causing an uncomfortable draft at ankle level. This uses the same formula in the PHIUS window comfort calculator (found in the Resource Library), evaluated at a window height of 10 feet and at the ASHRAE 99% outside design temperature.

The R-value requirements for the main assemblies (wall, roof, floor) are set using climate-dependent regression formulas fitted to the characteristics of the small houses, typical sized houses, and townhouses that were optimized in the 2018 standard-setting study, along with the tiny-home cases studied for 2021. The formulas are continuous functions of climate location parameters such as heating-degree days and design heating temperatures. The marginal electricity price (taken on a state average basis) also has an influence, with more insulation being justifiable at higher prices. Enclosure tradeoffs can be made using the alternative path where the total thermal transmittance (ΣUA) of the building thermal envelope is less than or equal to the ΣUA if the individual component requirements were applied. See Phius Standard Setting Document for details.

N-11.4 Mechanical Ventilation

N-11.4.1 Recovery Effectiveness

Heating Season

A minimum sensible recovery efficiency in heating mode is calculated as the efficiency needed to deliver supply air at 60°F or warmer, without post-heating, at the average outside temperature of the coldest month in the climate location. (The device rating adjustment takes credit for passive heat gain from the fan motors, in heating mode.)

[83] The original idea was to have uniform criteria on the raw metrics, e.g. net gain > 0 for winter and ST Pk/Av Jun+Sep < 1.XX for summer, but the zone-to-zone differences were large enough that testing suggested zone-by-zone criteria would be a better idea. As noted above, the final scoring methods shift all zones to a uniform “≤ 1” and “≥ 0”basis

Cooling Season

A minimum total recovery efficiency in cooling mode (latent + sensible) is set based on the climate zone, as shown in the table below. The required levels were set from consideration of both the range of available performance and the statistics of dehumidification degree-days zone-by-zone over 1,000 climate locations.

Table N-11.4.1.0 Cooling Season Minimum Requirements

Climate Zone	Total Recovery Efficiency (TRE)
0A – 3A	60%
3B – 3C	NR
4A	50%
4B - 8	NR

N-11.4.2 Ventilation Duct Lengths

There is also a maximum length imposed on the ducts between the ventilation recovery device and the enclosure, which is tied to the size of the building as indicated by its floor area and number of stories – notionally half the short side of the building if it was a rectangle of aspect ratio 1.6

N-11.4.3 Fan Efficiency

A limit on ventilation fan power was set based on the DOE ZERH Reference Home. The base limit is 0.83 [W/cfm] or 1.2 [cfm/W] on mechanical fresh air ventilation systems. A tradeoff path is allowed for fresh air ventilation system efficiency and is built into the Phius CORE Prescriptive checklist. This tradeoff works in tandem with the Lighting, Appliances & Water Heating tradeoffs.

N-11.5 Mechanical Space Conditioning Systems

For air-source heat pumps, the required efficiency goes by climate zone. Energy Star Most Efficient 2020 applies for CZ 0-3, 4C, and 5C. Other zones 4-8 must meet NEEP cold climate air-source heat pump v3.0 criteria.

For ground-source heat pumps, the requirement is tied to Energy Star Most Efficient 2020 criteria – it varies by equipment type but not by climate.

Table N-11.5.0 Heat Pump Minimum Performance

Climate Zones	Air Source Heat Pump	Ground Source Heat Pump
0-3C, 4C, 5C	HSPF ≥ 9.6 SEER ≥ 18	COP ≥ 3.1 EER ≥ 16.1
4A-B, 5A-B, 6-8	COP @ 5°F ≥ 1.75 SEER ≥ 15	

N-11.6 Lighting, Appliances & Water Heating

N-11.6.1 Lighting

Lighting is regulated by setting a minimum fixture efficacy of 83 lumens/watt for all fixtures.

Lighting is part of the equipment performance tradeoff path, and in that case, lamp efficacy can be lower if the overall annual energy budget for equipment is not exceeded. The annual energy use for the proposed building is calculated based on rated wattage of all fixtures installed and predetermined daily run times per fixture based on the room in which it is installed. The reference building annual lighting energy is calculated using the total lumens installed in the proposed building, applying the minimum efficacy of 83 lumens/watt to that lighting design to determine reference wattage per fixture, and using the same daily run times per fixture as the proposed building.

N-11.6.2 Appliances

Limits on individual appliance efficiencies were set based on either the top quartile of ENERGY STAR 2024 appliance ratings. Project designs can meet each of these requirements individually or take the performance tradeoff path in which these ratings are used for the 'reference' efficiency.

N-11.6.3 Water Heating

Water heating energy is regulated with two main requirements:

1. The water heater must be installed in conditioned space, with a few exceptions based on annual average ambient temperature.
2. The water heater must meet or exceed the specified reference efficiency based on the type of water heater – heat pump or solar with electric backup.

N-11.6.4 Performance Tradeoff Calculation

In the performance tradeoff for builder-installed appliances, lighting, and water heating, the reference energy allowances for the regulated items are calculated as shown in the table below. The rationale for including items on the list is that they are:

1. Rated by Energy Star and
2. Typically, builder-installed as opposed to resident-installed.

For each item there is a reference level of efficiency for the equipment, and an embedded assumption about how much it is used. Together these factors determine the contribution of each item to the pooled energy allowance for builder-installed equipment. For pool pumps, an amenity level is deduced from Building America benchmarks for annual energy use with ENERGY STAR Most Efficient 2020 device efficiency.

