Phius 2024
PASSIVE BUILDING STANDARDS CERTIFICATION GUIDEBOOK







phius

Phius 2024 Passive Building Standards

Certification Guidebook

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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.

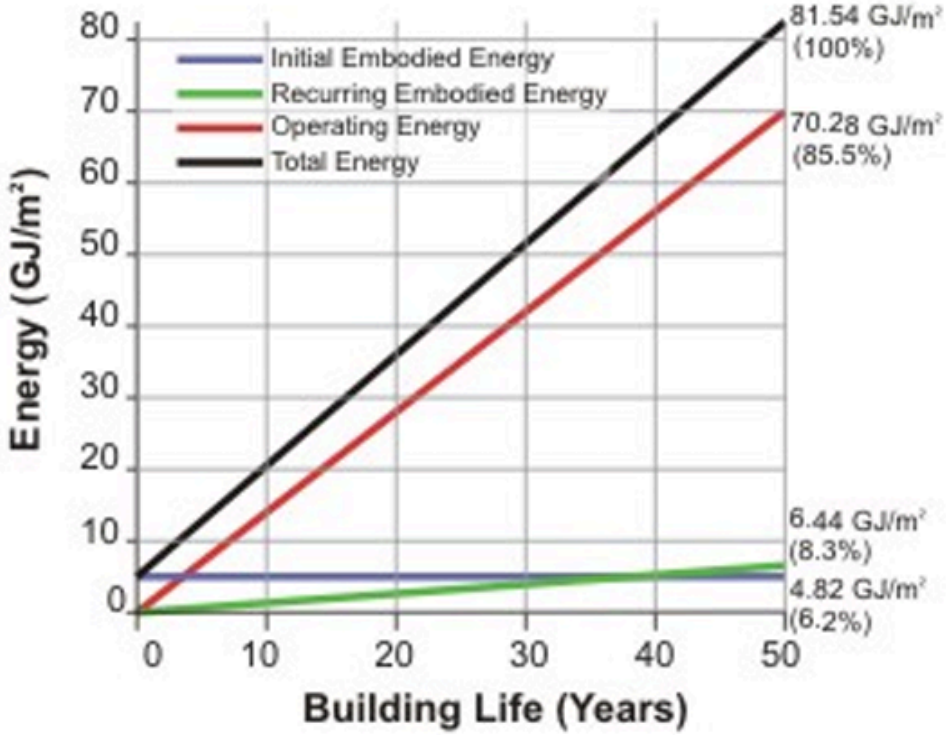
Historically, the operational energy consumed by a building over its lifetime has exceeded the embodied energy required to construct and maintain the building. Low energy buildings, however, shift the balance between operational and embodied energy impacts and make consideration of embodied energy more critical than is the case with traditional building practices. A historic illustration of embodied versus operating energy is shown in Figure 0.1, while Figure 0.2 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-optimization for multifamily projects and
2. Re-evaluation and future rubric for retrofit projects (Refer to Appendix R).

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.



Components of Energy Use During 50-Year Life Cycle of Typical Office Building with Underground Parking, Averaged Over Wood, Steel and Concrete Structures in Vancouver and Toronto [Cole and Kernan, 1996].

Figure 0.1. Example comparing operating energy and embodied energy of a building.

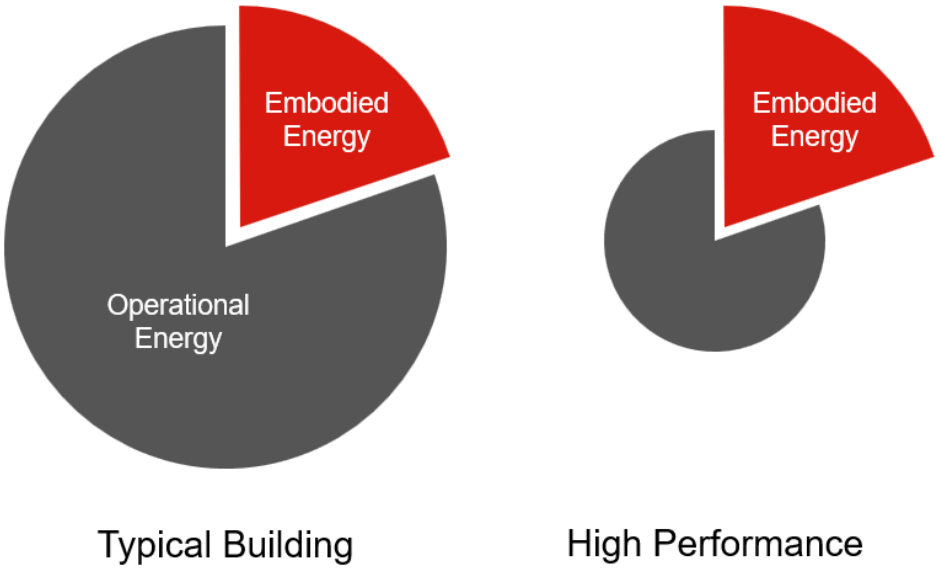


Figure 0.2. Example comparing embodied energy in typical vs high performance buildings. Source: West Cost Climate Forum

0.2 Reasons to Certify

The Phius certification process is the best way to design and construct any building. 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 Efficient New Homes 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.

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 or METr energy model for performance path certification or completing the Prescriptive Checklist for prescriptive path certification.

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 model alignment with as-built changes reported 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.

Example: Sample Letter of Intent (LOI)

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 Quality Control Field Checklist, the Phius Quality Assurance Workbooks and associated 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 0.5.0 Certification Programs Matrix			
Single-Family, Duplexes & Townhouses	1 - New Construction - Performance Path	2 - New Construction - Prescriptive Path	3 - Retrofit - REVIVE 2024
Multifamily		n/a	
Mixed-Use			
Non-Residential			

0.5.1 Single-Family, Duplexes & Townhouse Projects

Single-family, duplexes, and townhouses are all eligible for any 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). Single-family and duplex projects should follow the Phius Single-Family Quality Assurance Workbook.

Townhouses

"Townhouse" refers to single-family dwelling units 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.[1] Townhouse projects should fall under the single-family program version and follow the Phius Single-Family Quality Assurance Workbook.

[1]Aligns with the ANSI / RESNET / ICC 301 definition for "*Townhouse*"

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 (WUFI Passive) and Section 1.4.6 (METr).

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 all 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")

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.

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 Tip:

- Thermally isolate residential spaces from a non-residential 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. If no tenant is found, the space may still be certified, but only under Path A noted below.

The source energy allowance for non-residential 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 non-residential areas. An overall source energy limit for the building applies, consisting of a per person portion for residential space, per-square-foot portion for non-residential 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 or METr. The protocol for this is described later in Section 1.4.4.10.

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

Residential and non-residential 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 non-residential 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) → Non-Residential

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.

Net Source Energy Allowance: If the campus/community is 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.

Space Conditioning: Each individual enclosure must be modeled separately, allocating the correct internal loads to each enclosure for accuracy of the internal heat calculation (e.g., 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.

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 all projects (new construction or retrofit) 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 new construction single-family, duplexes, and 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.

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 achieving net-zero energy use on an annual basis.

1 - New Construction - Performance Path

1.1 Process

Table 1.1.0 New Construction Process Matrix

AIA Project Phase	Phius Phase	Phase Summary
Pre-Design (PD) / Schematic Design (SD)	**Phase 0** Feasibility Study / Red-Flag Review (Optional)	- **Feasibility Study:** Phius completes a preliminary energy model to determine if the project is on the right track before committing to certification. - **Red-Flag Review:** Phius conducts a preliminary review of the energy model and project documentation to identify major issues prior to official Design Certification Review. - See **Section 1.1.1**
	Phase 1 Paperwork	- Project team requests a quote, invoice, & contract. - See **Section 1.1.2**
	Milestone 1 Project Registered	- Project team signs the contract and pays the invoice. - Phius creates a project number, makes the project publicly visible on the Phius Certified Project Database, and shares a project Dropbox folder with the project team. - See **Section 1.1.3**
Design Development (DD) / Construction Drawings (CD)	**Phase 2** Design Review	- Submitter/CPHC uploads project documents. - Phius reviews the documents and provides feedback. - Project team responds to Phius' feedback and revises the project documents. - Repeat until all comments are resolved. - See **Section 1.1.4**
Bidding & Procurement	**Milestone 2** Design Certification	- Phius certifies the design and sends an official letter of Design Certification to the project team. - See **Section 1.1.5**

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	- Rater/Verifier performs site visits and communicates all changes to the Submitter/CPHC. - Submitter records all changes in the Phius Certification Feedback Form. - See **Section 1.1.6.1**
	Phase 3.2 Final Review	- Rater/Verifier uploads all documentation. - Phius reviews the documents and provides feedback. - Rater/Verifier responds to Phius' feedback and revises the project documents. - Repeat until all comments are resolved. - See **Section 1.1.6.2**
Post-Construction (PC)	**Milestone 3** Certification	- Phius certifies the as-built project. - Phius sends a plaque to the project owner and a digital certificate to the project team. - See **Section 1.1.7**

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

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

1.1.1.1 Feasibility Study

Detailed information about Feasibility Studies is available on the Phius website. Review Section 1.2.4.2 for fees.

1.1.1.2 Red-Flag Review

Requests for Red-Flag reviews can be made through the Phius website. There are two options for Red-Flag reviews:

Virtual Screen-Share Review

The project team schedules 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

Phius provides 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

Prior to submitting a project for Phius Certification, the project team should first conduct an in-depth review of the Certification Guidebook, which summarizes all certification requirements, energy modeling protocol and additional technical guidance.

1.1.2.1 Paperwork Steps

1. A representative from the project team, referred to from here on as the 'Submitter,' requests 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.' The Submitter may be the CPHC and/or the Client.

2. Phius creates and issues a contract that includes the quoted fee. Certification fees are outlined in Section 1.2.

3. The Submitter receives a link to the contract that can be forwarded to the Client for review and signature. Contracts can be digitally or physically signed, but must always be digitally uploaded.

4. After the contract is signed, the Submitter or Client (as requested by the Submitter) receives a link via email to the invoice.

1.1.3 Milestone 1: Project Registered

A project becomes Registered once Phius receives the signed contract and payment from the project team. Phius will then assign a project number, create a Dropbox folder and list the project in the Phius Certified Project Database.

Process Tip: Phius shares the Dropbox folder with the project Submitter. The Submitter receives a notification via email which will include a link to request access for additional team members. Appendix I-1.1 contains best-practice tips and guidance 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 includes the expected timeline for Design Review.

1.1.4.1 Design Review Steps

1. The Submitter and/or CPHC uploads project documentation into the Phius Project Dropbox folder.

2. The Submitter and/or CPHC submits 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 reviews and provides comments on the documentation uploaded by the Submitter and/or CPHC using the Phius Certification Feedback Document. Comments focus on items that should be addressed for Design Certification compliance.

4. Phius notifies the Submitter and/or CPHC via email when review has been completed. The project is removed from the Phius Project Certification Review Queue.

5. The Submitter and/or CPHC replies to comments in the Phius Certification Feedback Document and provides

updated documents and WUFI Passive or METr model for review.

6. The Submitter and/or CPHC repeats 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.

1. Phius sends a Design Certification Letter to the Submitter/CPHC via email with a link to request Dropbox access for the Rater/Verifier and additional team members.

2. The Submitter/CPHC uses 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 works closely with the Submitter and/or CPHC.

1. During construction, across various site visits, the Phius Rater or Verifier completes all of the on-site inspections and tests. Refer to Section 1.5 for more information.

2. Once the on-site inspections and tests are complete, the Phius Rater or Verifier communicates all as-built envelope changes to the Submitter and/or CPHC.

3. The Submitter and/or CPHC updates the WUFI Passive or METr energy model to match any known as-built changes per the Phius Rater or Verifier from Design Certification before submitting for final review.

Process Tip:

- A copy of the Design Certified WUFI-Passive (.mwp) or METr (.json) file should be created to make as-built changes. The as-built energy 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-2.3.

1.1.6.2 Final Review

Final Review may begin once the project reaches Milestone 2: Design Certification and completes Phase 3.1: Construction, Observation & Testing. Section 1.1.9 includes the expected timeline for final review.

1. The Phius Rater or Verifier uploads all documentation to the project DropBox after all on-site inspection and testing is complete.

2. The Phius Rater or Verifier submits 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 Phius Rater or Verifier 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 reviews the documentation and provides comments using the Phius Certification Feedback Document on the documentation uploaded by the Rater or Verifier.

4. Phius notifies the Rater or Verifier via email when Phius' review has been completed. The project is removed from the Phius Project Certification Review Queue.

5. The Phius Rater or Verifier replies to comments in the Phius Certification Feedback Document, provides necessary additional documentation and clarifies any questions or comments where requested.

6. The Phius Rater or Verifier then repeats 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 begins the Finalization process and sends an email notification to the Rater or Verifier. During Finalization, a Phius Building Certification staff member adjusts the final WUFI Passive or METr 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 Certified.

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

1.1.7 Milestone 3: Certification

Phius awards Certification after the final review process is complete and the project meets all certification requirements.

1. Phius sends a notification to the Submitter, CPHC and Rater or Verifier via email.

2. The Submitter, CPHC, Rater or Verifier reviews and confirms the following information:
    - Architecture Planning
    - Building Owner
    - Construction Company
    - Mechanical Systems Designer

3. Phius issues a digital project certificate.

4. Phius ships one plaque per project to the project address. Pricing information for additional plaques is found in Section 1.2.5.

5. The Submitter, CPHC, Rater or Verifier uses 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 the 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 Passive or METr model and 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, project teams can expect the review timelines outlined in Tables 1.1.9.0 and 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 and the completeness and accuracy of the first submission.

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
Expedited 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

Submission Date

This is the date a project has been submitted into the Phius Review Queue by the Submitter or CPHC. Phius approves submissions within 3 business days.

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.

Process Tip: Phius has a 'two strikes, you're out' policy. If the 'Document Upload Required' date is missed, Phius will push the project back two weeks in the queue and the Submitter will be notified via automated email. If, after two weeks, documents are still not available for review, Phius will remove the project from the queue entirely and the Submitter will be notified via automated email.

Feedback Return Date

Indicates the latest date that Phius will return project feedback, issue Design Certification or issue 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	$2,500		n/a				
Multifamily*	$3,800	$7,900	$15,100	$23,200	$34,700	$57,500	$83,200
Non-Residential*	$4,100	$8,300	$15,800	$24,200	$36,200	$59,800	$86,500
Mixed-Use*	Fees are based on the floor area of each mixed-use space type.						
Expedited Review	Available for an additional cost equal to 50% of the base certification fee (subject to Phius approval).						
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 $2,500 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 certification. Phius' fee does **not** include the fees associated with the CPHC, Rater or Verifier.

1.2.2 Discounts

- **Phius Alliance Members:** 15% discount, up to $600.
- **Non-profit organizations:** 25% discount, up to $1,000.
- **Duplicate or repeated buildings:** May receive a discount for each duplicate building submitted after the first at Phius' discretion. If you feel your building qualifies for a duplicate discount, include a note in your contract submission request.

1.2.3 Expedite Fee

An expedited review may be available for an additional 50% up-front cost on top of the base fee. See description of what this service entails in Section 1.1.9.

Example: A single-family home with a base fee of $2,500 would have an expedite fee of $1,250, totaling $3,750 for the full fee.

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. These services are **not** included in the project certification fee and are available for additional fees as needed. Typical consulting rates are noted in Table 1.2.4.1.0, but specific services may have different pricing.

Table 1.2.4.1.0 Phius Hourly Consulting Rate

Base Fee	$200/hr
Phius Alliance Member Fee	$175/hr

1.2.4.1 Red-Flag Review Fee

Red-flag reviews require 2-hours of consulting time at the hourly rates noted in Table 1.2.4.1.0.

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	$3,000	$4,000
10,001 - 50,000	n/a	$4,000	$5,000
50,001 - 100,000		$5,000	$6,000
Each additional 50,000		+ $1,000	+ $1,000

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 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 1601
  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	
DOE ENERGY STAR	Single-Family New Homes Version 3.2 Refer to Section 1.4.1.1 & Section 1.5.3	Multifamily New Construction (MFNC) Version 1.2 Refer to Section 1.4.1.2 & Section 1.5.3	
DOE Efficient New Homes	Single-Family Version 2 Refer to Section 1.4.1.1 & Section 1.5.3	Multifamily Version 2 Refer to Section 1.4.1.2 & Section 1.5.3	
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 outlined 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 Efficient New Homes Programs		Refer to Section 1.3.4.4

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.	

1.3.1 Scope Limitations

The Phius CORE 2024 & Phius ZERO 2024 Certification Programs are applicable to construction that falls within the following parameters:

- Stand-alone new construction buildings.
- New construction additions greater than 100% of the floor area of an existing building that is **not** being renovated.

Exceptions: Garages are **not** permitted to be included in the Certification scope or within the Certified enclosure.

Single-family homes are not eligible for partial certification.

Process Tip: Phius recommends all conditioned spaces within the building to be included as part of certification, but understands that this is not always possible. When considering spaces to include/exclude from the thermal envelope, consider the following questions. If the answer is **"Yes"**, to any of them, then that space should be included within the Certification.

1. Is the intended purpose to serve only the occupants of the certified portion of the building?
2. Are mechanical systems shared with a certified portion of the building? (heating/cooling and/or ventilation)
3. Are the benefits of passive building strategies important to the occupants? (indoor air quality, comfort, noise reduction)
4. Is it connected to a certified portion of the building with minimal thermal and air control? (ie. only uninsulated interior partitions or openings)

Commercial kitchens should be included within the thermal and airtight envelope if it is serving the occupants of the building, or portion of the building, being certified. Review Appendix I-3.17 for modeling protocol and additional guidance.

Trash rooms may be included or excluded at the discretion of the project team. Review available options and additional guidance here.

Contact Us early in the design phase when determining which spaces are to be included/excluded.

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 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)

[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.

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 durability airtightness limit(s)[4] 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.

[3]Gross enclosure area is measured at the exterior of the thermal boundary and includes surfaces in contact with the ground.

[4] Refer to Section 1.5.2.3 for more information on durability vs. operational blower door testing protocol

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 1.4.2.6 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 or fire rated
- Skylights

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 1.4.2.6 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[5]	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		

[5] 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 net annual usage after accounting for renewable energy production. 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]		
	United States	Canada	Japan
1A	31.0	-	42.9
1B	28.0	-	-
2A	28.0	-	38.8
2B	25.0	-	-
3A	27.0	-	37.4
3B	23.0	-	-
3C	22.0	-	-
4A	28.0	-	38.8
4B	23.0	-	-
4C	21.0	20.6	-
5A	30.0	29.4	41.6
5B	25.0	24.5	-
5C	23.0	22.5	-
6A	34.0	33.3	47.1
6B	30.0	29.4	-
7	39.0	38.2	-
8	46.0	45.1	-

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”.

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. Review the recommendations outlined in Appendix I-2.3.

Process Tip: 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 makeup 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:

Option 1: Total measured supply and exhaust airflows are within 10% of each other.

Process Tip: 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% (exhaust > supply only), the energy penalty must be accounted for per Section 1.4.4.9.

Option 2: 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 flow exponent *n* from the multi-point airtightness test results.

Where intermittent direct exhaust systems are provided (ie. kitchen range hoods and/or exhaust dryers), use the Phius Intermittent Allowance Estimator to determine if a make-up air system is required.

Minimum Ventilation Rates

Residential Requirements

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

- **Supply air requirements:** A minimum of 15 cfm per person[6] must be provided and dedicated outdoor air supply to all bedrooms is required. Refer to Section 1.4.4.4 for occupancy calculations of buildings with dwellings.

  Process Tip: 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. Refer to Appendix C-4.

- **Exhaust air requirements:** Based on kitchens and bathrooms. Minimum continuous **or** intermittent exhaust air flow rates are dependent on project type and the local building code which may override the values below:
  - **Kitchens**[7]
    - 25 cfm continuous **or** 100 cfm intermittent
  - **Bath/toilet rooms**[8]**:**
    - 20 cfm continuous **or** 50 cfm intermittent

Exception: For projects in jurisdictions that require compliance with the 2024 International Mechanical Code (or newer), the minimum continuous exhaust rates for kitchens and bathrooms of Multifamily (4+ stories) buildings is higher: 50 cfm for kitchens and 25 cfm for bathrooms. Phius' space conditioning and source energy targets are built with these airflow rates in mind.

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

Unit type B: 4 bed / 2 bath
- Minimum supply rate: 75 cfm
  - 15 cfm * 5 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)

[6] 18 cfm per occupant is recommended.

[7] Future update to align with EPA Indoor AirPlus v2 as required by DOE's Efficient New Homes program. Direct, intermittent kitchen exhaust will be required in single-family, duplex, and townhouse buildings.

[8] Half-baths and powder rooms should be treated as full bathrooms and 20 cfm should be achieved.

Non-Residential Requirements

For non-residential buildings, the design[9] occupancy shall be used to size the system and the applicable mechanical code (IMC, ASHRAE 62.1 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.

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

Ventilation System Distribution Requirements

All ventilation distribution ductwork from the ventilation unit to the interior supply and exhaust registers must be within the thermal envelope.

Kitchen exhaust registers: If the kitchen exhaust is connected to the ventilator (E/HRV), the register must maintain a minimum distance of 6 feet[10] 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.

Process Tip: From a practical approach, you may consider providing both a MERV 3 filter at the exhaust inlet and a washable filter in the recirculation hood. The reason is, there is no guarantee the occupants will actually use the hood while the ERV is running continuously. This recommendation is to help ensure fumes/grease are captured at the source (near the cooktop) and the ERV is protected if the hood is not used regularly.

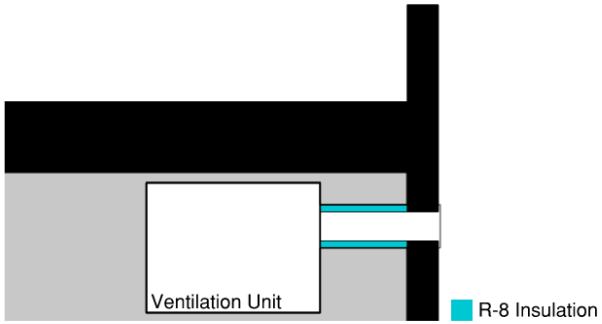
[10] Recommended to maintain this distance in plan, but the stretched-string distance is the minimum requirement.

Ventilation Intake & Outlet Ductwork Requirements

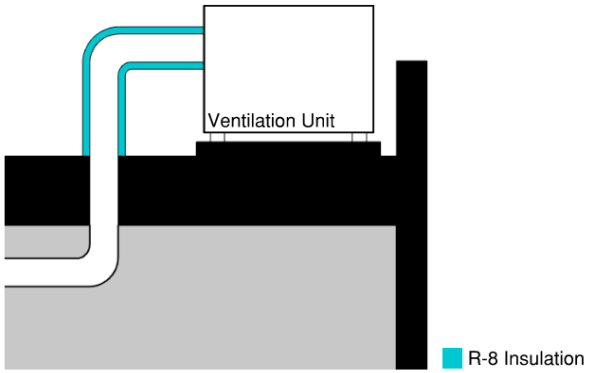
Ventilation ducts from both scenarios in the diagrams to the right shall be insulated to a minimum of R-8[11].

Process Tip: It is best practice for ductwork from the ventilation unit to the thermal envelope to be as short and direct as possible to reduce losses through the ductwork.

1. **Ductwork from ventilation units inside of the thermal and airtight envelope to the interior face of the exterior assembly:**



2. **Ductwork from ventilation units outside of the thermal and airtight envelope to the exterior face of the exterior assembly:**



[11] For air-permeable insulation (such as fiberglass duct wrap), an air-sealed, class 1 vapor retarder shall be installed.

1.3.4.3 Cooling Distribution

Cooling distribution systems that rely on transfer fans to supply cooling air to rooms from adjacent rooms are prohibited.

1.3.4.4 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 U.S. DOE Efficient New Homes Single Family National Rater Checklist Version 2, Revision 3.

Multifamily

All multifamily Phius projects must comply with the Phius Annotated: DOE Efficient New Homes Multifamily National Program Requirements and Phius Annotated: DOE Efficient New Homes Multifamily National Rater Checklist.

Process Tip: For project teams that obtain ENH Certification, the documents above do not apply.

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 Efficient New Homes 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 Efficient New Homes 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 Efficient New Homes 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-2.4 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.

Process Tip:
The intent laid out above applies to both interior and exterior fireplaces.

Phius ZERO projects

Fossil-fueled combustion fireplaces 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 (WUFI Passive) Review Section 1.4.5 (METr)
Modeling Protocol	Review Section 1.4.4 (WUFI Passive) Review Section 1.4.6 (METr)

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:

- DOE ENERGY STAR Single-Family New Homes
- EPA Indoor AirPlus (IAP)
- DOE Efficient New Homes 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.

DOE 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 Efficient New Homes Program.

Exceptions: Projects located in California shall meet the California Single-Family Version 3.4 program requirements per the Efficient New Homes 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 ≥ 4' above grade and/or roof deck[12].

  Process Tip: Projects located in ASHRAE climate zones 4 through 8 are recommended to provide ventilation air outlets ≥ 4' above grade and/or roof deck[11].

- Lines 3.1, 4.1 and 5.1

  Process Tip: WUFI Passive and METr 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

[12] Phius considers the roof deck to include the roof membrane or coverboard as the intention of the requirement is to prevent inlets and outlets from being clogged with potential snow drifting.

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: A minimum of MERV 8 filters are required for ducted ventilation systems. Alternate filtration ratings that demonstrate equivalency to the MERV 8 rating may be accepted at Phius' discretion (e.g., Class G4 per EN 779).

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 Efficient New Homes program (permit dates after 1/1/2027). Indoor AirPlus Version 2 | US EPA is now available.

Exception: 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.

DOE Efficient New Homes

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

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:

- DOE ENERGY STAR Multifamily New Construction (MFNC)
- EPA Indoor AirPlus (IAP)
- DOE Efficient New Homes 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.

DOE 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 Efficient New Homes 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 ≥ 4' above grade and/or roof deck[12].

      Process Tip: Projects located in ASHRAE climate zones 4 through 8 are recommended to provide ventilation air outlets ≥ 4' above grade and/or roof deck[12].
- 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: A minimum of MERV 8 filters are required for ducted ventilation systems. Alternate filtration ratings that demonstrate equivalency to the MERV 8 rating may be accepted at Phius' discretion (e.g., Class G4 per EN 779).

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 Efficient New Homes program (permit dates after 1/1/2027). 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 Efficient New Homes

Multifamily, mixed-use, and non-residential projects must meet the applicable certification criteria from the National Multifamily Version 2 program according to Phius Annotated document linked below. Actual ENH Certification is **not** required.

- Phius Annotated: DOE Efficient New Homes Multifamily National Program Requirements

Exception: For projects located in California, the California Multifamily Version 2 program requirements shall be met.

National Program Requirements, Version 2 (Rev. 1)

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

- Sections 4 & 5

  Phius Amendment: Phius requires multifamily projects to provide on-demand controls for decentralized (in-unit) domestic hot water recirculation systems.

- Sections 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

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 1.5.2.8

1.4.2 Required Documentation

Table 1.4.2.0 Required Design Documentation	
Compliance Tool	WUFI® Passive Energy Model **or** METr Energy Model
Drawings	Architectural, Mechanical, Electrical, Plumbing and Structural Sets
	Civil or Landscape Set (refer to Site Plan)
Technical Datasheets	Fenestration
	Mechanical Ventilation, Heating/Cooling and Domestic Hot Water (DHW) Equipment
	Insulation
	Appliances
	Light Fixtures
	Miscellaneous Equipment (e.g., pumps, fans and appliances)
Calculations & Analyses	Phius 2024 Criteria Calculator
	Take-off Documents
	Fenestration Condensation Assessment
	Thermal Bridge and Moisture Risk Calculations
	Additional Calculators
Letter of Intent	From a Rater or Verifier as outlined in Section 0.4.5
Co-Requisites	HVAC Design Report & Rater Design Review Checklist (refer to Section 1.4.1)
Process Tip: Review the Phius Single-Family Sample Project for examples of documentation noted above.	

1.4.2.1 Required Documentation for Submission

At a minimum, the following documents must be uploaded to the Phius DropBox folder shared during Milestone 1: Project Registered for the first submission:

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

1.4.2.2 Required Documentation for Design Certification

In addition to the documentation above, the following must be uploaded to the Phius Dropbox folder and approved by the Phius Building Certification team before Design Certification can be awarded:

4. Technical Datasheets (or basis of design documents)
    a. Fenestration
    b. Systems (Ventilation, Heating/Cooling, Water Heating)
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

> **Exception:** The National HVAC Design Report is **only** applicable to projects pursuing *Track B - HVAC Credential* (most common). If *Track A - HVAC Grading* is being pursued, the National HVAC Design Supplement must instead be provided.

1.4.2.3 Compliance Tool

There are now two compliance tool options available for new construction performance path projects:

- WUFI® Passive Energy Model (**.mwp** file)
  - Review Section 1.4.3 for software information
  - Review Section 1.4.4 for modeling protocol
- METr Energy Model (**.json** file)
  - Review Section 1.4.5 for software information
  - Review Section 1.4.6 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:

- Overall 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. 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, slab on grade, or elevator pit slab (section)
- Junctions between exterior walls and intermediate floors (section)
- Junctions between exterior walls (plan)
- Window, door, and roof hatch installation (section and plan)
    - Including dimensioned window reveal depths. Refer to diagram in Section 1.4.4.6
- 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.

- **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 or METr 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 dimensions of each unit.

Process Tip: Phius does **not** dictate strict naming conventions. However, clear naming conventions should be used for all windows and assemblies in the energy model that can be easily understood by a reviewer that is unfamiliar with the project. The best way to do this is to align the assembly names in the energy model with the detail drawings or schedules provided for review.

Example: The drawing set for a multifamily project includes an exterior wall types schedule with three assemblies: EX1, EX2, and EX3. The first two wall types are identical except for the cladding material, while the third is completely unique. The project also includes a partition schedule which includes two unique assemblies between the certified space and garage: W1 and W2. The schedules are on separate sheets.

In WUFI Passive or METr, the naming conventions of the assemblies include the wall tag as well as the sheet number, allowing the Phius reviewer to quickly identify where to look in the drawing set to verify the modeled assemblies:

- EX1-EX2 / A0.01
- EX-3 / A0.01
- W1 / A0.02
- W2 / A0.02

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, which must include:

Mechanical Ventilation Systems

Review recommendations outlined in Appendix I-2.3.

- 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. See Ventilation Intake & Outlet Ductwork Requirements.

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)

Additional Systems / Equipment

- Pumps, fans, solar thermal, defroster, ground loop, earth tube, etc...
- Amenity systems (pool/hot-tub pumps, heaters, etc,.)

Electrical Set

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. Must include:

Lighting

- Fixture schedule
- Locations & quantities of fixtures

Plumbing Set

The make and model of all domestic hot water equipment noted below should be provided through either an equipment schedule or annotations within the plans. Takeoffs for DHW Piping are also required. Must include:

- Piping layout, material, insulation, and sizes
- Fixture type (standard or low flow)
- Circulation, booster or well pumps
- Off-grid water supply and/or wastewater treatment

Structural Set

If the dimensions of structural members are **not** included in the Architectural Set, be sure to provide the associated Structural Set.

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 any of the five sources listed below[13].

Process Tip: The sources listed are 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. **Home Ventilation Institute (HVI) > Section 3 Directory (for ventilators up to 300 cfm)**
    - Adjusted Sensible Recovery Efficiency (ASRE)[14]
    - Net Moisture Transfer (NMT) or Latent Recovery/Moisture Transfer (LRMT).
2. **Air-Conditioning, Heating, and Refrigeration Institute (AHRI)**
    - AHRI Standard 1060 based simulation data required.
        - Net Sensible Effectiveness[14]
        - Net Latent Effectiveness

    Process Tip: Ratings for commercial units do not include electrical efficiency data. For design certification calculations, estimate electrical consumption from manufacturer's specifications by dividing the total fan power (W) by the design air-flow rate (cfm).
3. **Eurovent Certified Products Database**
    - EN 308:2022 based simulation data required

[13] 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.
[14] This data accounts for potential duct leakage and exhaust air transfer.

4. **Passivhaus Institut (PHI) Certified Component Data (PHI)**
    - 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 specified. If the humidity recovery listed on the certificate is 0%, 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.

5. **Individual Manufacturers**

> **Process Tip:** If no 3rd party verification data is available, the stated manufacturer efficiency minus 12 percentage points shall be used.

> **Example:** A ventilator manufacturer lists the Sensible Recovery Efficiency of their unit as 95%, but **no** third party rating data is available.
>
> - 95% - 12% = 83% → Required value to be input in the energy model per Phius' modeling protocol

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 1.4.4.18 for modeling protocol for certification.

Heating Systems

- Heat Pumps
    - Coefficient of Performance (COP)[15]
        - Rated at 17°F
        - Rated at 47°F
    - Heating Seasonal Performance Factor (HSPF or HSPF2)
- 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)

> **Process Tip:** If only EER is provided, use the following formula to estimate SEER:
>
> - SEER **=** **(**1.12-**√(**1.2544 **-** 0.08 **x** EER**))** **/** 0.04

[15] 17°F and 47°F are typical temperatures used for heating COP ratings. However, COPs rated at temperatures other than 17F and 47F are also acceptable

Standalone Dehumidifiers

- Energy Factor (L/kWh)

> **Process Tip:** A default COP of 1.2 may be used in the energy model for cooling systems that provide latent cooling as a product of sensible cooling (e.g., air source heat pump, mini-split, VRF etc)

Domestic Hot Water (DHW) Equipment

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

Typical performance data available based on product type are outlined below. Review Section 1.4.4.19 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.

Thermally Broken Fasteners & Systems

Datasheets are required for thermally broken fasteners.

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.

> **Process Tip:** Projects using commercial-grade clothes washers should download the 'Excel File' found in the upper right corner on the ENERGY STAR Certified Commercial Clothes Washers webpage to obtain the annual energy consumption (kWh/yr).

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 Section 1.4.4.8) for common areas.

Miscellaneous Equipment (pumps, fans, 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 Sections 1.4.4.16 - 1.4.4.21.

1.4.2.6 Calculations & Analyses

Phius 2024 Criteria Calculator

This calculator is required all performance path projects[16]. A screenshot of the calculator should accompany the WUFI Passive file uploaded for Phius' review.

Exception: This calculator is now built-in and not required to be completed outside of the energy model for teams using METr.

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 or METr model within the `PH Verification Report`[17] 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.

Non-Residential Mode

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

- **Design (Max) Occupancy:** Maximum occupancy of the building. Refer to Section 1.4.4.10.

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. 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.

Process Tip: This custom calculator may not be used for any other projects except the one for which it was purchased, unless they share a site.

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

[17]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.

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.

Process Tip: iCFA take-offs must clearly show the boundary at which the iCFA was measured on each floor. It is best practice to use a colored overlay with 25% opacity for the takeoffs so it is visually clear if any spaces have been cut out of the floor area (e.g., elevator shafts). In addition, for multi-level buildings, the calculation of the total iCFA (sum of all floors) should also be included either directly in the takeoff document (PDF), or in a separate Excel file.

Foundation Interface

Possible take-offs needed for the foundation interface include, but are not limited to, slab/floor area, perimeter, depth below grade, and extents of perimeter insulation. Refer to Section 1.4.4.4 below for detailed information on how take-offs should be performed for different foundation types.

Site Shading Study

Phius requires a shading study of the project site. 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 Piping

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 the Phius DHW Piping Protocol.

Mechanical Ducts

Mechanical plans should be annotated with the following information:

- Lengths of supply and exhaust ducts as measured from the inside of the exterior wall or roof to the ventilator
- Duct sizes
- Distance between ventilation system intake and exhaust registers (stretched string distance)
- Distance of exhaust register from cooktop

Fenestration Comfort & Condensation Assessment

Refer to Section 1.3.3 and use Phius' Window Comfort & Condensation Risk Assessment Tool to determine the climate-specific comfort requirements per window height[18], as well as the required temperature factor (fRsi) for a given project. For the condensation risk assessment, **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.

[18] Review Appendix N-3 for exceptions

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**[19]

Thermal Bridge 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. Supporting take-offs showing the length of each positive linear thermal bridge must also be provided for review.

Point Fastener Correction Calculator

Generates an adjusted continuous insulation R-value per inch. 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.

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.

[19] Passivhaus Institut (PHI) Certified Component Data

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 Passive or METr inputs

Process Tip: Calculators linked below that have "*(WUFI Passive)*" next to the name have been integrated into the METr software and are not necessary to be completed externally.

Shading

Blinds Calculator *(WUFI Passive)*

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.

Conversions

Airtightness Pressure Conversion Calculator

Phius allows airtightness testing at either 50Pa or 75Pa. The current software used for certification only accepts inputs at 50Pa. This resource allows projects to convert between 50Pa and 75Pa airtightness results.

Multifamily Specific

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.

Non-Residential Specific

Non-Residential Occupancy Estimator

This calculator should be used to determine average and design occupancy of non-residential and non-residential portions of mixed-use projects.

Non-Residential Lighting Calculator

This calculator should be used to determine lighting inputs in WUFI Passive or METr for non-residential projects and non-residential portions of Mixed-Use projects pursuing Phius Certification.

Non-Residential Effective DHW Usage Estimator

Use this estimator to determine the average gallons per person per day and the number of tap openings per person per day for non-residential buildings.

Space Conditioning Systems

Heat Pump Performance Estimator

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.

Mechanical Ventilation Systems

Intermittent Exhaust Allowance Estimator

Use this estimator to determine if a building targeting Phius Certification is required to provide a dedicated make-up air system when using intermittent direct exhaust systems such as exhaust dryers or exhaust kitchen range hoods.

Combined Space Conditioning and Ventilation Systems

CERV2 COP & Ventilation Efficiency Estimator

This estimator is available upon request. Provide the project number, ventilation type, and Phius climate location through the Contact Us form. This system requires dynamic (hourly) climate data to determine the performance values for WUFI Passive or METr modeling.

MINOTAIR COP & Ventilation Efficiency Estimator

This estimator is available upon request. Provide the project number, ventilation type, and Phius climate location through the Contact Us form. This system requires dynamic (hourly) climate data to determine the performance values for WUFI Passive or METr modeling.

Note: This device is no longer in production.

Domestic Hot Water Systems

DHW Storage Tank Loss Estimator

Use this estimator to determine storage losses for domestic hot water storage or swing tanks in Btu/hrF or Btu/hr when performance data is **not** available in these units from the manufacturer or a 3rd party rating system (ie. AHRI).

ECO2 CO2 HPWH Climate-Adjusted EF Calculator

Calculates a climate-adjusted Energy Factor for the ECO2 (formerly Sanden) CO2 Heat Pump Water Heater. Applies to Gen 1 - Gen 5.

Daikin Mega-Q Heat Pump Water Heater COP Estimator v26.1.0

Use this estimator to determine a climate-adjusted coefficient of performance (COP) for the Daikin Mega-Q Heat Pump Water Heater. Applies to RXHWQ120MQTJA heat source unit model paired with the BWLP120TJU cascade unit model.

ICE AIR Heat Pump Water Heater COP Estimator

Use this estimator to determine a climate-adjusted coefficient of performance (COP) for the Ice Air ccHPWH. Applies to 275-D-B, 275-S-B, 550-D-B and 550-S-B models.

Lync by WATTS - Aegis A CO2 Heat Pump Water Heater COP Estimator

Use this estimator to determine a climate-adjusted coefficient of performance (COP) for the Aegis A CO2 Heat Pump Water Heater. This estimator also includes instructions on modeling storage losses associated with water storage tanks per Lync by WATTS' available products. Applies to 250, 350 and 500 models.

Mitsubishi QAHV CO2 Heat Pump Water Heater COP Estimator

Use this estimator to determine a climate-adjusted coefficient of performance (COP) for the Mitsubishi QAHV CO2 Heat Pump Water Heater. Applies to N136TAU-HPB and N136YAU-HPB models.

Transom Heat Pump Water Heater COP Estimator

Use this estimator to determine a climate-adjusted coefficient of performance (COP) for the Transom Heat Pump Water Heater. Applies to V105, V210 and V420 models.

Auxiliary and Amenity Systems

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.

Snow Melt Energy Estimator

Use this estimator to determine the auxiliary energy associated with an active snow-melt system.

Pool Energy Use Estimator

Use This estimator to determine the auxiliary energy associated with the pumping and heating energy of indoor or outdoor swimming pools.

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 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.

Note: Version 3.5.0.1 is the final version of WUFI Passive; the desktop app will not be receiving any new updates. New CPHCs and those with licenses for WUFI Passive that are expiring soon should consider switching to METr.

1.4.3.2 WUFI Passive Online Tutorials

Free online tutorials can be found here.

Process Tip: Some of the tutorials may contain outdated guidance, or refer to modeling protocol that is not current. When referring to these tutorials for modeling assistance, please double check the modeling protocol outlined in this Guidebook, which supersedes these videos.
Due to the recently released METr cloud-based software, these tutorials will not be updated.

1.4.3.3 WUFI Passive Settings

Table 1.4.3.3.0 WUFI Passive Settings

Options	Selections	Instructions and Descriptions
General	Dimensions, visualized geometry	Choose Outer, extern partitions included
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 CORE or ZERO 2021[20]

1.4.3.4 Dynamic modeling in WUFI Plus

Not required for Certification. Refer to Appendix I-3.16.