Table 11.6.4.0 Prescriptive Path Appliance, Lighting & DHW Reference Efficiencies

Item	Efficiency Unit	Reference Efficiency	Reference Site kWh/yr
Clothes Washer	LER [kWh/yr]	99	# planned * LER
Clothes Dryer	CEF [lbs/kwH]	3.93	# occupants * (283/4.5)/CEF *8.45
Dishwasher	LER [kWh/yr]	234	# planned * LER
Refrigerator-freezer	LER [kWh/yr]	396	"
Stand-alone Refrigerator	LER [kWh/yr]	260	"
Stand-alone Freezer	LER [kWh/yr]	394	"
Pool pump	WEF [kgal/kWh]	9.3	# planned * 158.5 kWh/yr
Ventilator	[W/cfm]	0.83	0.83 W/cfm * 8760 * max(ASHRAE 62.2 or IMC 2021) (cfm)
Light Fixtures	Lumens/Watt [lm/W]	83	# installed lumens / 83 lm/W * annual runtime per fixture
Water Heating	SEF	1.975	# occupants * amenity[84] / 1.975
	UEF	3.00	# occupants * amenity / 3.00

LER = label energy rating
SEF = solar energy factor
UEF = uniform energy factor
WEF = weighted energy factor

[84] Amenity = 6.6 gal/person.day at 90F temperature rise * 1.25 operational waste factor, in kWh/person.yr.

N-12 Co-Generation

There are two ways to operate a combined-heat-and-power (CHP) unit:

1. On electrical demand. (E-Priority)
   a. CHP is run independently of the heating load, with the intent of producing electricity, and the heat production is a byproduct, which may or may not be usable.
2. On heating demand. (H-Priority)
   a. CHP is run to match the heating demand (hot water and/or space heat), and the electricity produced while the CHP operates is regarded as a byproduct, that is either used on site or sold to the grid.
   b. The H-priority path in turn has two variants depending on whether the backup heat is supplied by electricity or fuel combustion.

With a combined-heat-and power (CHP) unit, the adjusted annual source energy for the building is given by:

$$PE = D_{ELEC}F_{ELEC} + D_{HEAT}F_{HEAT}$$

where

D_{ELEC} is the annual electricity demand of the building (excluding any supplemental heat provided by grid electricity.)

D_{HEAT} is the annual heating demand plus hot water demand (including storage and distribution losses) of the building.

F_{ELEC} is the adjusted SE factor for electricity.

F_{HEAT} is the adjusted SE factor for heating.

The adjusted SE factor for electricity F_{ELEC} is given by

$$F_{ELEC} = \frac{E_{CHP}F_{E,CHP}}{D^*_{ELEC}} + \frac{\left(D^*_{ELEC} - E_{CHP}\right)\cdot F_{E,GRID}}{D^*_{ELEC}}$$

The annual electrical energy production E_{CHP} by the CHP units / generators is given by

$$E_{CHP} = \begin{cases} \text{the intended amount}, & \text{for E-priority} \\ D_{HEAT}K_{COVG}\cdot\dfrac{\eta_{ELEC}}{\eta_{HEAT}}, & \text{for H-priority} \end{cases}$$

η_{ELEC} is the electrical generation efficiency of the CHP units (e.g. typically 25%.)

η_{HEAT} is the heat and hot water generation efficiency of the CHP units (e.g. typically 50%.)

$F_{E,GRID}$ is the source energy factor for grid electricity (currently 2.0).

$$D^*_{ELEC} = \begin{cases} D_{ELEC} + H_{GRID}, & \text{for H-priority with grid electric backup heat} \\ D_{ELEC}, & \text{otherwise} \end{cases}$$

H_{GRID} is the supplemental heat from grid electricity on the H-priority path with electric backup, given by

$$H_{GRID} = D_{HEAT}\cdot\left(1 - K_{COVG}\right)$$

K_{COVG} is the fraction of the heat demand intended to be covered by CHP for H-priority, e.g. 90%.

The source energy factor for electricity from CHP, $F_{E,CHP}$, is given by

$$F_{E,CHP} = \begin{cases} F_{FUEL}/\eta_{ELEC}, & \text{for E-priority} \\ 0, & \text{for H-priority} \end{cases}$$

in which F_{FUEL} is the source energy factor of the fuel for the CHP units (e.g. currently 1.07 for gas.)

The adjusted SE factor for heating F_{HEAT} is given by

$$F_{HEAT} = \begin{cases} \frac{(H_{CHP} \cdot K_{UTIL}) F_{H,CHP}}{D_{HEAT}} + \frac{(D_{HEAT} - H_{CHP} \cdot K_{UTIL}) \cdot F_{FUEL}}{D_{HEAT}}, & \text{for E-priority} \\ K_{COVG} \cdot F_{H,CHP} + (1 - K_{COVG}) \cdot F_{FUEL}, & \text{for H-priority with fuel heat for backup} \\ F_{H,CHP}, & \text{for H-priority with grid electric heat for backup} \end{cases}$$

where the annual CHP heating byproduct H_{CHP} is given by

$$H_{CHP} = E_{CHP} \cdot \frac{\eta_{HEAT}}{\eta_{ELEC}}$$

K_{UTIL} is the usable fraction of CHP heat (if CHP heat is available when the building needs heat, $K_{UTIL} = 1$). This may require an additional side calculation, depending on how the CHP unit is intended to run.

The source energy factor for heat generation from CHP, $F_{H,CHP}$, is given by

$$F_{H,CHP} = \begin{cases} 0, & \text{for E-priority} \\ F_{FUEL}/\eta_{HEAT}, & \text{for H-priority} \end{cases}$$