[20] This is the most current option available in the software, which is no longer receiving updates. This setting will not impact the results of the model other than the automatically-calculated source energy target (shown in the reports and 'Results' window). This target should not be used for Certification compliance.

1.4.4 Phius Energy Modeling Protocol for WUFI Passive

Energy Model Defaults

The accepted software versions agree on default input values for several input parameters. Most pre-filled fields in WUFI Passive 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. Phius' Excel-based calculators are linked in their respective sections throughout this document. Common calculators are also linked above in Additional Calculators. Any calculator used to support modeling inputs should be uploaded to the project Dropbox folder for review.

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, review the Guidelines for 3D Geometry in WUFI Passive.

Note: This section follows the structure of the WUFI Passive project tree.

Table 1.4.4.0 Modeling Protocol Table of Contents	
1.4.4.1 Cases	General
	Reports
1.4.4.2 Localization / Climate	Localization
	Climate
	Source Energy / CO_2-Factors
1.4.4.3 Building	Building Wizard
	Orientation
	3-D Editor
	SketchUp Import
1.4.4.4 PH Case	General
	Additional Data
	Foundation Interface
1.4.4.5 Zone 1	Interior Conditioned Floor Area (iCFA)
	Specific Heat Capacity / Thermal Mass
1.4.4.6 Visualized Components	Type / Attachment
	Opaque Assemblies
	Transparent Assemblies
	Window Parameters
	Solar Protection
1.4.4.7 Thermal Bridges	Positive vs Neutral vs Negative
Internal Loads / Occupancy	[R] Residential: Section 1.4.4.8
	[NR] Non-Residential: Section 1.4.4.10
	[UF] Unfinished: Section 1.4.4.12

Table 1.4.4.0 Modeling Protocol TOC (continued)	
Ventilation / Rooms	[R] Residential: Section 1.4.4.9
	[NR] Non-Residential: Section 1.4.4.11
	[UF] Unfinished: Section 1.4.4.13
1.4.4.14 Attached Zones	Attached Zone Inputs
1.4.4.15 Remaining Elements	General
1.4.4.16 - 1.4.4.21 Systems	Systems Set-Up
	Mechanical Ventilation Systems
	Space Conditioning Systems
	Domestic Hot Water (DHW) Systems
	Renewable Energy Systems
	Supportive Devices / Auxiliary Energy

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 Phius Certification, there should only be **one** case per WUFI Passive file submitted for review.

Exception: For Mixed-Use projects, it is helpful to import the residential and non-residential portions of the building as two cases. This keeps the entire building in one WUFI Passive model which allows shared assemblies and window types to be easily updated across all cases.

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.

Case 1 > General Tab

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** have a 'Phius 2024' dropdown menu option. 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`

Exception: Unfinished (UF) projects must set the `Certificate Criteria` to `PHIUS+ 2018`. This setting is only appropriate in mixed-use projects that contain UF spaces. Refer to Section 0.5.3 for more information.

- ☑ **`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.

Case 1 > Report: Data & Results Tab

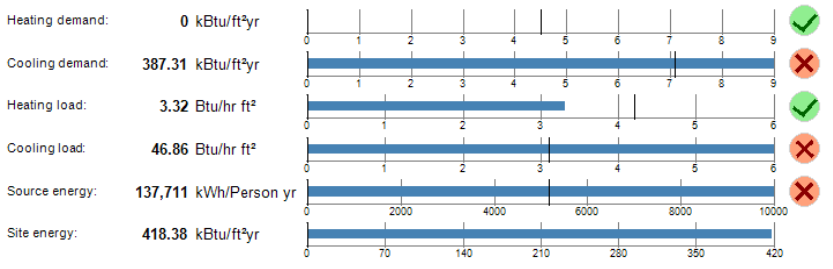
Reports are automatically generated upon completion of a WUFI Passive model. If results are present, the reports are available. Reports can be printed to PDF or exported into Microsoft Word. If exported into MS Word, charts can be copied into Excel if needed. Review WUFI Passive Tutorial 3: Report Data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

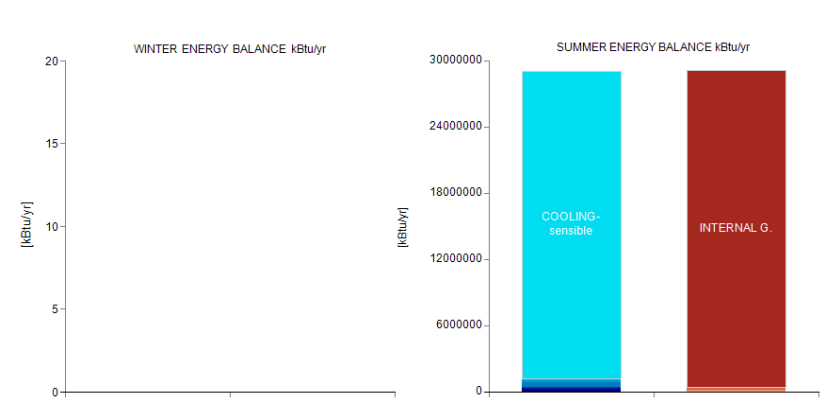
Scope

- **`Passive House Verification`:** Comprehensive summary of results and verification of compliance for all performance-based certification requirements, breakdown of losses and gains for calculation of annual demands and peak loads, electricity & DHW consumption, etc.

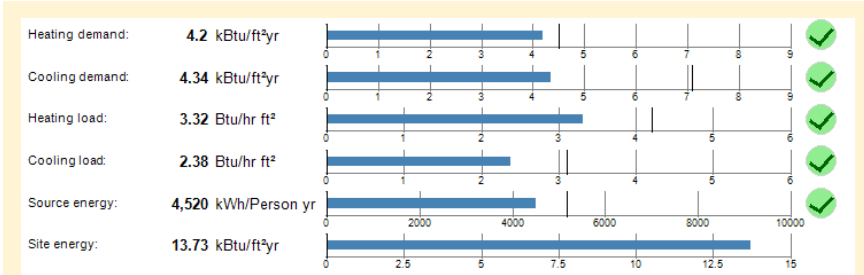
Process Tip: This report is especially useful for identifying areas of improvement in the design, or troubleshooting why the project is having difficulty meeting the Performance Criteria Targets.

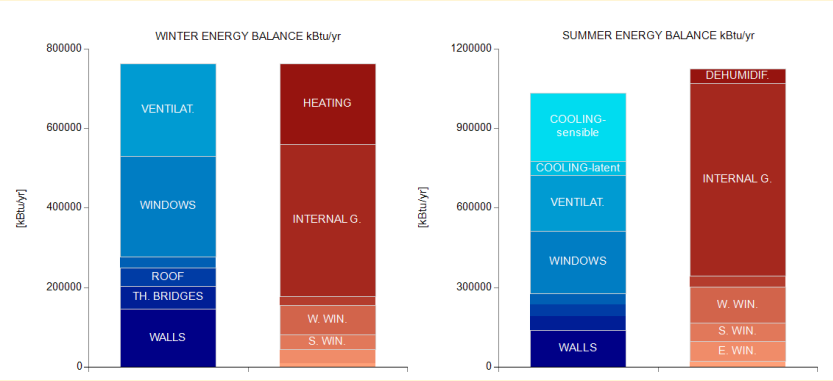
Example: An energy model for a mid-rise multifamily project is missing the cooling demand by an absurd amount. The team checks the PH Verification report and sees that the internal gains are causing the extreme results:





The team navigates to the `Internal Loads / Occupancy` branch and finds that input for refrigerators was set to kWh/day rather than kWh/yr. Once corrected, the results returned to normal:





- **`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: Navigate to `Options` > `Usability`, then check the box for `Show Project/Case in Footnote`.

1.4.4.2 Localization / Climate

Localization / Climate > Localization Tab

Phius has generated >1,000 climate datasets for locations across the United States, Canada and Japan; they are available as individual Text and Excel files per city. 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. Climate data must be approved by Phius for each project. Keep in mind the following when choosing climate data for a project:

The dataset must meet the following criteria:

- ≤50 linear miles from the project location.
- ≤400' difference in elevation from the project location

  Exception: Projects located in New York City may use the Central Park climate data set only if they are located within 2-blocks of Central Park.

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.

Exception: 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.

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. Review WUFI Passive Tutorial 4: Import Climate Data.

- The file types available for import are: Text files (.txt) and Excel (.xlsx)

  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.

Parameters

- **`Altitude Building`:** The altitude of the project site must be input. Use the typical elevation at grade. If there is a large grade change (e.g., 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
  - Japan 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.

  Process Tip: The climate zone can be found in both the standard and custom Phius 2024 Performance Criteria Calculator

- **`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 2	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 2	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 2	17.1	21.9	33.0	41.2	52.7	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			

Localization | Climate | Source energy/CO2-Factor

Data: User defined

Speed setting	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Heating W. 1	Heating W. 2	Cooling W. 1	Cooling W. 2
Temperature [°F]																
Ambient 1																
Dew point 3																
Sky* 4																
Ground*																
Solar radiation [kBtu/ft²Month]													Solar radiation [Btu/hr ft²]			
North																
East 2																
South 2																
West 2																
Global 2																

* Optional input. Sky/Ground: if not defined, temperatures will be estimated)

Review [WUFI Passive Tutorial 6: Entering Climate Data in WUFI Passive Free](#).

Localization / Climate > Climate Tab

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

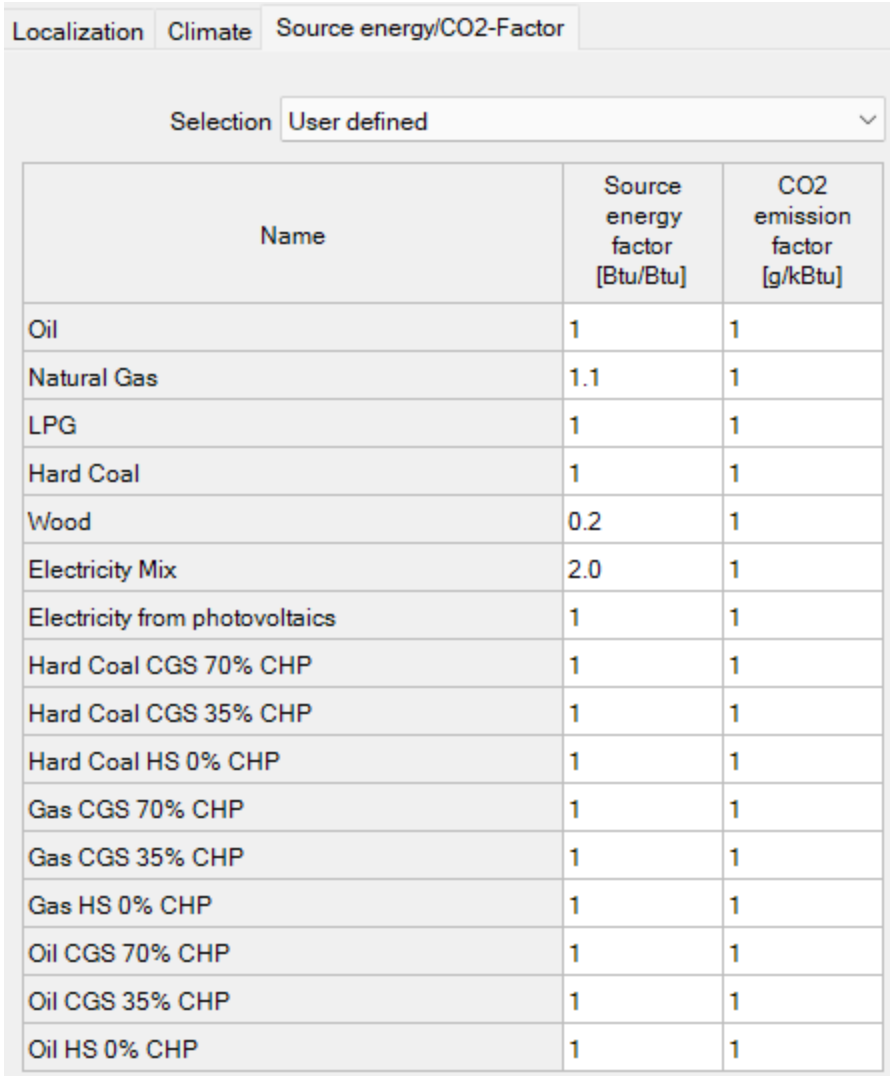
- **`Ambient Temperature`:** Monthly average outdoor air temperatures used for the annual heating and cooling demand calculations.
- **`Heating W.1`:** This column of data is used to calculate one of two peak heating load scenarios. This extreme weather condition uses a cold, clear day to calculate the 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.

Localization / Climate > Source Energy / CO_2-Factors Tab

- **`Electricity Mix`:** Use the national average values indicated below for certification, regardless of regional differences[21].
  - USA: 2.0[22]
  - Canada: 1.96
  - Japan: 2.77

Update the `Source Energy Factors` within WUFI Passive as shown in the screenshot to the right. Align the `Electricity Mix Source Energy Factor` with the country value noted above.



Name	Source energy factor [Btu/Btu]	CO2 emission factor [g/kBtu]
Oil	1	1
Natural Gas	1.1	1
LPG	1	1
Hard Coal	1	1
Wood	0.2	1
Electricity Mix	2.0	1
Electricity from photovoltaics	1	1
Hard Coal CGS 70% CHP	1	1
Hard Coal CGS 35% CHP	1	1
Hard Coal HS 0% CHP	1	1
Gas CGS 70% CHP	1	1
Gas CGS 35% CHP	1	1
Gas HS 0% CHP	1	1
Oil CGS 70% CHP	1	1
Oil CGS 35% CHP	1	1
Oil HS 0% CHP	1	1

Process Tip: WUFI Passive does not use the `Source Energy Factors` for fuel types other than `Natural Gas`, `Wood`, and `Electricity Mix` The `CO2 Emissions Factors` also are not considered in the results of the energy model, and therefore may be input as 1.

[21] 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.

[22] This value is reflecting a 2050 outlook, see Appendix I-3.2.

1.4.4.3 Building

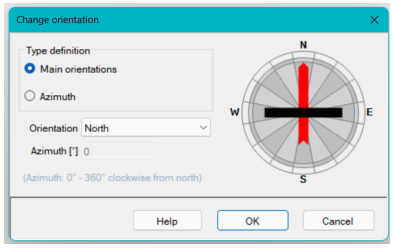
Building Wizard

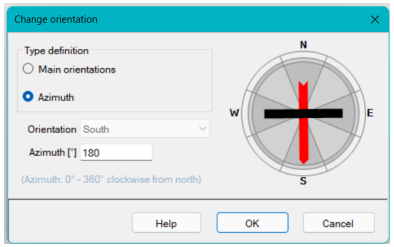
The building wizard can be used to create basic opaque massings by entering numeric values for plan, roof and foundation section dimensions. Review [WUFI Passive Tutorial 9: The Building Wizard].

Process Tip: Phius does **not** recommend using the Building Wizard 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

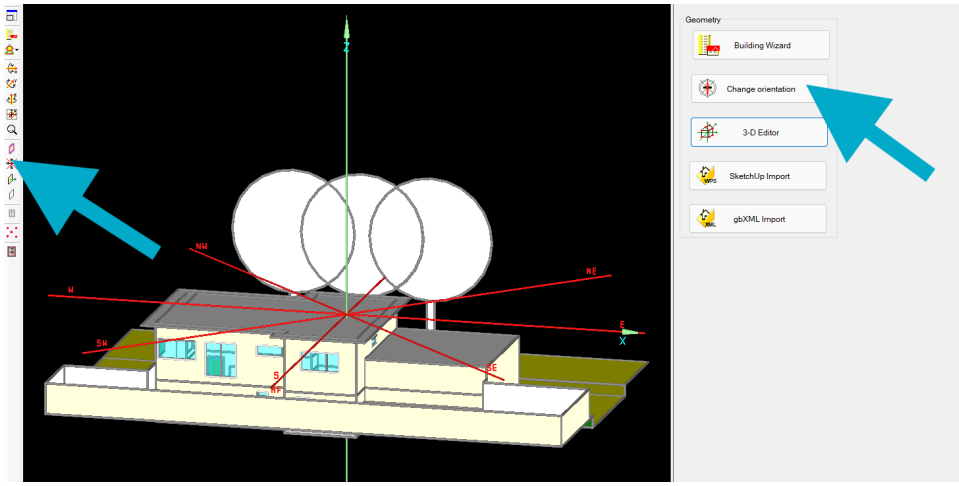
The orientation of the building can be changed by either selecting the main orientation from the built-in dropdown menu, or by entering a user-defined value for the azimuth (0° - 360° clockwise from N). Review [WUFI Passive Tutorial 10: Change Building Orientation].





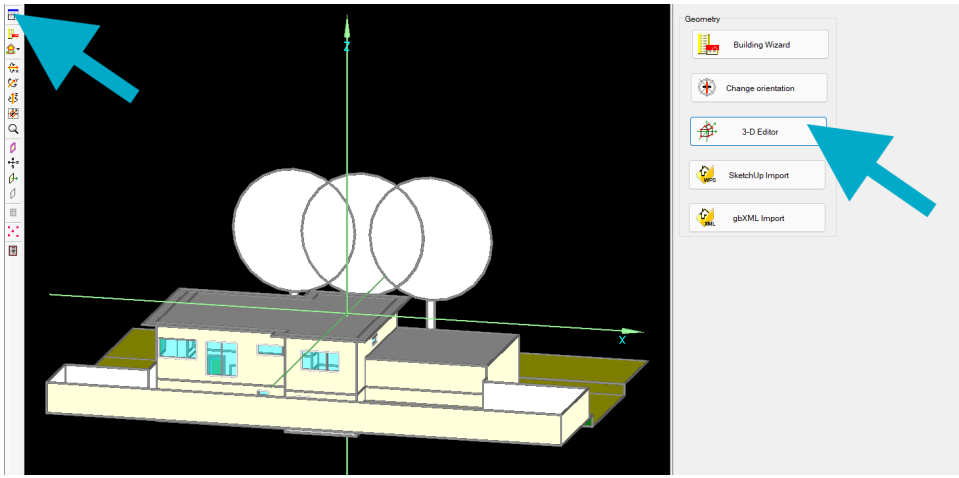
Process Tip: The orientation can also be changed using the `Orientation` toggle within the ribbon of the geometry viewer. This will turn on the compass as well to verify that the orientation is set correctly.

Phius recommends modeling all geometry orthogonally and setting the orientation in WUFI Passive rather than rotating it in SketchUp prior to import in order to reduce import errors.



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 ideal option for importing 3D geometry. For Sketchup modeling guidance, please refer to the Guidelines for 3D Geometry in WUFI Passive.

Note: `gbXML Import` is **not** recommended due to the tendency for import errors to occur. As an alternative, the Revit-to-Sketchup-to-WUFI Passive 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 Passive modeling purposes. For access to the guideline for this workflow, Contact Us.

1.4.4.4 PH Case

PH Case > General Tab

Review WUFI Passive Tutorial 15: PH Case General.

Building Category

Select whether the project pursuing certification is residential or non-residential according to the definitions in Section 0.5.

Occupancy Type

- **Residential:** Occupancy type must also be set to `Residential`.

  Process Tip: `Nursing Home` and `Other` occupancy types may not be used for Phius Certification

- **Non-Residential:** Select one of the following options based on the descriptions below:

  Process Tip: `Other` occupancy type may not be used for Phius Certification

  - **`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.
  - **`Undefined/Unfinished`:** Used for Unfinished (UF) non-residential projects with undefined programs.

    Process Tip: To use this setting, the `Certificate Criteria` must be set to `PHIUS+ 2018`

Indoor Temperature

68F is the required input regardless of the planned winter setpoint temperature.[23]

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.

  Exception: Private or shared dwelling areas in projects, such as dormitories or nursing homes, that do not contain a kitchen or bathroom are also considered 'units'.

  Process Tip: The quantity of units for multifamily projects should be taken from the Multifamily Lighting & Misc Load Calculator.

- **Non-Residential:** Input 1.

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'.

Process Tip: A full floor is defined as a regularly occupied space with a floor plate that is at least 25% of the overall footprint or typical floor plate.

Example: The roof level of a multifamily project is accessed via stairs (rather than a roof hatch). The stair shaft on the roof level should not be counted as a floor for this input in WUFI Passive.

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

PH Case > Additional Data Tab

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 because the `Simplified individual pipes` DHW distribution calculation method cannot be used for design certification for residential buildings. WUFI Passive, however, requires an input in order to function, so the default of 3 is acceptable.

- **Non-Residential:** Use the Non-Res Effective DHW Usage Calculator to determine this input. This calculates the tap openings based on the total typical occupancy on an average day of building use.[24]

Hot water tap-opening utilization days per year:

- **Residential:** Full-time occupancy is a required assumption for residential projects pursuing Phius Certification. For this reason, the default input of 365 must remain.

- **Non-Residential:** Input the annual utilization days for the project as entered in the Phius Non-Residential Occupancy Estimator.

Envelope airtightness at 50 Pa:

Review Section 1.3.3 for the durability airtightness limits required for Certification.

Process Tip: Phius recommends entering the maximum durability limit for the building, however for Certification to be issued, the operational airtightness limit is used.

A lower value may be used to meet space conditioning targets, but note that if you rely on this value to meet various space conditioning target requirements, you must meet this target value on-site or risk not meeting all certification requirements.

For some large buildings with elements that are considered non-threatening leakage (Review Appendix C-2.2), 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 operational blower door test value.

For mixed-use projects with multiple energy models, the whole-building airtightness result should be used for each model.

[24] **(**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**)**

☐ 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.

Type of Ventilation System

- **`Balanced PH Ventilation`:** Default system type for Phius projects. Incorporates continuous ventilation and allows the sensible and humidity recovery efficiencies 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 efficiencies 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. Select a screening level based on the conditions described below:

Process Tip: The number of facades exposed (either `Several Sides` or `One Side`) have no impact on the results in WUFI Passive. These settings control the **`Wind Exposure Factor (f)`** which is not included in WUFI Passive's calculations.

- **`No Screening`:** Low or non-existent neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)
  - **`Wind Screening Coefficient (e)`:** 0.10
- **`Moderate Screening`:** Similar height neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)
  - **`Wind Screening Coefficient (e)`:** 0.07
- **`High Screening`:** Tall and dense neighboring structures or landscape obstructions. (ie. buildings, trees, topography etc...)
  - **`Wind Screening Coefficient (e)`:** 0.04
- **`User Defined`:** When a building falls between one of the pre-defined screening factors, a user-defined entry may be used[25].
  - **`Wind Screening Coefficient (e)`:** 0.04 < X < 0.10

Process Tip: To justify a user-defined input, a well-documented site plan and narrative from the project team is required.

Examples:

`No Screening`: Building located in an open field with a non-existent or distant (>100') tree line. Highrise or skyscraper that towers above adjacent buildings or structures.

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

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

`User Defined`: 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.

  Process Tip: Refer to Appendix I-3.5 for additional information.

- **Non-residential:** 3.2 gal/person/day

  Process Tip: The default above will **not** fit for all non-residential projects. The entry may vary if supporting documentation is provided and approved by Phius. Refer to the Non-Residential DHW Usage Estimator.

Average cold water temperature of the supply

Leave this input blank.[26] WUFI Passive will calculate it using an average annual ground temperature.

[25] Inputs for Wind Exposure Factor (f) and Wind Shield Factor do not have an impact on the model. Input 15 and 0.1, respectively.

[26] 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.

Mechanical Room Temperature

Input here should be based on one of the following scenarios:

1. Ventilator **within** the thermal and airtight envelope:
    - This input may be left blank. WUFI Passive will assume 68F, which is the required input for Phius Certification.
2. Ventilator in unconditioned space **outside** of the thermal and airtight envelope:
    - Refer to the mechanical room temperature indicated at the bottom of the Phius 2024 Performance Criteria Calculator
3. Ventilator in **conditioned** or **semi-conditioned** space **outside** of the thermal and airtight envelope:
    - Input the setpoint temperature of the space.

PH Case > Foundation Interface Tab

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.

Process Tip: `Unheated Basement` should never be used.

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]`:** Measure from the interior face of the basement walls.
- **`U-value of basement slab [Btu/hr.sf.°F]`:**
    - **`Detect Automatically`:** Select if one assembly is assigned. The software will automatically align with the assembly assigned to `Ground`.
    - **`User Defined`:** Select if more than one assembly is assigned. Align the U-value with the assembly-specific value calculated by the software.
- **`Floor slab perimeter [ft]`:** Measure from the interior face of the basement walls.

  Process Tip: Do **not** include perimeter lengths in contact with conditioned space.

- **`Depth of basement slab below grade [ft]`:** Input the depth of the slab below grade, measured to the top (finish floor) of the slab. 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]`:**
  - **`Detect Automatically`:** Select if one assembly is assigned. The software will automatically align with the assembly assigned to 'ground'.
  - **`User Defined`:** Select if more than one assembly is assigned. Align the U-value with the assembly-specific value calculated by the software.
- **`Additional Parameters`:** This section should always be left blank.

Slab on Grade

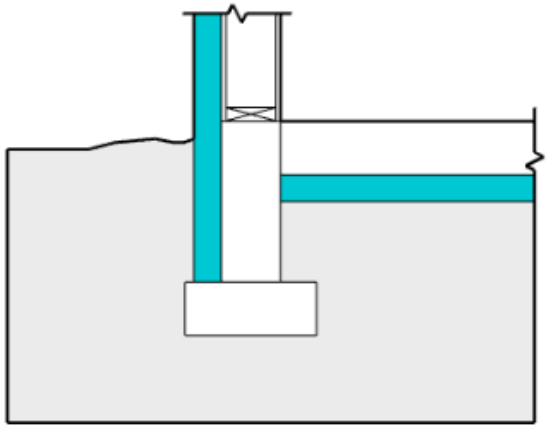
Use this type when a slab on grade is planned (i.e. no basement or crawlspace). Review WUFI Passive Tutorial 17: Foundation Interface - Slab on Grade.

- **`Floor slab area [sf]`:** Measure from the exterior face of the thermal envelope. (Will align with the area calculated in the software)
- **`U-value of slab on grade [Btu/hr.sf.°F]`:**
  - **`Detect Automatically`:** Select if one assembly is assigned. The software will automatically align with the assembly assigned to 'ground'.
  - **`User Defined`:** Select if more than one assembly is assigned. Align the U-value with the assembly-specific value calculated by the software.
- **`Floor slab perimeter [sf]`:** Measure from the exterior face of the thermal envelope. Do **not** include lengths of slab that are in contact with conditioned space.

`Additional Parameters`:

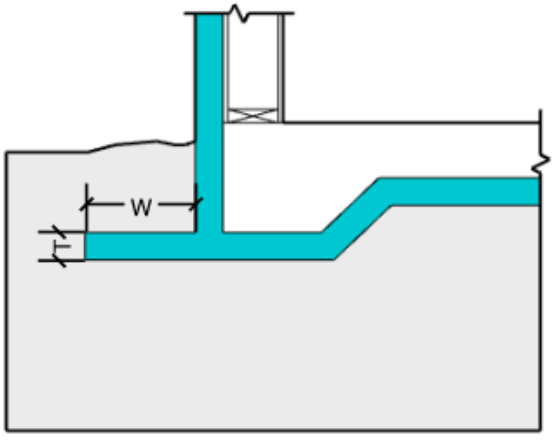
- **`Position of the Perimeter Insulation`:** Perimeter insulation should only be accounted for if the perimeter condition is **not** a thermal bridge. See diagrams below.

- **`Not defined`:** Use this setting for all positive or neutral thermal bridge calculations or in early design when perimeter detail is unknown. A choice of not defined will override all inputs noted below.



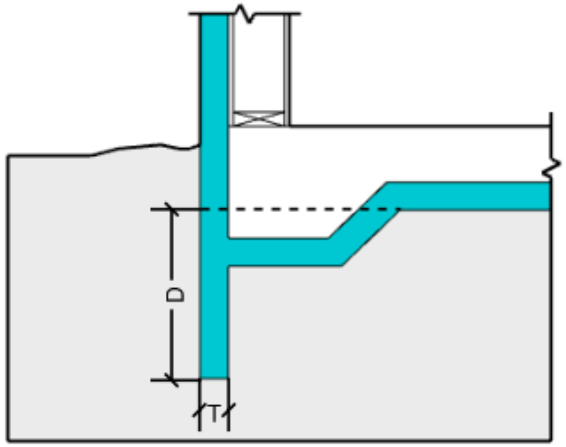
Not Defined

- **`Horizontal`:** Use this setting for negative thermal bridge calculations where a horizontal frost skirt extends beyond the thermal boundary of the building.



Horizontal

- **`Vertical`:** Use this setting for negative thermal bridge calculations where vertical insulation extends below the thermal boundary of the building.



Vertical

- **`Perimeter insulation width/depth [ft]`:** Measured from the exterior face of the thermal envelope (outward for horizontal frost skirts and downward for vertical perimeter insulation). Refer to the 'W' and 'D' dimensions in the horizontal/vertical perimeter insulation diagrams.
- **`Thickness of perimeter insulation [in]`:** Measured in inches. Refer to the 'T' dimension in the horizontal/vertical perimeter insulation diagrams.
- **`Conductivity perimeter insulation [Btu/hr.ft.°F]`:** The lambda value of the perimeter insulation.

  Process Tip: Click into this cell and use the `[ . . . ]` button to input the R-value per inch.

Suspended Floor:

This option may be used when an unconditioned crawl space outside of the thermal and airtight envelope is planned.

Exception: Raised-pier foundations: no foundation interface should be modeled, and the floors should be assigned to `Outer Air` on the outer side.

- **`Floor / Ceiling area [sf]`:** Measure from the exterior face of the thermal envelope. (Will align with the area calculated in the software)
- **`U-value ceiling to unheated cellar [Btu/hr.sf.°F]`:** Select from the following options:
  - **`Detect Automatically`:** Select if one assembly is assigned. The software will automatically align with the assembly assigned to 'ground'.
  - **`User Defined`:** Select if more than one assembly is assigned. Align the U-value with the assembly-specific value calculated by the software.
- **`Floor slab perimeter [ft]`:** Measure from the exterior face of the thermal envelope. Do **not** include lengths of slab that are in contact with conditioned space.
- **`Height of crawlspace wall above grade [ft]`:** The vertical height of exposed crawlspace walls. If there are multiple depths of basement or a significant grade change, use the average depth.
- **`U-value of crawlspace wall [Btu/hr.sf.°F]`:** Set to 'User defined', build the assembly and manually input the calculated U-value.
- **`U-value of crawlspace floor [Btu/hr.sf.°F]`:** For an uninsulated crawlspace floor, input 1 Btu/hr.ft.F to represent the surface film. If the floor of the crawlspace is to be insulated, build the assembly and manually input the calculated U-value.
- **`Crawlspace vent openings [sf]`:** This input should be 0 unless one of the IAP exceptions outlined in Appendix I-3.6 are applicable (ie. 100-year flood zone, dry/marine climate zones).

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

Unconditioned crawlspaces in moist climate (A) zones and marine climate (C) zones, supplemental dehumidification must be provided and the energy use must be accounted for as auxiliary energy. Review Section 1.4.4.21 Supportive Devices / Auxiliary Energy.

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 must have separate cases or entirely separate WUFI Passive files for the different space types.

Volume Settings

- **`Visualized Volume`:** No selection required. This value is **not** used in the calculation of model results; 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`:** Select `From Visualized Geometry and Components`. No calculation is required for certification.

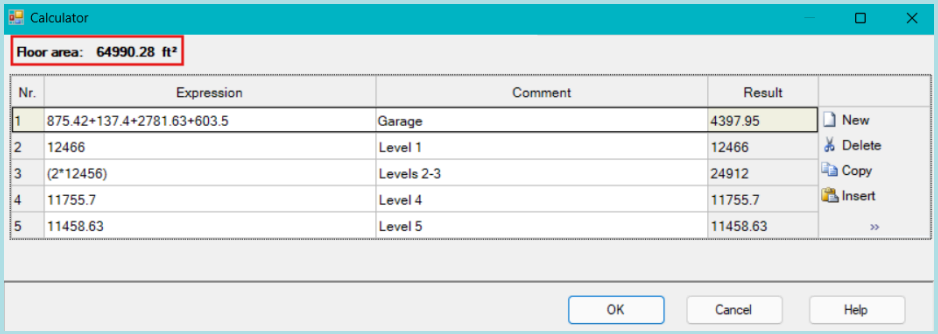
  Process Tip: This volume represents the volume of the building measured from the exterior boundary of the thermal envelope. Generally, this is the same as the visualized volume. However, if objects are included in the 3D geometry that are **not** part of the thermal boundary, for shading, etc., the visualized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

- **`Net Volume`:** Select `Estimated from Gross Volume`. The net volume does **not** affect the results of the energy model and is **not** a required calculation for certification. 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.

Process Tip: Click into the cell and use the `[ . . . ]` button to expand the built-in iCFA calculator. This allows users to input the iCFA per floor using separate line items, or type an expression/formula in a single line item. This avoids the need for manual/external calculations (supporting takeoffs must still be provided); WUFI Passive will sum the line items added to the calculator and show the total iCFA in the upper left corner of the window:



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.

- **`Lightweight`:** Used for lightweight wood- or steel-frame construction
- **`Mixed`:** Used when there is a balanced mix of lightweight and massive construction

  Process Tip: ICF construction is considered mixed due to insulation on the interior which reduces the heat lag effect.

- **`Massive`:** Used for massive (concrete/masonry) construction
- **`User Defined`:** Used to calculate a project-specific value

  Process Tip: Click into the cell and use the `[...]` button to input the number of heavy surfaces. This will generate a project specific heat capacity that uses the formula to the right.

`Specific Heat Capacity` is calculated using the following formula:

- [60+***n(heavy)****24]*0.176 (BTU/ft^2.F).
- To obtain the variable ***n(heavy)***, refer to the table below:

Table 1.4.4.5.0 Heavy Surfaces of Common Materials

Material	n(heavy)
½" Drywall	0
⅝" Drywall	0.34
Double/High-density Drywall	0.5
Flagstone/Tile	0.5
≥2" Concrete	1

Examples: A 1-story building has a concrete slab and ⅝" drywall on all of the walls and the ceiling.

- Concrete floor = **1** heavy surface
- Other 5 surfaces = 0.34 each = **1.7** heavy surfaces
- Total n (heavy surfaces) = **2.7**
- `Specific Heat Capacity` = (60+**2.7***24) *0.176 = **21.96** Btu/ft^2°F

A 2-story building has a concrete slab on the ground floor, a wood framed floor on the second level and ⅝" drywall on all of the walls and the ceilings.

- Concrete floor = **0.5** heavy surfaces
  - 1 heavy surface / 2 stories
- Other 5 surfaces = 0.34 each = **1.7** heavy surfaces
- Total n (heavy surfaces) = **2.2**
- `Specific Heat Capacity` = (60+**2.2***24) *0.176 = **19.85** Btu/ft^2°F

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. See Section 1.4.2.6 for additional guidance.

Name / Type / Attachment

Each component should be given a name that clearly identifies the component (e.g., roof, wall, overhang floor, etc.) and/or assembly type/tag (e.g., R1, EX1, FL1, etc.). Some project teams elect to align the component name with the assembly name to help with consistency and organization in the model.

The `Type` and `Attachment` settings are 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 1.4.4.14 below for guidance on setting up an attached zone.
    - **`Zone 1`:** Only appropriate if the adjacent zone is also being certified

Openings

Openings are often auto-generated when importing a building geometry from sketchup into Wufi Passive to separate extrusions from the main plane of the building. 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 Tab

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.

Assembly Tab: Material Layers

Opaque assemblies in WUFI Passive 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-3.8 for default materials from the WUFI Passive database that can be used for modeling typical assemblies.

Process Tip: Do **not** include air gaps over 6" in the assembly. If an assembly includes an air gap larger than this limit, only model the outermost layers of insulation.

Other materials to exclude from assemblies are:

- Soil in a green roof
- Sand / gravel outboard of the insulation
- Vented air gaps & cladding

Insulation Specifications

Input the insulation R/in according to the datasheet for the insulation selected for the project. If a specific insulation has not been selected, review Appendix I-3.8 for default material R-values that may be used for typical insulation types for Design Certification.

Process Tip: Click the `[...]` button to expand the `R/in` dialogue box in the `Conductivity ( λ [Btu/hr.ft°F] )` column.

Actual R-values must be used according to product datasheets for final Certification.

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

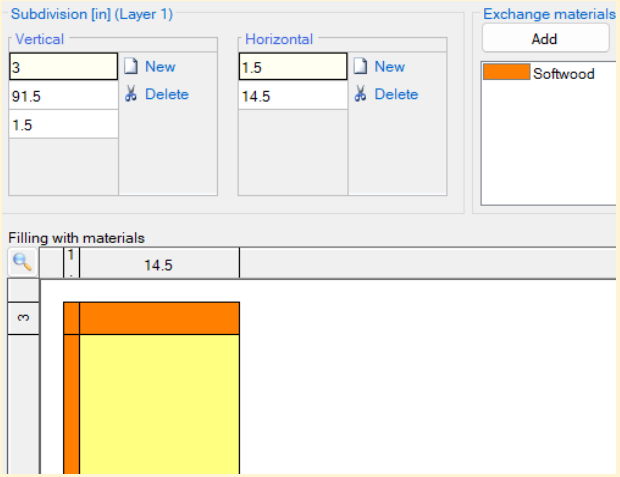
- Using the 'Metal Framing Deration Method' to account for steel framing
- Using mechanical fasteners for the installation of exterior continuous insulation. See Appendix I-3.1 Default Fastener Deration Values

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.

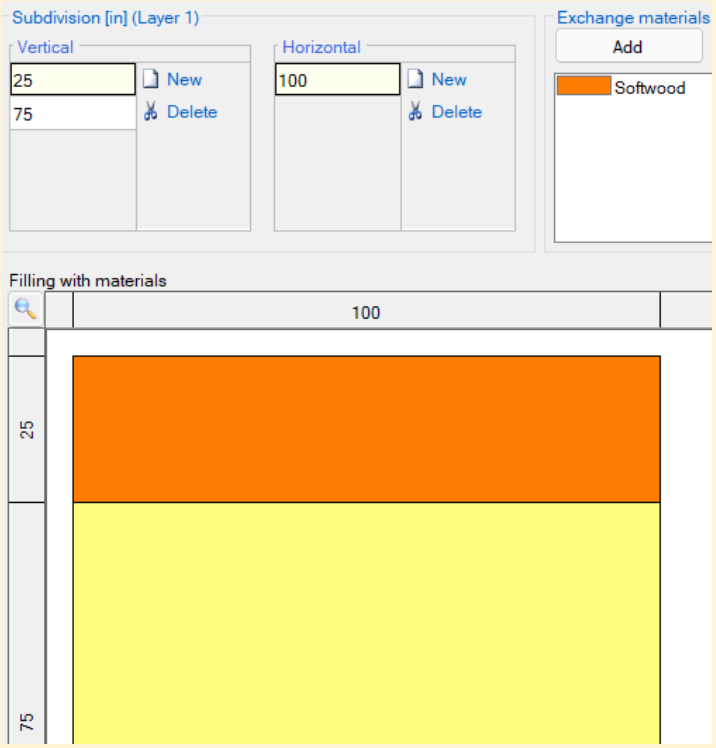
- **3D Method:** Use this method **only** for typical wood-frame assemblies with exterior continuous insulation.
    - Use the 'vertical subdivisions' in the assembly editor to account for top and bottom plates. The overall 'height' of the assembly created should be defined by a typical floor to floor 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.

Example: Below is a screenshot from WUFI Passive demonstrating the modeling approach for 16" o.c. framing (horizontal subdivisions) in an 8' tall wall (vertical subdivisions).



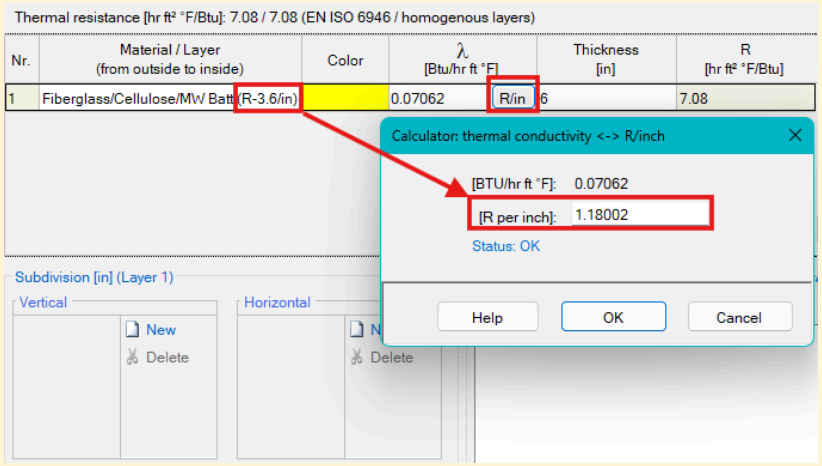
- **Wood Framing Factor Method:** Use this method for typical wood-frame assemblies with **no** exterior continuous insulation.
    - Model 25% of the cavity as framing for 16” o.c. assemblies
    - Model 15% of the cavity as framing for 24” o.c. assemblies

Example: Below is a screenshot from WUFI Passive demonstrating the modeling approach for a 25% framing factor (16” o.c.). The vertical subdivisions would be changed to 15 & 85 for a 24” o.c. assembly.



- **Metal Framing Deration Method**[27]: Calculate the effective R-value of an insulated steel-frame cavity wall using one of the following formulas based on stud spacing:
    - For 16” o.c. assemblies: Derate the cavity insulation R-value by 67% **(**R/in **x** 0.33**)**
    - For 24” o.c. assemblies: Derate the cavity insulation R-value by 61% **(**R/in **x** 0.39**)**

Example: Below is a screenshot from WUFI Passive demonstrating the modeling approach for 16” o.c. steel framing with R-3.6/in batt insulation.



[27] This deration method is based on ASHRAE 90.1 Table A9.2-2.

Opaque Doors

Panel doors with up to 33% glazing should be modeled as an opaque assembly where the total R or U-value aligns with performance data[28] 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 not impact the results in the model, but will avoid the opaque doors being categorized as exterior walls in the Reports.

Packaged Terminal Heat Pump / Air Conditioner Penetrations[29]

Packaged terminal heat pump or air conditioner units (PTAC / PTHP) that penetrate the thermal envelope should be accounted for in the modeling of the building envelope. The face area of the louver shall be modeled as an opaque surface, with a maximum insulative value of R-2 °F ft^2 hr/Btu.

Exception: Phius does not allow the use of through-wall AC (cooling only) systems due to the inherent risk of condensation due to thermal bridging at the installation of the unit.

Surface Tab

Default values for radiation balance and solar absorption/emission are applied for all components according to the component type in WUFI Passive. No user inputs are needed in this section unless white finish materials are used specifically to reflect radiation heat gains.

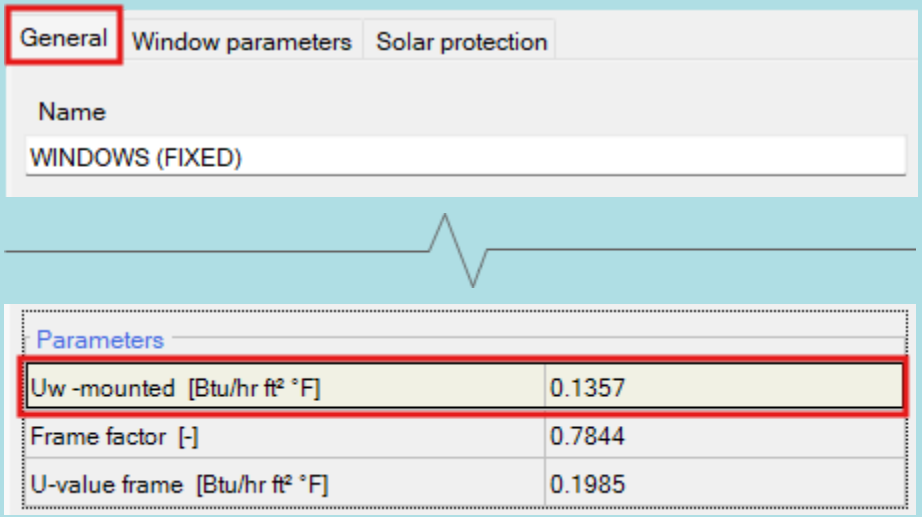
Transparent Assemblies

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 Tab

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

Process Tip: `Uw-Mounted` on the `General` tab is calculating the exact Uw based on both the specific window size and the data input on the `Window Parameters` tab (Ug, SHGC, frame data, etc).



Note: This is the value that should be used to check compliance with comfort/condensation risk requirements. Refer to Section 1.3.3.3. The psi-install should be temporarily set to 0 for all sides when checking compliance.

[28] If both ASTM C518 and ASTM C1363 data are available, C1363 data must be used.

[29] This modeling protocol aligns with the Energy Star Multifamily New Construction Program Simulation Guidelines - Appendix G 90.1-2016 Version 1, Revision 05. Section 6.1.2.3 HVAC Penetrations

Window Geometry

In the energy model, each individual lite or 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 whole window, including the frame. 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. Refer to Window Parameters for additional guidance on this protocol.

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):

1. **Window type**
   a. Fixed, operable, storefront, glazed door, etc.
2. **Mulled conditions**
   a. Top / bottom mulled; Left / right mulled; Top + right mulled; Bottom + left mulled, etc.
3. **Shading conditions**
   a. Cladding condition causing varying reveal depths across windows

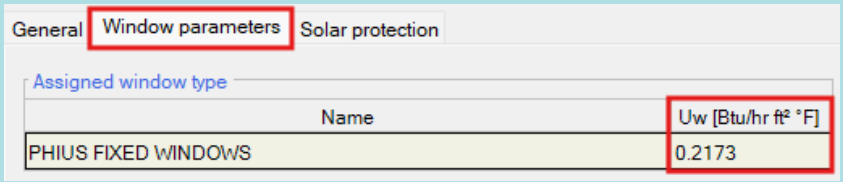
Projects that include more than 15 window groups in a model should re-evaluate and consolidate if possible.

Window Parameters Tab

Process Tip: The `Assign Data` button 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.

  Process Tip: The `Uw` on the `Window Parameters` tab is calculated using the window data inputs, and is based on the NFRC default window size.



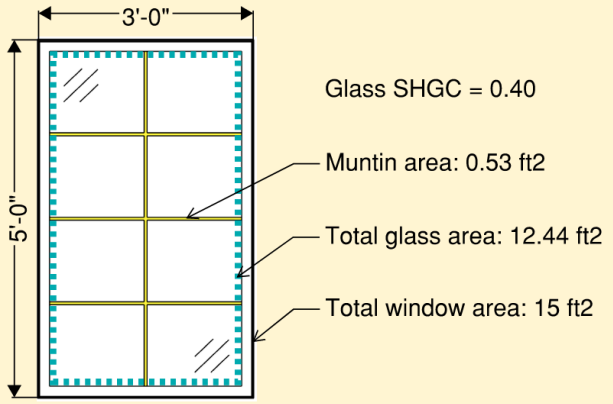
- **`Frame Factor`:** Leave blank, this value will be auto-calculated by WUFI Passive.
- **`Glass U-Value`:** Input the product specific center-of-glass U-value. Review Section 1.4.2.5 Fenestration.
- **`SHGC`:** Input the product specific center-of-glass U-value. Review Section 1.4.2.5 Fenestration.

  Exceptions: Spandrel panels should have an SHGC=0.

  The SHGC of Windows with simulated divided lites (muntins) should be derated according to the example below.

  Example: Use the following formula for calculating SHGC muntin deration:

  - **(**1 **-** **(**muntin area **/** total glass area**)) x** SHGC



  - **Derated SHGC = (**1 **-** **(**0.53 **/** 12.44**))** **x** 0.40 **=** 0.38

- **`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.

- **`Frame-to-Wall Psi-Value` (*psi-installation*):** This input is dependent on how the window is installed within the wall:
    - Outer/Inner-mounted: 0.030 [BTU/hr.ft.F]
        - Use this value as a conservative default while installation details are in development
    - Mid-mounted **not** over-insulated: 0.020 [BTU/hr.ft.F]
    - Mid-mounted **and** over-insulated: 0.015 [BTU/hr.ft.F]

Exceptions: A thermal bridge calculation, using THERM or equivalent software and following the Phius Psi-Install Modeling Protocol, is necessary if:

- Inputs lower than the defaults above are used
- The connector is substantially more conductive than the frame
- Manufacturer value for a project specific installation detail.

For mulled conditions, 0 [Btu/hr.ft.F] may be used. Refer to Window Groups.

Process Tip: Two methods are available for accounting for mulled conditions:

1. Set the `Frame-to-Wall Psi-Value` to 0 for mulled sides directly in the window assembly
2. On the `General` tab, uncheck the box for `From window parameters` in the `Frame-to-Wall Psi-Value` section at the bottom of the tab window.
    - Input 0 for sides of the window that is mulled
    - Input the typical `Frame-to-Wall Psi-Value` for the sides that are not mulled

Example: The following example is meant only for early design/feasibility assessments. This method may **not** be used for Design Certification compliance.

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 Passive, the team should input 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 Tab

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

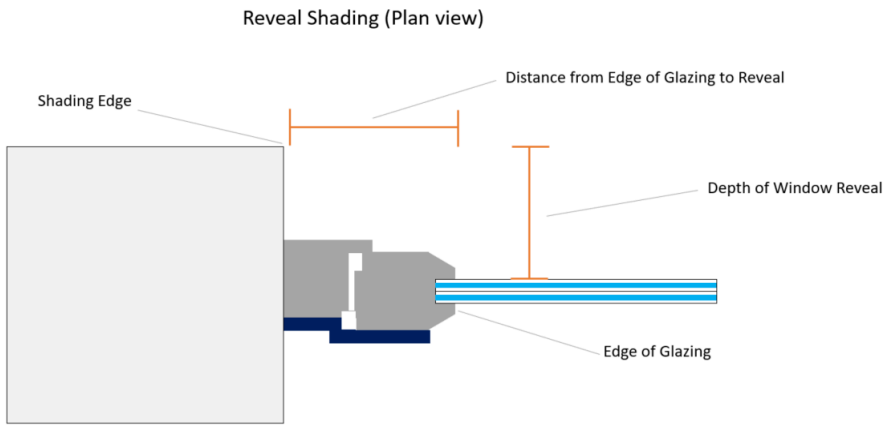
`Solar Protection` > `General` Tab

Often windows are not installed flush with the exterior of the building façade which causes shading to the left, right and top sides of the window. Reveal shading must be input for all windows. This can be done quickly with the `Assign Data` button. All reveal entries are calculated as if on all 4 sides of the window.

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

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.

- **`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.



- **`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 fixed blinds, window screens or as a seasonal shading factor 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 year-round fixed blinds, window screens or as a seasonal shading factor 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.

Process Tip: Review the Site Shading Modeling in the New WUFI Passive Shading Tool webinar for guidance on how to implement Solar Pathfinder images in the 3D geometry. Contact Us to get the excel-based tool.

`Solar Protection` > `Shading Device` Tab

Sunscreen/shading devices in WUFI Passive are assumed to be used only during the cooling season. If year-round fixed blinds are used, model them as an `Other Shading Fraction of Solar Exposure`.

Process Tip: 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.

Refer to Appendix I-3.7 for additional information on insulated interior blinds and other blind terminology.

- **`Reduction Factor` / `Solar Exposure for Shading Device`:** Use 0.85 as a default for typical interior venetian blinds.
    - For exterior blinds, or other types of interior blinds, use the Phius Blinds Calculator. This calculator requires a **Ts** (solar transmittance) rating from the manufacturer.
        - This calculator follows the deration method outlined in Appendix N-6 and derates the effectiveness of the window blinds to account for occupant behavior.

`Solar Protection` > `Window Overhang` Tab

Overhangs may be included in the 3D geometry (recommended) or entered numerically into WUFI Passive.[30] Angled or complex overhangs should be modeled in the 3D geometry.

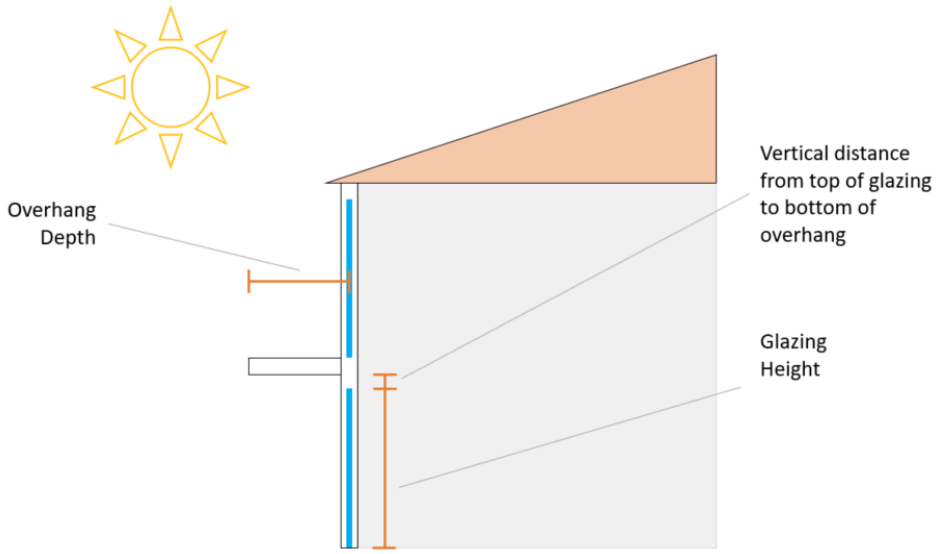
Process Tip: If an overhang is both included in the 3D visualization and entered numerically, WUFI Passive will not double count the shading.

[30] 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 in WUFI Passive, an overhang parallel to the window head will be simulated. The numerically entered overhangs will appear in the 3D geometry. Three parameters must be defined:

1. **`Depth of overhang [ft]`:** Measured horizontally out from the glazing to the shading edge.
2. **`Vertical Distance from Top of Glazing to Bottom of Overhang [ft]`:** Measured vertically from edge of glazing to shading edge.
3. **`Side Spacing [ft]`:** Measured horizontally from the window jamb to the edge of the overhang.

Process Tip: The default side spacing is 0, which would simulate an overhang that matches the width of the window it is assigned to. The extension must be the same on each side of the window.



`Solar Protection` > `WUFI Mean Month Shading Factors` Tab

Process Tip: If this tab does not appear under the *Solar Protection* tab, go back to Case 1: General Tab and check the box for `Use WUFI Mean Month Shading Factors`.

- **Shading due to building geometry:** Shading from building geometry such as overhangs, bump-outs, complicated geometry, surrounding buildings, etc. must be accounted for. 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 Passive. 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 (< 0 Btu/hr.ft.F), all thermal bridges in the project must be calculated and input in the energy model, no matter how small.

Process Tip: Phius strongly recommends against taking negative thermal bridges in the design phase, and only using these as a "last line of defense".

Neutral Thermal Bridges

Phius considers any psi-value that calculates ≥ 0, but ≤ 0.006 Btu/hr.ft.F as neutral. This means that the thermal losses calculated in the energy model are roughly equal to the thermal losses of the 2D detail in question and no input is required.

Process Tip: If a neutral perimeter thermal bridge is calculated, the `Position of the Perimeter Insulation` under the `Additional parameters` section within the `Foundation Interface` should be set to `Not Defined`.

Thermal Bridge Inputs

- **`Name`:** 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 Passive.
- **`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 thermal bridge for WUFI Passive would be the linear length of the ledger board.

- **`Attachment`:** Set the attachment according to the boundary conditions within the thermal bridge calculation. See Table 1.4.4.7.0 and corresponding descriptions below.

Table 1.4.4.7.0 Thermal Bridge Attachment Assignments			
WUFI Passive Attachment	Boundary 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** boundary conditions 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** boundary conditions used in the THERM calculation – interior, exterior, and ground.
- **`Basement Floor`:** Use this selection for thermal bridges below grade (including grade beams). Only **two** boundary conditions 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 [R] Internal Loads / Occupancy

[R] Occupant Quantity

- **Single-family:** The occupant quantity is calculated 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.

[R] Number of Bedrooms

Based on the total number of bedrooms[31] in the building.

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

[R] 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.[32] 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 (default) + 0.00003 lb/ft^2.hr = **0.00044 lb/ft^2.hr**

[R] 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).

[R] 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.

Exception: When appliances are supplied by the tenants of the Certified building (i.e. appliances are **not** builder-installed), refer to Appendix I-3.15 for non-rated appliance performance values.

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

[31] 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.

[32] ASHRAE Standard 160, clause 4.3.2.1.1

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

Process Tip: 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[33]
DHW	PH case occupants	239 kWh/yr	Standard (12)

Table 1.4.4.8.1 Cooking

Choice	Reference Quantity	When Applicable?	Energy Demand[34]
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
<15	PH case Units or User Defined	Year	260 kWh/yr
15-20			451 kWh/yr
>20			615 kWh/yr

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

Table 1.4.4.8.3 Freezer

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

Table 1.4.4.8.4 Clothes Dryers

Type	When Applicable?	Reference Quantity	CEF[35]
Condensation	Ventless	PH case occupants	2.68
	Heat Pump		5.85
Exhaust Air	Electric		3.93
	Natural Gas		3.48

Example: For natural gas dryers, Match the electrical kWh/yr divided by 392/yr of the washer and assign the rest to gas consumption. 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.

Table 1.4.4.8.5 Clothes Washer

Reference Quantity	Energy Demand	Utilization Factor	Capacity	MEF[36]
PH case occupants	110 kWh/yr	1	4.5 ft^3	3.13

[35] Combined Energy Factor calculated per ANSI/RESNET/ICC 301-2019.
[36] 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

[R] Device/end use (Lighting and Miscellaneous Loads)

Lighting and MELs are modeled differently according to project type.

- **Single-family:** In addition to typical appliances, line items for `PHIUS+ MELS`, `PHIUS+ Interior lighting` and `PHIUS+ Exterior Lighting` will also populate when selecting the `Set Standard Dataset` option. These items are **only** applicable to single family projects and must be modeled according to Table 1.4.4.8.6 below.
  - The `Reference Quantities` indicated below are the default settings and should **not** be modified
  - If a garage is present, an additional line item should be added by choosing `New` and selecting `PHIUS+ Garage Lighting` from the `Device / End Use` dropdown menu. 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, engine 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

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			☑	

Process Tip: Input values from the calculator in WUFI Passive as whole-numbers with no comma delineations.

[R] Device/end use (Additional Devices)

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. Some examples of possible uncommon devices include, but are not limited to:

- Saunas
- Steam showers
- Standalone ice makers
- Vending machines

Process Tip: 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.

1.4.4.9 Residential [R] Ventilation / Rooms

[R] Ventilation / Rooms > Utilization Pattern Tab

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

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.

- **`Operating Days per Week`:** Input 7 to indicate that the device will run every day of the week (continuous, typical).
- **`Operating Weeks per Year`:** Input 52 to indicate that the device will run every week of the year (continuous, typical).
- **`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 Passive 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[37] (see Balanced Ventilation above). Keep this in mind when selecting a mechanical ventilation device.

- **`Average Air Flow Rate (cfm)`| `Average Air Change Rate (ACH: 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 Air flow` at the scheduled hours.

- **`Daily Operation Schedule (h)`:** Input 24 at the `Maximum` setting to indicate that the ventilation device operates continuously at the design air flow rate.

- **`Fraction of Design Air Flow`:** No entry is required if 24h was entered for the `Maximum` setting as previously noted (typical).

  Exception: Custom hours and fractions may be entered **if** a mechanical ventilation device is tied to a schedule (e.g., for an amenity fitness room that is open only during the day with a ventilation system that automatically reduces airflow during unoccupied hours). A 'fraction' of 1 represents 100% of the design airflow rate (0.77 = 77%, etc.)

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

[R] Ventilation / Rooms > Rooms Ventilation Tab

Methods of Capturing Ventilation Airflow Rates

Phius has specific requirements for minimum ventilation airflow rates for exhaust registers (kitchens, bathrooms and water closets) and total supply to dwelling units (based on occupancy). Therefore, mechanical plans must show register-level supply and exhaust ventilation airflows.

However, Phius does not require register-level airflows to be captured in the energy model in all residential building types. The following methods are approved and should be used depending on the building type and ventilation system configuration.

- **Room-by-Room Method:** This approach should only be used for single-family projects. Every supply and exhaust room (or register) should be input as unique line items.

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

- **Dwelling Unit Method:** This approach is appropriate for multifamily projects that include multiple dwelling units with identical flow rates that share, or are served by, identical devices (e.g.,. one rooftop DOAS unit for common areas; identical ventilation devices serving individual dwelling 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.)

- **Ventilation Unit Method:** This approach is appropriate for multifamily projects that include a semi-centralized mechanical ventilation system (e.g., multiple devices with different efficiencies are planned). 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.

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

WUFI Passive Inputs

After determining a modeling method based on the descriptions above, complete the inputs in WUFI Passive as noted below.

- **`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`
  - `User defined`:
    - Room-by-Room Method: Supply rooms
    - Dwelling Unit Method: Total airflow
    - Ventilation Unit Method: Total airflow

- **`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: Room-by-Room Method
  A single family project has 2.5 bathrooms and 4 bedrooms:
  - Line 1: Bathrooms, quantity = 2
  - Line 2: ½ bath, quantity =1
  - Line 3: Kitchen, quantity =1
  - Line 4: Bedrooms, quantity = 4
  - Line 5: Living/Dining, quantity = 1

  Example: Dwelling Unit Method
  A 50-unit multifamily project has 13: 2 bed / 2 bath units, 37: 1 bed / 1 bath units and 4: double-loaded corridors:
  - Line 1: 2 bed / 2 bath, quantity = 13
  - Line 2: 2 bed / 1 bath units, quantity = 37
  - Line 3: Common areas, quantity = 4

  Example: Ventilation Unit Method
  A 100-unit multifamily project has two semi-decentralized rooftop ventilation units with one unit serving the dwelling units and a second smaller unit serving the common areas:
  - Line 1: ERV-DU, quantity = 1
  - Line 2: ERV-C, quantity = 1

- **`Utilization Pattern`:** Assign the continuous pattern previously created to all line items in this section.

  Exception: If modeling multiple utilization patterns, assign them to their corresponding spaces. All utilization patterns should be used if done correctly.

- **`Design Volume Flow Rate`:** Input the design airflow rates according to the mechanical plans for the project for each room, dwelling unit, or ventilation device (depending on the selected method). All projects must meet the Minimum Ventilation Rates.

  Process Tip: In early design, before ventilation rates are known, the total exhaust/supply airflow rate for **common areas** can be estimated by referencing local code requirements, or using the following calculation:
  - 0.06 cfm **x** iCFA

  The Phius Multifamily Lighting & Misc Load Calculator can be used to determine minimum requirements for dwelling units.

[R] Ventilation / Rooms > Summer Ventilation Tab

Inputs in this section should be mostly left blank, unless no cooling system is planned (atypical). Review Appendix I-3.11.1 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 Passive 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/ERV 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.

  Process Tip: Higher end ventilators typically have advanced controls that enable bypass mode, while simpler ventilators do not.

  In WUFI Passive, 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.

  Exception: WUFI Passive cannot account for a mix of ventilation units with and without bypass. 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 through a device that **has** bypass mode available, choose `Temperature-` or `Enthalpy-Controlled Bypass`.
  - If **less than 50%** of the planned average airflow through the outdoor air ventilation system with heat recovery is through a device that **does not** have bypass mode available, choose `Always`.

- **`ACH via Natural Ventilation (day)` | `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 input '0'.

- **`Additional Automatic Control Ventilation [1/hr]` | `Specific Power Consumption Cooling [W/cfm]` | `Automatic Control System via`:** These inputs should be left blank.

  Exception: A heat relief mechanical direct exhaust system that is tied to either temperature or humidity control. The ACH must be calculated based on the total volume of the building.

  Example: A non-residential building has an electrical room with an overheat relief fan that is tied to a thermostat. The following variable must be known to complete the inputs in WUFI Passive
  - Air flow rate (cfm)
  - Building net volume (Found in Zone 1)
  - Fan power (W)

  Once obtained, the variables are used to complete the inputs in WUFI Passive as follows:
  - `Additional Automatic Control Ventilation [1/hr]` **= (**air flow rate **x** 60**) /** building net volume
  - `Specific Power Consumption Cooling [W/cfm]`**=** fan power **/** air flow rate
  - `Automatic Control System via` **=** `Temperature difference`

- **`Additional Mechanical Ventilation Exhaust Air [1/hr]` | `Specific Power Consumption [W/cfm]`:** This input should be left blank.

  Exception: A mechanical direct exhaust system that operates continuously during the summer.

[R] Ventilation / Rooms > Exhaust Ventilation Tab

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 makeup air system will be required based on the direct exhaust devices planned.

Process Tip: 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.
  - Input a single line item in WUFI Passive
  - Assign the `Type` to `Exhaust Dryer`
  - 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. The airflow of a single range hood should be input and uses a default annual usage pattern for cooking.

  Exception: Multifamily/mixed-use projects with commercial kitchens / un-dampered range hoods due to fire code should refer to Appendix I-3.17.

  - **`Exhaust Volume Flow Rate`:** Input the flow rate of a single range hood.
    - Use 100 cfm as a default for residential exhaust range hoods

    Exception: Use the rated airflow from the manufacturer if available.

    Example: A duplex building has direct exhaust range hoods in each kitchen. They are rated for 250 cfm.
    1. Input a single line item in WUFI Passive
    2. Assign the `Type` to `Exhaust Range Hood`
    3. Input 250 cfm as the `Exhaust Volume Flow Rate`

- **`Type` > `Other Exhaust Appliances`:** If other direct exhaust devices such as bathrooms, trash rooms, etc… are planned for a project, input a line item for this device type.
  - ***Bathroom direct exhaust:*** Assume 60 min / bathroom / day[38]
    - **`Exhaust Volume Flow Rate [cfm]`:** Sum total flow rate of bathroom exhaust fans in the building
    - **`Run Time per Year [min]`: (**365 days/yr ***** 60 min/day**) =** 21,900 minutes/yr
  - ***Trash direct exhaust:*** Assume continuous exhaust
    - **`Exhaust volume flow rate [cfm]`:** Sum total trash exhaust fans in the building
    - **`Run time per year [min]`:** 525,600
  - ***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% (exhaust > supply) by inputting:
    - **`Exhaust Volume Flow Rate [cfm]`:** Input amount of airflow beyond the allowable limit
    - **`Run Time per Year [min]`:** 525,600

    Exception: Centralized ventilation systems with AHRI efficiency calculations that reflect the unbalanced airflows should **not** use this approach.

    Example: An ERV is measured to have 100 cfm of exhaust and only 85 cfm of supply. The ventilation system commissioner is unable to rectify the difference and the project must take a penalty on the heat recovery of the unit.

    - 10 cfm is the allowed imbalance (10% of 100 cfm)
    - 15 cfm imbalance is present (100 cfm- 85 cfm)
    - The difference between the allowed imbalance and measured imbalance is **5 cfm**

    In WUFI Passive:
    - Add a new line item to the `Exhaust Ventilation` tab
    - Assign the `Type` to `Other Exhaust Appliances`
    - Input an `Exhaust Volume Flow Rate` of **5 cfm**
    - Input a `Run Time per Year [min]` of **525600 min**

[38] Per BAHSP protocol

Note: The next section is for Non-Residential [NR] projects. If this does not apply to your project, proceed to Section 1.4.4.14 Attached Zones.

1.4.4.10 Non-Residential [NR] Internal Loads / Occupancy

[NR] Internal Loads / Occupancy > Utilization Pattern Tab

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 Passive, and should be referenced for all of the following inputs.

Process Tip: Simplicity is key when determining how many utilization patterns should be included in the model. The naming convention of each `Utilization Pattern` in WUFI Passive should align with the Appendix N-8 space types. In general, only one utilization pattern per unique space type should be modeled. Lighting assumptions will be further broken out later.

Example: 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.

- **`Begin/End Utilization`:** Beginning and end hour of utilization for the space type. input 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 Passive, 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 Passive, 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.

- **`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

- **`Illumination Level`:** Typical illumination level, in lux, required to perform the activities that occur within the space. input 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.

- **`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

- **`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

- **`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

- **`Optional Data`:** Do **not** input anything in this section. It should be left completely blank.

[NR] Internal Loads / Occupancy > Occupancy Tab

Must be defined for the whole building as well as for unique space types in correspondence with the `Utilization Patterns` previously defined. Calculate non-residential occupancy inputs for WUFI Passive by using the Phius Non-Residential Occupancy Estimator.

- **`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.
- **`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 each 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.

  Process Tip: For known tenants, it is critical to determine the realistic 'maximum' occupancy of a given space. Using a fire code or ASHRAE square-foot-per-person design occupancy is **not** generally recommended as this may exaggerate the internal gains associated with occupants. Phius requires a narrative to accompany any assumptions made for design occupancy.

`Additional Data`: Complete the inputs as noted below.

- **`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`:** Input 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.

[NR] Internal Loads / Occupancy > Office Equipment Tab

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 and add `User defined` equipment as needed.

- **`Type`:** Select an option from the dropdown menu according to the options outlined below:
    - ***Typical office equipment:*** Select from the predefined options below
        - `PC, Monitor`
        - `Copier, Printer`
        - `Server`
        - `Telephone system`
    - ***Miscellaneous office equipment:*** Select `User defined` for office equipment that does not fit the predefined options above
        - 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`:** Input the physical quantity of the equipment type.
- ☑ **`Within thermal envelope`:** Check this box if the equipment is within the thermal envelope (typical). Checked equipment will impact internal heat gains.
- **`Power Rating / Power Rating (saving mode) [W]`**
    - ***Typical office equipment:*** Use Appendix I-3.10 to determine the `Power Rating` entries for predefined equipment and some unique equipment types. The following predefined equipment types also require an entry for `Power Rating (saving mode)`:
        - `PC, Monitor`
        - `Copier, Printer`
        - `Server`
    - ***Miscellaneous office equipment:*** For `User defined` office equipment, input the annual kWh/yr of the unique equipment as the `Power Rating [W]`.

`Additional Data`: Some equipment types will prompt the user to input 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.
- **`Utilization Hours per Year`:** For user defined equipment, input 1000 hrs/yr for. 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.

[NR] Internal Loads / Occupancy > Kitchen Equipment Tab

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 and add `User defined` equipment as needed.

Process Tip: The input for `Marginal performance ratio DHW` should always be left blank.

- **`Type`:** Select an option from the dropdown menu according to the options outlined below:
    - ***Typical kitchen equipment:*** Select from the predefined options below
        - `Cooktop` (includes ranges, microwaves, toasters, etc.)
            - Only **one** line item for cooking should be included in the model regardless of the quantity of cooking appliances
        - `Dishwasher`
        - `Refrigerator`
    - ***Miscellaneous kitchen equipment:*** Select `User Defined` for kitchen equipment that does not fit the predefined options above
        - 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`:** Input quantity of 1, regardless of the quantity of appliances. The annual usage of these devices will be calculated based on the `Additional Data` inputs, explained later in this section.
    - **`Refrigerator`:** Input 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`:** Input quantity of 1.
- ☑ **`Within Thermal Envelope`:** Check this box if the equipment is within the thermal envelope (typical). 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 input additional data about the selected equipment. See instructions on how to complete these inputs below:

- **`Type`** > **`Cooktop`:** Define the fuel type and estimated number of meals per utilization day.
    - **`Fuel Type`:** 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 Tip: By default, the model will assume 0.25 kWh/meal for cooking energy. All cooking energy is accounted for, **not** just the cooktop.

- **`Type`** > **`Dishwasher`:**
    - **`Dishwashing`:** 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 utilization day. Align with the entry for the cooktop.

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

- **`Type`** > **`Refrigerator`:** Norm demand [kWh/day] must be input. This data is available from Energy Star for residential fridges and some commercial fridges.
- **`Type`** > **`User Defined`:** Input the kWh/yr of the unique equipment into the **`kWh/day`** field. Input 1 day/yr. These entries are multiplied to calculate the unique equipment's total annual energy consumption in kWh/yr.

[NR] Internal Loads / Occupancy > Lighting Tab

Grouping of rooms is appropriate if they share a utilization pattern and have a similar required or designed lighting power density [W/ft^2]. Use the Phius Non-Residential Lighting Calculator to determine inputs for WUFI Passive.

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 inputs 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`:** Input 0.
- **`Glazing Visible Transmittance`:** Default is 'Double low-e glazing: 0.78'. Do **not** change this input.
- **`Room Depth`, `Width`, `Height [ft]`:** Input 10 ft for all. This input will **not** have an impact on the model.

`Additional data`: Complete the inputs as noted below.

- ☐ **`Facade has Windows`:** Do **not** check this box.
- **`Lintel Height [ft]`:** Input 1 ft.
- **`Window Width [ft]`:** Input 1 ft.
- **`Lighting Control[ft]`:** Set to `Manually`
- ☐ **`Motion Detector`:** Check **only** if occupancy sensors are installed.

  Exception: If taking credit for occupancy sensors in the Phius Non-Residential Lighting Calculator, do **not** check this box.

- **`Installed Lighting Power [W/ft²]`:** Input 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]` defined in 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 [hrs/yr]`:** This entry should be left blank. It is used to override the utilization pattern previously defined for each space type.

[NR] Internal Loads / Occupancy > Process Loads Tab

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 grocery stores do. Contact Us about process load allowances for other usage types.

- **`Quantity`:** Input the quantity of devices / equipment being accounted for.
- **`Total Energy Use`:** Input 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.

1.4.4.11 Non-Residential [NR] Ventilation / Rooms

[NR] Ventilation / Rooms > Utilization Pattern Tab

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.

For non-residential projects, 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: 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

- **`Operating Days per Week`:** It is recommended to input 7 to represent continuous ventilation for most non-residential projects.

  Exception: If airflow rates will regularly differ dramatically day-to-day each week over the course of the whole year, input 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: 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`:** It is recommended to input 52 to represent continuous ventilation for most non-residential projects.

  Exception: 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: 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 (WUFI Passive 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:
        - Supply air requirement (based on occupancy)
        - Exhaust air requirement (based on kitchens, baths, etc.)

Process Tip: The capacity of the ventilation system installed needs to exceed whichever rate is greatest[39] (see Balanced Ventilation above). Keep this in mind when selecting a mechanical ventilation device.

    - **`Average Air Flow Rate (cfm)` / `Average Air Change Rate (ACH: 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 Air flow` at the scheduled hours.

- **`Daily operation schedule (h)`:** It is recommended to input 24h at the Maximum setting to represent continuous ventilation for most non-residential projects.

Exception: This input may be revised to reflect the appropriate ratios of design airflow rates during occupied and unoccupied hours (if different).

- **`Fraction of design air flow`:** No entry required if using the 'Maximum' setting and averaging the airflow over 24 hours.

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

Example: 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).

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

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.

[NR] Ventilation / Rooms > Rooms Ventilation Tab

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

Methods of Capturing Ventilation Airflow Rates

Phius does not have specific requirements for minimum ventilation airflow rates for non-residential projects. Project teams should defer to their jurisdictional requirements.

Phius does not require register-level airflows to be captured in the energy model. The following methods are approved and should be used depending on the building type and ventilation system configuration.

- **Room-by-Room Method:** This approach should only be used for small and simple projects. Every supply and exhaust room (or register) should be input as unique line items.

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

- **Ventilation Unit Method:** This approach is appropriate for all 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.

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

General

After determining a modeling method based on the descriptions above, complete the inputs in WUFI Passive as noted below.

- **`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`
  - `User defined`:
    - Room-by-Room Method: Supply/Exhaust rooms
    - Ventilation Unit Method: Total airflow

- **`Quantity`:** 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: 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

- **`Utilization Pattern`:** For most projects, assign the continuous utilization pattern that was previously created to all line items in this section.

  Exception: 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`:** Input the design airflow rates according to the mechanical plans for the project. All projects must meet the Minimum Ventilation Rates. See example on the next page.

  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: 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.*

[NR] Ventilation / Rooms > Summer Ventilation Tab

Inputs in this section should be mostly left blank, unless no cooling system is planned (atypical). Review Appendix I-3.11.1 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 Passive 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/ERV 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.

  Process Tip: Higher end ventilators typically have advanced controls that enable bypass mode, while simpler ventilators do not.

  In WUFI Passive, 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)`** | **`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 input '0'.
- **`Additional Automatic Control Ventilation [1/hr]`** | **`Specific Power Consumption Cooling [W/cfm]`** | **`Automatic Control System via`:** These inputs should be left blank.

  Exception: A heat relief mechanical direct exhaust system that is tied to either temperature or humidity control. The ACH must be calculated based on the total volume of the building.

  Example: A multifamily building has an electrical room with an overheat relief fan that is tied to a thermostat. The following variable must be known to complete the inputs in WUFI Passive
  - Air flow rate (cfm)
  - Building net volume (Found in Zone 1)
  - Fan power (W)

  Once obtained, the variables are used to complete the inputs in WUFI Passive as follows:
  - `Additional Automatic Control Ventilation [1/hr]` **= (**air flow rate **x** 60**) /** building net volume
  - `Specific Power Consumption Cooling [W/cfm]`**=** fan power **/** air flow rate
  - `Automatic Control System via` **=** `Temperature difference`

- **`Additional Mechanical Ventilation Exhaust Air [1/hr]`** | **`Specific Power Consumption [W/cfm]`:** This input should be left blank.

  Exception: A mechanical direct exhaust system that operates continuously during the summer.

[NR] Ventilation / Rooms > Exhaust Ventilation Tab

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 makeup air system will be required based on the direct exhaust devices planned.

Process Tip: If no direct exhaust devices are planned, skip this section.

- **`Type` > `Exhaust Dryer`:** Never use this option for non-residential projects.
- **`Type` > `Exhaust Range Hood`:** Never use this option for non-residential projects.
- **`Type` > `Other Exhaust Appliances`:** Select this option for **all** direct exhaust fans/appliances in non-residential projects.

  Process Tip: Projects with commercial kitchens / un-dampered range hoods due to fire code should refer to Appendix I-3.17.

  - **`Exhaust Volume Flow Rate [cfm]`:** Input value according to design/scheduled airflow.
  - **`Run Time per Year [min]`:** Input value according to schedule or narrative.

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% (exhaust > supply) by inputting:

- **`Exhaust Volume Flow Rate [cfm]`:** Input amount of airflow beyond the allowable limit
- **`Run Time per Year [min]`:** 525,600 min/yr

Exception: Centralized ventilation systems with AHRI efficiency calculations that reflect the unbalanced airflows should **not** use this approach.

Example: An ERV is measured to have 100 cfm of exhaust and only 85 cfm of supply. The ventilation system commissioner is unable to rectify the difference and the project must take a penalty on the heat recovery of the unit.

- 10 cfm is the allowed imbalance (10% of 100 cfm)
- 15 cfm imbalance is present (100 cfm- 85 cfm)
- The difference between the allowed imbalance and measured imbalance is **5 cfm**

In WUFI Passive:

- Add a new line item to the `Exhaust Ventilation` tab
- Assign the `Type` to `Other Exhaust Appliances`
- Input an `Exhaust Volume Flow Rate` of **5 cfm**
- Input a `Run Time per Year [min]` of **525600 min**

Note: The next section is for Unfinished [UF] projects. If this does not apply to your project, proceed to Section 1.4.4.14 Attached Zones.

1.4.4.12 Unfinished [UF] Internal Loads / Occupancy

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 (UF) spaces. For the source energy criterion, there is no additional source energy allowance for unfinished spaces and therefore no assumption about their energy use.

Process Tip: WUFI Passive automatically assumes 1 Btu/hr.ft^2 of internal heat gains for unfinished projects.

[UF] Internal Loads / Occupancy > Utilization Pattern Tab

A utilization pattern must be defined for the required `Toilet Utilization Pattern` selection, defined later.

Complete the default inputs for all UF projects as noted below:

- **`Begin/End Utilization`:** Set 'Begin utilization' to 0, and 'End utilization' to 24.
- **`Annual Utilization Days`:** Set to 365.
- **`Illumination Level`:** Set to 300.
- **`Height of Utilization`:** Set to 2.62 ft.
- **`Relative Absence`:** Set to 1.
- **`Part Use Factor of Building Period for Lighting`:** Set to 1.
- **`Optional Data`:** Do **not** input anything in this section. It should be left completely blank.

[UF] Internal Loads / Occupancy > Occupancy Tab

- **`Occupant Quantity` (*whole building*):** 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`:** Leave default value

Occupancy Groups: Only one line item should be created in this section for unfinished (UF) projects.

- **`Utilization Pattern`:** Select the previously defined utilization pattern (Pattern 1).
- **`Activity of Persons`:** Select from the available options that most closely represents the most likely 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`:** Assume 70% of 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 * 70% = 14 occupants
- Average occupancy (for target setting)
    - 20 * 0.3 = 6 occupants

`Additional Data`: Complete the inputs as noted below.

- **`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`:** Input the total quantity of flush toilets planned in the project if known. Otherwise, input 1.
- **`Toilet Utilization Pattern`:** Select the previously defined utilization pattern (Pattern 1).
- ☐ **`Use Default Values for School`:** Do not check this box for unfinished (UF) projects.

[UF] Internal Loads / Occupancy > Office Equipment Tab

Skip this section for unfinished (UF) projects. No inputs needed here.

[UF] Internal Loads / Occupancy > Kitchen Equipment Tab

Skip this section for unfinished (UF) projects. No inputs needed here.

[UF] Internal Loads / Occupancy > Lighting Tab

Skip this section for unfinished (UF) projects. No inputs needed here.

[UF] Internal Loads / Occupancy > Process Loads Tab

Skip this section for unfinished (UF) projects. No inputs needed here.

1.4.4.13 Unfinished [UF] Ventilation / Rooms

[UF] Ventilation / Rooms > Utilization Pattern Tab

WUFI Passive automatically assumes 0.3 ACH for unfinished (UF) projects. However, this section is still necessary to complete in order for results to populate.

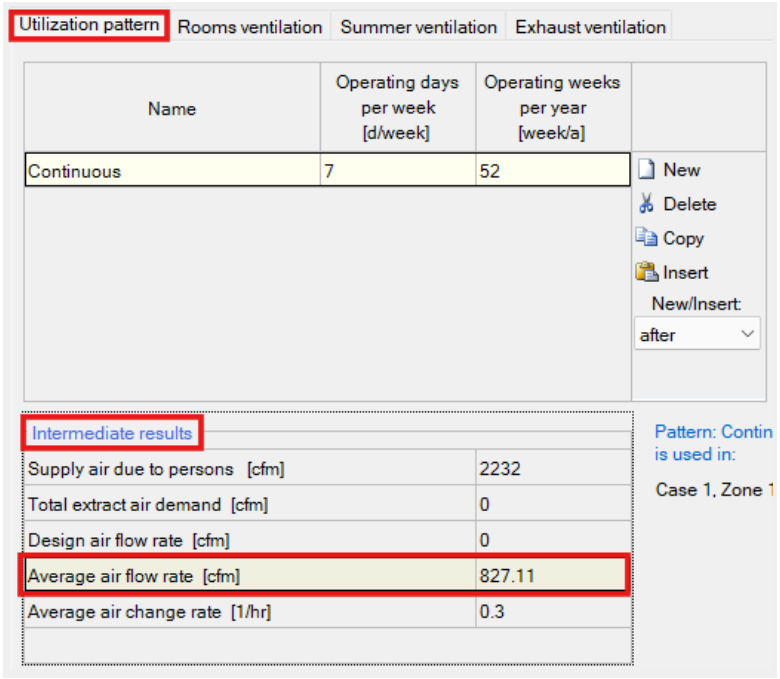
- **`Operating Days per Week`:** Input 7
- **`Operating Weeks per Year`:** Input 52
- **`Intermediate Results`:** Values will automatically populate as modeling inputs are completed.
    - **`Supply Air due to Persons (cfm)`:** Calculated supply air needed to satisfy 18 cfm/person (WUFI Passive default, defined previously under PH Case)
    - **`Total Extract Air Demand (cfm)`:** Total exhaust air volume as defined on the `Rooms Ventilation` tab.
    - **`Design Air Flow Rate (cfm)`:** Maximum air flow rate.
    - **`Average Air Flow Rate (cfm)`** | **`Average Air Change Rate (ACH: 1/hr)`:** These values are locked in for unfinished projects regardless of inputs on the `Rooms Ventilation` tab. The `Average Air Flow Rate` is the continuous ventilation rate needed to achieve 0.3 ACH.
- **`Daily operation schedule (h)`:** Input 24h at the `Maximum` setting
- **`Fraction of design air flow`:** No entry required.

[UF] Ventilation / Rooms > Rooms Ventilation Tab

Create one line item in this section and complete the inputs as noted below:

- **`Room Type`:** Select `User Defined`.
- **`Quantity`:** Input 1.
- **`Utilization Pattern`:** Select `Pattern 1`.
- **`Design Volume Flow Rate`:** Align supply and exhaust airflow rates with the `Average Air Flow Rate` calculated under `Intermediate Results` on the `Utilization Pattern` tab.

Process Tip: A positive value for Exhaust volume flow rate must first be input before this value is calculated.



[UF] Ventilation / Rooms > Summer Ventilation Tab

Inputs in this section should be mostly left blank, except for `Summer HRV/ERV Recovery Mode`:

- If the unfinished space will be served by a centralized ventilation system that is already captured in another residential/non-residential model, align input.
- If the unfinished space will be served by an unknown standalone ventilation system, select `Always`.

[UF] Ventilation / Rooms > Exhaust Ventilation Tab

Skip this section for unfinished (UF) projects. No inputs needed here.

1.4.4.14 Attached Zones

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.). Fully conditioned adjacent spaces (i.e residential and occupied, non-residential and always conditioned) should **not** be modeled as attached zones.

Within the `Attached Zones` branch, click `New` to create a new attached zone. Name the new zone in accordance with the space being modeled.

- **Type:** Regardless if the attached zone is unheated or semi-heated, the 'Type' should always be set to 'Unheated space'.

Attached Zone Inputs

Once the attached zone is created, click into the WUFI Passive sub-branch that was created called `Attached Zone #: [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)

1.4.4.15 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.

1.4.4.16 Systems Set-Up

In WUFI Passive, one system consists of a set of multiple devices. Often, only one system is needed per building.

Exception: Multiple systems are necessary if the cooling system capacity exceeds 682 kBtu/sf.yr (~56 tons of cooling). This is due to software limitations, where WUFI Passive is limited to a maximum cooling capacity per modeled system. More on this below under Section 1.4.4.18.

Within the `Systems` branch, click `New` to add a system to the energy model.

Process Tip: The `System type` should **not** be changed from the default selection `User Defined (ideal system)`.

The table of contents to the right outlines the structure of the remaining modeling protocol sections, which provide guidance on completing the inputs for mechanical systems.

Note: 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.

Table 1.4.4.16.0 Systems Table of Contents

1.4.4.16 Systems Set-Up	System 1 (User Defined): General Tab
	System 1 (User Defined): Distribution Tab
1.4.4.17 Mechanical Ventilation Systems	Mechanical Ventilation Device
	Mechanical Ventilation Ducts
1.4.4.18 Space Conditioning (Heating/Cooling) Systems	Heat Pumps: Heating
	Heat Pumps: Cooling
	Electric Resistance heaters
	Boiler or Furnace (Space Heating)
	Wood or Pellet Stove
	Hydronic Heating
1.4.4.19 Domestic Hot Water (DHW) Systems	Heat Pump Water Heaters: (Inside/Outside)
	Tankless Water Heaters
	Tanked Water Heaters (except heat pumps)
	Hot Water Storage
	Swing Tanks
	Solar Collector
	Drain Water Heat Recovery
	Hot Water Piping
1.4.4.20 Renewable Energy Systems	On-Site Renewable Energy
	Off-Site Renewable Energy
1.4.4.21 Supportive Devices / Auxiliary Energy	DHW Circulating Pumps
	Other (Misc.) Equipment

System 1: (User Defined) > General Tab

Once a system is created, navigate to:

- `Systems`
  - `System 1 (User Defined)`
    - `General` (tab)

On the `General` tab, add devices to the `Device/Equipment` table for the following systems:

- Mechanical Ventilation
- Space Conditioning (heating/cooling)
- Domestic hot water (DHW)
  - Water Heater(s)
  - Storage tank(s) (if applicable)
- Photovoltaics / Renewable energy

Exception: For Unfinished (UF) spaces, the **only** device that should be included in the model is the mechanical ventilation device (E/HRV). This is the only device that impacts the space conditioning results.

The following inputs are required on the `General` tab for each device:

- **`Type`:** Select from the dropdown menu. See system-specific sections below for appropriate `Type` selections for each piece of equipment.

☑ **`Used For`:** Use the check-boxes to identify the purpose for each piece of equipment.

Exception: This is **not** necessary for the following device types:

- `Mechanical Ventilation`
- `Photovoltaic / Renewable Energy`
- `Drain Water Heat Recovery`

Example: A project team is using the following systems:

- Mechanical Ventilation: ERV
- Space Conditioning: Mini-split heat pump
- Domestic Hot Water: Electric resistance water heater (with tank)

The `Device/Equipment` table is set up as follows:

Type	Used for			
	Space heating	DHW	Space cooling	Space ventilation
Mechanical ventilation				☑
Heat pump	☑	☐	☑	
Electric resistance space heat / DHW	☐	☑		
Water storage		☑		

- **`Coverage`:** Defined below the `Device/Equipment` table. If more than one device serves the same purpose, all devices should be added and the appropriate coverage should be assigned for each. The total coverage must sum to 1 in each `Used For` column. This is generally applicable in the following scenarios:
  - Capacity of the cooling system exceeds the limit of a single system input (>682 kBtu/hr).
    - Refer to Space Conditioning (Heating/Cooling) Systems.
  - Multiple devices for space heating (e.g., heat pump + wood stove) are planned
  - Multiple devices for domestic water heating (e.g., heat pump water heater + swing tank) are planned

Process Tip: Details on how the Coverage calculations are performed are given in the system-specific sections below.

System 1: (User Defined) > Distribution Tab

The `Distribution` tab and the sub-sections described below will only populate once devices are added to the `General` tab. The tabs that appear are dependent on the types of devices and the functions they are assigned to in the `Device/Equipment` table.

Distribution > Hydronic Heating

This tab will only appear when a device assigned to `Space Heating` is present. Refer to the Hydronic Heating section below for modeling protocol.

Distribution > DHW

This tab will only appear when a device assigned to `DHW` is present. Refer to the Hot Water Piping section below for modeling protocol.

Distribution > Cooling

This tab will only appear when a device assigned to `Space Cooling` is present. Refer to the Heat Pumps: Cooling section below for modeling protocol.

Distribution > Ventilation

This tab will only appear when a device assigned to `Mechanical Ventilation` is present. Refer to the Mechanical Ventilation Ducts section below for modeling protocol.

Distribution > Supportive Device / Auxiliary Energy

This tab will only appear when any device is present. Refer to Section 1.4.4.21 below for modeling protocol.

1.4.4.17 Mechanical Ventilation Systems

Add a line item to the `Device/Equipment` table on the `System 1: (User Defined)` > `General Tab` for each unique ventilator in the project. Complete the inputs as noted below:

- **`Type:`** Select `Mechanical ventilation`
  - This device type is reserved for ventilation devices that have passive heat recovery. Do **not** add ventilation devices for direct exhaust fans.

☑ **`Used For:`** Checked by default.

- **`Coverage:`** No inputs necessary.

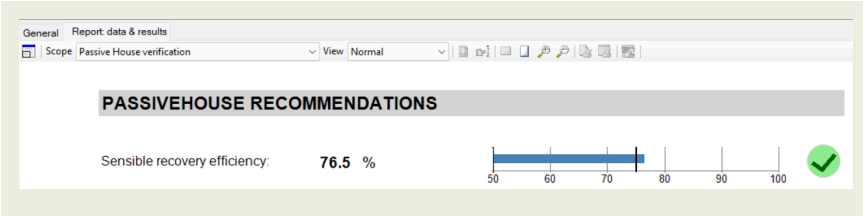
Process Tip: Identical devices with the same model number **and** planned airflow will have the same performance inputs and should be consolidated by modeling one `Device` and adjusting the `Quantity` within each unique device as needed.

Mechanical Ventilation Device

Click into the `Device #: (Mechanical Ventilation)` sub-branch. Review Section 1.4.2.5 for accepted sources for the performance inputs.

- **`Name:`** Input an appropriate name for the device that aligns with the device tag, model number, other unique identifier.
- **`Sensible Recovery Efficiency:`** Input decimal value based on device-specific performance data. Also commonly known as ASRE (HVI) or Net Sensible Effectiveness (AHRI).

  Exception: Unfinished (UF) projects should match the average performance for the rest of the building for all inputs. The average sensible recovery efficiency can be found in the Passive House Verification Report:



- **`Humidity Recovery Efficiency:`** Input decimal value based on device-specific performance data. Also commonly known as NMT or LRMT (HVI) or Net Latent Effectiveness (AHRI).

  Exception: Input 0.40 as a default for ERVs if **not** specified and for all Unfinished (UF) projects. Input 0 for HRVs which do not have humidity recovery.

- **`Electric Efficiency [W/cfm]:`** Input decimal value based on device-specific performance data. Also known as ventilator fan power or its inverse, fan efficacy (cfm/W, typical for HVI ratings).

  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).

  Note: While this is a required input in order for WUFI Passive to calculate results, this input does not matter for Unfinished (UF) projects. It only impacts source energy, which is not applicable to UF projects.

☑ **`Equipped with frost protection:`** This box must always be checked.

☑ **`Rooms Ventilated by this Unit:`** All ventilation rooms

defined on the `Rooms Ventilation` tab 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 modeled as separate devices.

☑ **`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.
    - This scenario would be likely in a multifamily project with E/HRVs in each dwelling unit and a rooftop DOAS unit serving the common areas.
- 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.
    - This scenario would be likely in a multifamily project with a rooftop DOAS unit serving most spaces and a smaller unit serving an individual space (e.g., fitness room)

☑ **`No Summer Bypass Feature`:** Check this box if the ventilation device **does not** have a bypass mode and runs continuously in heat recovery mode.[40] Refer to Summer Ventilation above for additional information.

☐ 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.[41]

☑ **`Defrost`:** This box must always be checked.

- **`Temperature below which defrost must be used`:** No matter the method of defrost, Phius requires accounting for defrost energy. Input a value between 23°F-28°F.

  Exception: If using a ground loop pre-heater/subsoil heat exchanger, defrost energy does **not** need to be

[40] `Summer HRV/ERV Recovery Mode` = **`Always`**

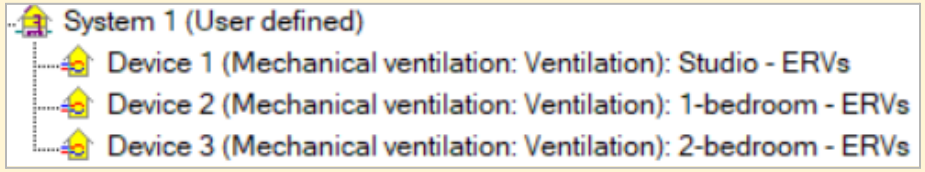
[41] `Summer HRV/ERV Recovery Mode` = **`Temperature/Enthalpy-Controlled Bypass`**

accounted for in the energy model and this box may be unchecked.

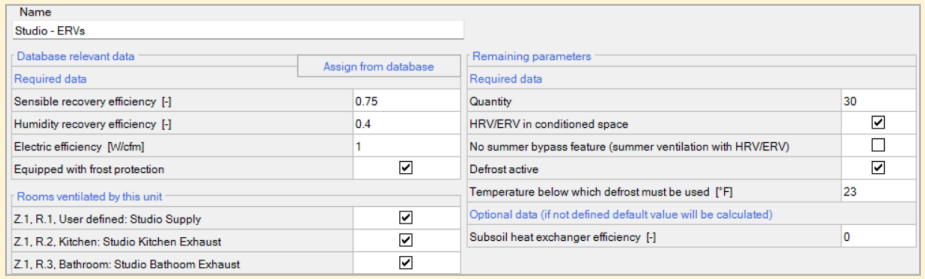
- **`Subsoil Heat Exchanger`:** Use for earth air tubes and liquid-based ground loops for tempering supply air. Typical efficiency ranges from 40-60%. For entries above 60% efficiency, a corresponding calculation is required for certification.

Example:

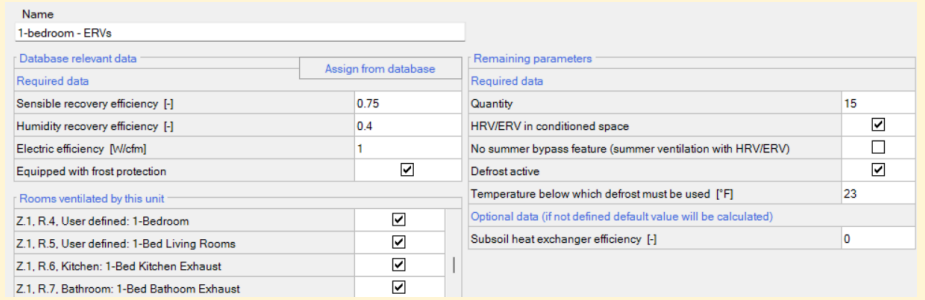
A 50-unit multifamily has one identical ERV per dwelling unit. The building consists of 30 studios, 15 one-bedrooms and 5 two-bedrooms.



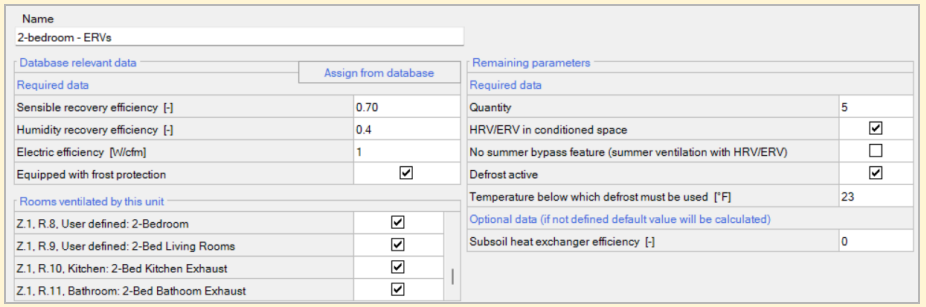
The studio dwelling units would be input as noted below:



The one-bedroom dwelling units would be input as noted below:



The two-bedroom dwelling units would be input as noted below:



Mechanical Ventilation Ducts

To model the intake and exhaust ductwork for the mechanical ventilation system, navigate to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `Ventilation` (tab)

This tab captures the ducts from the ventilator to the exterior of thermal boundary, **not** the ducts from the ventilator to interior spaces. Add line items to the `Ducts` table using the by clicking `New`. Then, complete the associated inputs for each duct.

Process Tip: If the multiple ducts are the same, or have some of the same properties such as duct size, insulation thickness, and/or thermal conductivity, it is recommended to complete **all** of the inputs for a single duct, `Copy` and `Insert` it, then modify the unique properties as needed.

- **`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 for `Assigned Ventilation Units` to assign those two average-length ducts to the appropriate ventilator type. This will accurately assign those ducts to each of the 50 ventilators.

- **`Additional Data`:** Complete the following inputs below the `Ducts` table
  - **`Duct Length [ft]`:** Review Section 1.4.2.6
  - **`Duct Diameter` or `Width and Height [in]`:** 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 input 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 checkboxes (bottom right, below `Ducts` table).

1.4.4.18 Space Conditioning (Heating/Cooling) Systems

Add one new line item to the `Device/Equipment` table on the `System 1: (User Defined)` > `General` Tab for each unique space conditioning system in the project (primary and supplementary, if applicable).

Process Tip: Projects with multiple unique heat pumps should only add one line item to account for the average performance of all heat pumps under a single device.

Complete the inputs as noted below:

- **`Type`:** Select the appropriate device type from the available dropdown options:
    - **`Heat Pump`:** Use this type when heat pump technology is used for space heating and/or cooling.
    - **`Electric Resistance Space Heat / DHW`:** Use this type when electric resistance heaters are used for space heating
    - **`User Defined`:** Use this type when a boiler, furnace or wood/pellet stove is used for space heating

Process Tip: Do **not** use the following device types:

- Boiler
- District heating

☑ **`Used For`:** Check the box for `Space Heating` and/or `Space Cooling` for each device.

Process Tip: For heat pumps that do both heating and cooling, add a single device and check both boxes.

When additional cooling systems are needed for those that exceed 682 kBtu/hr capacity, do **not** check the box for `Space Heating` for the additional systems. The capacity limit of the cooling systems does **not** impact the heating system capacity. There is no input for heating system capacity.

- **`Coverage`:** Inputs are only necessary when:
    - There are multiple devices serving the same function
    - If the cooling system capacity exceeds WUFI Passive's maximum limit per system (>682 kBtu/hr).
    - Post-heaters are used on make-up air systems

Refer to Appendix I-3.14 for more examples and guidance. Determine the coverage using the methods below:

- ***Cooling Systems (>682 kBtu/hr capacity)***
    - Automatically calculated in the Phius Heat Pump Performance Estimator
- ***Heating Systems***
    - Capacity weighted calculation
    - Area weighted calculation

Example: A 100,000 ft^2 multifamily has a VRF heat pump system as the primary space conditioning system serving the dwelling units, corridors, and common

areas (~93,000 ft^2). Electric resistance heaters are used in stairwells and utility rooms (~7,000 ft^2).

The project team chooses to calculate the coverage for each system based on areas served:

- VRF Coverage: 93,000 ft^2 / 100,000 ft^2 = **0.93** (93%)
- Electric Resistance Coverage: 1 - 0.93 = **0.07** (7%)

- ***Make-up Air System Post-Heaters***
  - Record the heating demand result
  - Zero-out the airflow rate of the exhaust device associated with the make-up air system, then record the new heating demand result
  - Calculate the coverage using the following formula: 1 **-** **(**HD w/o exhaust **/** HD w/ exhaust**) =** Coverage (decimal)

Example: A building has an electric resistance duct heater on their make-up air system, which was required due to the quantity of exhaust dryers. The current heating demand in the model is 4.47 kBtu/sf.yr. The project team calculates the coverage of the duct heater by doing the following:

- Exhaust dryer airflow rate set to 0
  - New heating demand = 4.17 kBtu/sf.yr
- 1 **-** **(**4.17 **/** 4.47**) =** 0.07 → **7% electric resistance coverage**

Heat Pumps: Heating

Click into the `Device #: (Heat Pump)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.

  Process Tip: For projects with multiple heat pumps, name the device "Heat Pump Performance Estimator"

Air Source Heat Pumps (ASHP)

- **`Type`:** Select `Heat Pump Rated Monthly COP`

  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 inputting 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.

- **`Parameters`:** Use the Phius Heat Pump Performance Estimator to determine the following inputs:

  Exception: For small projects that have a single heat pump with rated COP data at two temperatures, the COPs and corresponding temperatures should be input exactly as shown on the device datasheet.

  - **`Rated COP 1`:** Input as calculated.
  - **`Ambient Temperature 1 [°F]`:** Input 17°F
  - **`Rated COP 2`:** Input as calculated.
  - **`Temperature 2 [°F]`:** Input 47°F

Water/Ground Source Heat Pumps (WSHP/GSHP)

- **`Type:`** Select `Heat Pump`
- **`Annual Heating Coefficient of Performance (COP):`** Use the Phius Heat Pump Performance Estimator to determine inputs.
- **`Total System Performance Ratio of Heat Generator:`** Input the inverse of the COP as a decimal.

Heat Pumps: Cooling

To complete the cooling system inputs, navigate to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `Cooling` (tab)

Exception: If no active cooling system is designed into the building as-delivered, refer to Appendix I-3.11.2 for modeling protocol.

`Cooling Distribution:` To assign cooling, check all the boxes that best represent the cooling system planned.

☐ **`Cooling via Ventilation Air:`** Do **not** check this box for Phius Certification.

Note: This type of cooling is typical for combination cooling/ventilation units, such as a DOAS, CERV, or Minotair. However, WUFI Passive 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.

For this reason, all cooling should be modeled as `Cooling via Recirculation Air`.

☑ **`Cooling via Recirculation Air:`** Check this box when using heat pump systems for cooling (typical). Then, complete the `Additional Data` inputs:

- **`Minimum Temperature of Cooling Coil (for recirculation air):`** Input 45°F (default).

- **`Recirculation Air Flow Rate`:** Calculate this input based on the assumption of 300 cfm for every 12 kBtu/hr (1 ton) of total cooling capacity.

  Example: The outdoor compressor of the cooling system has a rated cooling capacity of 18,000 Btu/hr.

  1. Convert Btu/hr to kBtu/hr
     - (18,000 Btu/hr ÷ 1,000) **=** 18 kBtu/hr
  2. Calculate estimated air flow rate
     - 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`:** Use the Phius Heat Pump Performance Estimator to calculate the cooling COP input for WUFI Passive. Typical cooling metrics and acceptable data sources are outlined under Heating & Cooling Equipment.

☑ **`Dehumidification`:** Check this box when using a heat pump system and/or stand-alone dehumidifiers.

- **`Dehumidification COP`:** Input 1.2 (default)

  Exception: If a stand-alone dehumidifier is specified, use the rated Energy Factor (L/kWh) value from the manufacturer.

  Process Tip: Click into this input cell and click the `[...]` button to open the built-in calculator. Input the Liter/kWh rating.

☐ **`Panel Cooling`:** Check this box when using radiant cooling systems (atypical).

- ☐ **`Panel Cooling COP`:** An external calculation is required.

  Process Tip: Dehumidification control is required for projects that employ radiant cooling systems, which are only typical to dry [B] climates.

Electric Resistance Heaters

The only input needed for the `Electric Resistance Space Heat / DHW` device type is a clear, descriptive name that indicates the device tag and/or function. No additional inputs are required.

Boiler or Furnace (Space Heating)

Click into the `Device #: (User Defined)` sub-branch. Find the Thermal Efficiency (%) or Annual Fuel Utilization Efficiency (AFUE) of the planned device. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **`Performance Ratio of Heat Generator`:** Input the 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`:**
  - Input 2.0 for electric devices.
  - Input 1.1 for natural gas devices.
- **`CO2 Emissions Factor [g/kBtu]`:** Input required, but has no impact on the results.
  - Input 199.31 for electric devices.
  - Input 73.28 for natural gas devices.

Wood or Pellet Stove

Click into the `Device #: (User Defined)` sub-branch. Find the Thermal Efficiency (%) from the planned device or use 60% as a default if unknown. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **`Performance Ratio of Heat Generator`:** Input the inverse of the efficiency.

  Example: Efficiency = 60%: 1 / 0.60 = 1.67

- **`Source Energy Factor`:** Input 0.2 as a default for biomass fuel.
- **`CO2 Emissions Factor [g/kBtu]`:** Input required, but has no impact on the results. Input 14.66.

Hydronic Heating

If there are hydronic pipes used for heating in the project, navigate to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `Hydronic Heating` (tab)

The inputs on this tab are related to 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.

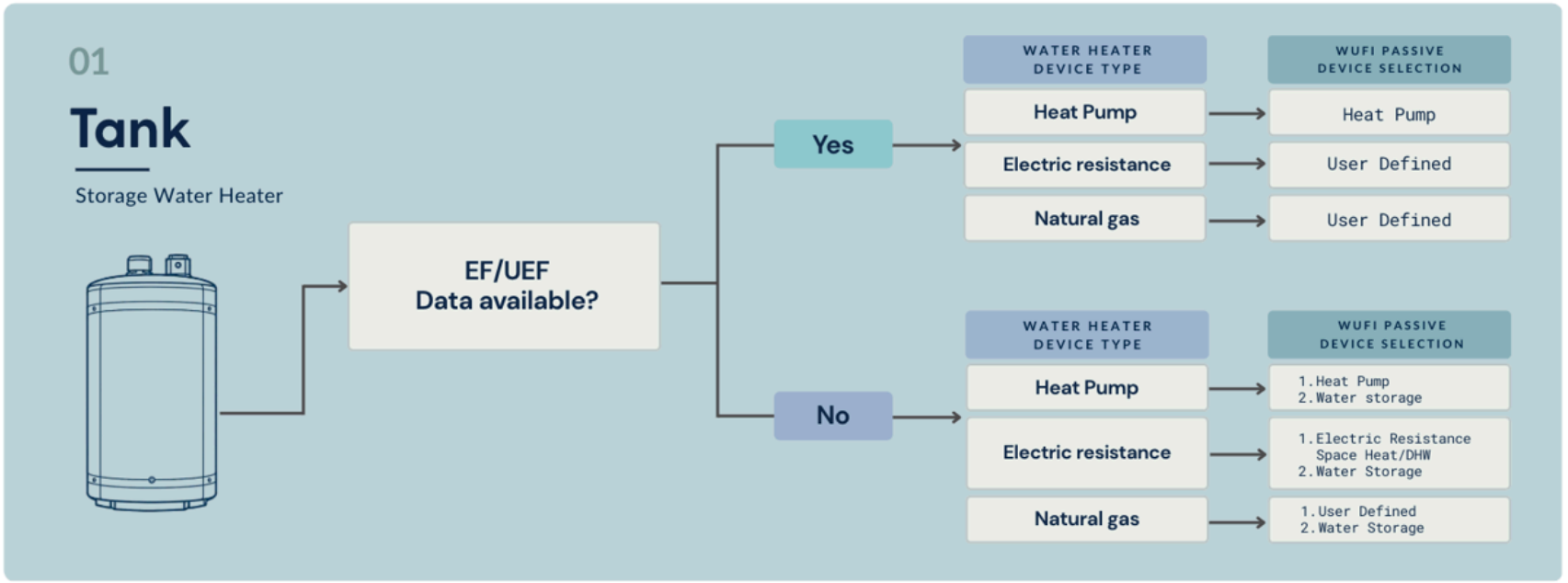
- **`Design Flow Temperature`:** The temperature of the water in the piping. This can be determined by the mechanical sequence of operations, or leaving water temperature on the mechanical schedules for the heating plant equipment.
- **`Length of Distribution Pipes`:** The total length of hydronic heating 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.

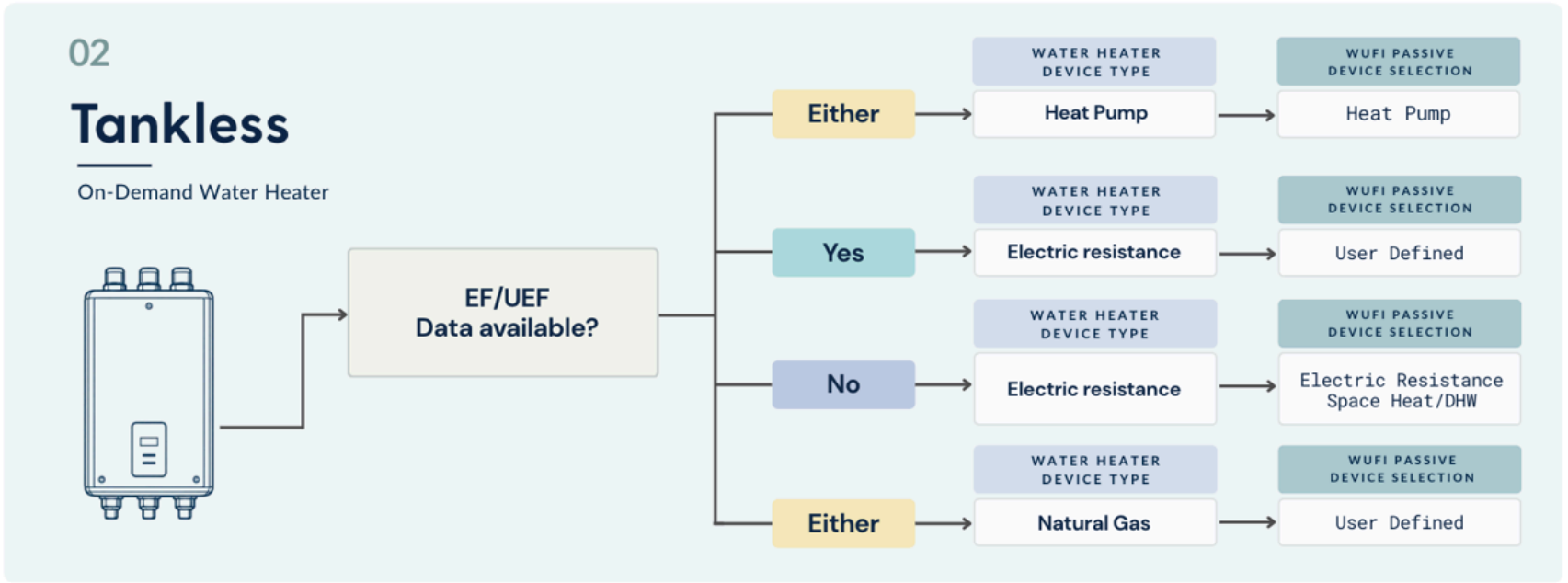
  Example: A project team is modeling hydronic heating for their building. They provide the takeoffs for the following pipe lengths, add them together, and Input the total length of pipes in WUFI Passive.
  - Between the boiler and the fan coil unit
  - Between the boiler and the manifold for the radiant 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 click the `[...]` box 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 auto-calulate.
- **`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.

1.4.4.19 Domestic Hot Water (DHW) Systems

Add one new line item to the `Device/Equipment` table on the `System 1: (User Defined)` > `General` Tab for each unique DHW device in the project. Use the matrix below to determine the `Type` selection based on the device type and performance data available:





- **`Type` (Continued):** Additional devices may be required for the following scenarios:
    - **`Water Storage`:** Use this device for additional storage and/or swing tanks (typically part of DHW recirculation systems)
    - **`Solar Collector`:** Use this type when using a solar collector to supplement domestic hot water heating
    - **`Drain Water Heat Recovery`:** Use this type when implementing technology that recovers heat from drain water to pre-heat the incoming cold fresh water (atypical).

☑ **`Used For`:** Check the box for `DHW` for all devices.

- **`Coverage`:** This input is only necessary if there are multiple devices serving the same function (water heating).

  Process Tip: Coverage inputs are **not** applicable to `Water Storage` devices.

  Determine the coverage of multiple water heating systems using one of the methods below:
    - Capacity weighted calculation
    - Fixture (quantity) weighted calculation

      Example: A multifamily project has a total of 100 hot water fixtures. 90 of the fixtures are served by a centralized domestic hot water system, while 10 additional fixtures located in amenity spaces and common restrooms are served by a standalone indoor heat pump water heater.

      The project team chooses to calculate the coverage for each system based on fixture quantity:
        - Centralized system fixtures = **0.90** (90%)
        - Decentralized system fixtures = **0.10** (10%)

      Exception: There is a unique protocol for Swing Tanks, outlined below.

Process Tip: For all DHW systems, it is recommended (but not required) 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.

Heat Pump Water Heaters: Inside

Follow this protocol when the compressor and tank are within the thermal envelope. Click into the `Device #: (Heat Pump)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and model number.
- **`Type`:** This selection depends on the type of performance data available:
    - **`Heat Pump Water Heater (HPWH) Inside`:** Select this type for devices **with** EF/UEF data.

      Process Tip: 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.
    - **`Heat Pump`:** Select this type for devices that **do not** have EF/UEF data.

      Process Tip: Once the heat pump inputs are completed, proceed to modeling the associated `Water Storage` device.

2. **`Annual Heating Coefficient of Performance (COP)`:** Input the average COP of the *space heating* system.
3. **`Total System Performance Ratio of Heat Generator`:** Input the inverse of the COP as a decimal.
4. **`HPWH EF`:** Input the rated Energy Factor (EF) for the Heat Pump Water Heater. If UEF data is provided, convert to EF using the formulas outlined in Appendix I-3.12.

   Process Tip: This input is only available if the `Type` is set to `Heat Pump Water Heater (HPWH) Inside`.

Heat Pump Water Heaters: Outside

Follow this protocol when any combination of the compressor and/or tank is located outside of the thermal envelope of the building. Click into the `Device #: (Heat Pump)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **`Type`:** Select **`Heat Pump`** from the dropdown menu.
- **`Annual Heating Coefficient of Performance (COP)`:** Contact Us for the climate specific Outdoor HPWH COP Estimator.

  Process Tip: If using the Phius Outdoor HPWH COP Estimator **and** UEF data is available, use the following values in the estimator:
    - UEF = COP at 77°F
    - 1 = COP at 40°F.

  Exception: For the following CO_2 HPWHs follow the instructions outlined in the COP Estimators:
    - SanCO$_2$: Use the Phius ECO2 CO2 Heat Pump Water Heat COP Estimator
    - QAHV CO$_2$: Contact Us for climate specific calculator.
- **`Total System Performance Ratio of Heat Generator`:** Input the inverse of the COP as a decimal.

Tankless Water Heaters

Click into the `Device #: (User Defined)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **`Performance Ratio of Heat Generator`:** Input the inverse of the EF or UEF.

  Process Tip: EF and UEF are equivalent for tankless (instantaneous) gas-fired and electric water heaters, so no conversions are necessary.

- **`Source Energy Factor`:**
  - Input 2.0 for electric devices.
  - Input 1.1 for natural gas devices.
- **`CO2 Emissions Factor`:** Input required, but has no impact on the results.
  - Input 199.31 for electric devices.
  - Input 73.28 for natural gas devices.

Tanked Water Heaters (except heat pumps)

If a tanked water heater is used for water heating, the modeling method depends on the fuel type and performance data available. Review the appropriate `Type` settings at the beginning of Section 1.4.4.19, then complete the inputs for each device as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **For devices *with* EF or UEF performance data:**
  - **`Performance Ratio of Heat Generator`:** Input the inverse of the EF as a decimal. If UEF data is provided, convert to EF using the formulas outlined in Appendix I-3.12.
  - **`Source Energy Factor`:**
    - 2.0 default for electric devices.
    - 1.1 default for natural gas devices.
  - **`CO2 Emissions Factor`:** Input required, but has no impact on the results.
    - Input 199.31 for electric devices.
    - Input 73.28 for natural gas devices.
- **For devices *without* EF or UEF performance data:**
  - **Electric resistance water heater:** No efficiency inputs are required for the `Electric Resistance Space Heat / DHW` device type.
  - **Natural gas (`User Defined`) water heater:** Follow the modeling protocol for a Boiler or Furnace**.**
  - **All systems:** Complete `Water Storage` device inputs.

Hot Water Storage

The modeling protocol for hot water storage tanks depends on the type of performance data available. Click into the `Device #: (Water Storage)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.

1. **If AHRI Rating with storage losses is available:**
    - **`Input Options`:** Set to `Total Losses.`
    - **`Storage Capacity`:** Input the tank size in gallons.
    - ☑ **`Within Thermal Envelope`:** Check this box if the storage tank is located within the thermal envelope.
    - **`Average Heat Released From Storage [Btu/hr]`:** Use the following calculation to determine this input: 8.3454 **x** Tank Size [gal] **x** AHRI Standby Loss [F/h]

2. **If no storage loss rating is available:**
    - **`Input Options`:** Set to `Specific Total Losses`
    - **`Storage Capacity`*:*** Input the tank size in gallons.
    - **`Specific Total Thermal Storage Losses [Btu/hr.F]`*:*** Use the Phius DHW Storage Tank Loss Estimator[42] to determine this input.
    - ☑ **`Within thermal envelope`:** Check this box if the storage tank is located within the thermal envelope.

[42] A default of R-12 tank insulation may be used as a placeholder for Design Certification.

Swing Tanks

Swing tanks are most commonly used when a DHW recirculation system is planned. To account for this, add the following two devices to the `System 1 (User Defined)` > `General` tab:

1. **`Electric Resistance Space Heat / DHW`:** Assign 25% DHW coverage

    Exception: Engineer calculations may be provided and used in the model in lieu of the 25% default coverage.

2. **`Water Storage`:** Complete the inputs as outlined in Hot Water Storage above.

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

Process Tip: This device does **not** work in combination with the `Simplified Individual Pipes` hot water distribution calculation method.

Click into the `Device #: (Drain Water Heat Recovery)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **`DW Heat Recovery Unit Indoor Temp`:** Input 97°F (default)
- **`DW Heat Recovery Unit Efficiency`:** Input value as rated and labeled in accordance with CSA 55.1
- **`Pipe Length`:** Input 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.

Hot Water Piping

Refer to the Phius DHW Piping Protocol document for guidance on modeling hot water piping. This document covers the modeling protocol for the `General` and `Hot Water Piping` tabs. These tabs can be found by navigating to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `DHW` (tab)

Process Tip: See Appendix I-3.13 for recommended schematic/early-design modeling methods.

1.4.4.20 Renewable Energy Systems

Add a line item to the `Device/Equipment` table on the `System 1: (User Defined) > General Tab` for each unique renewable energy system in the project. Complete the inputs as noted below:

- **`Type`:** Select `Photovoltaic / Renewable Energy`
- ☑ **`Used For`:** No inputs necessary.
- **`Coverage`:** No inputs necessary.

On-Site Renewable Energy Systems

For Design Certification, on-site renewable energy must be documented[43]. On-site PV arrays are permitted for both Phius CORE & ZERO projects. Click into the `Device #: (Photovoltaic / Renewable Energy)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the array size, annual energy production, and manufacturer (if available).
- **`Location`:** Select **`On-Site`** from the dropdown menu.
- **`Onsite Utilization`:** Select from the dropdown menu based on the Certification tier and project type:
    - ***For Phius CORE projects*:**
        - **Residential:** Select `PV Utilization Calculator`
        - **Non-Residential:** Select `User Defined`
    - ***For Phius ZERO projects*:**
        - **All projects:** Select `User Defined`
- **`Photovoltaic / Renewable Energy [kWh/yr]`:** Input the annual energy production based on the Certification tier and project type:
    - ***For Phius CORE projects*:**
        - **Residential:** Input the total annual production of the renewable system planned.
        - **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. Review Appendix N-1 for more information.
    - ***For Phius ZERO projects*:**
        - **All projects:** Input the total annual production of the renewable system planned.
- **`Array size [kW]`:** Input the total planned size of the PV array.

> **Process Tip:** This input is only available for projects when `Onsite Utilization` is set to `PV Utilization Calculator`.

[43] NLR'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.

Off-Site Renewable Energy Systems

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. Off-site renewable energy is permitted for Phius ZERO projects **only**. Click into the `Device #: (Photovoltaic / Renewable Energy)` sub-branch. Then, complete the inputs as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the annual energy production and energy source.
- **`Location`:** Select **`Off-Site`** from the dropdown menu.

  > **Process Tip:** The `Off-site` dropdown option is only available when the `Certificate Criteria` is set to `Phius ZERO`

- **`Utilization`:** Select one of the following options based on the type of off-site renewable energy system:
  - `Directly owned off-site renewables`
  - `Community renewable energy`
  - `Virtual power purchase agreement`
  - `Renewable energy certificates (RECs)`

  > **Process Tip:** Utilization factors for each system type are automatically populated in the software and align with Table N-4.2.0.

- **`Photovoltaic / Renewable Energy [kWh/yr]`:** Input the annual energy production for all project types.

1.4.4.21 Supportive Devices / Auxiliary Energy

Additional pieces of equipment not yet accounted for such as pumps, fans, or other miscellaneous devices that either 1) support the operation of the primary systems serving spaces within the thermal envelope or 2) serve auxiliary spaces outside of the thermal envelope, must be captured in the model. Navigate to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `Supportive Device / Auxiliary Energy` (tab)

First, determine whether default values are appropriate for the project:

☑ **`Use Default Values`:** This box is checked by default, which applies to many projects.

☐ **`Use Default Values`:** Uncheck this box if any additional pumps, fans or other auxiliary energy devices are planned. Including, but not limited to:

  - Pumps associated with water systems such as:
    - DHW Recirculation
    - Potable water (e.g.,. booster, well)
    - Amenities (e.g., pool, hot tub/spa)
  - Fans associated with systems such as:
    - Makeup air
    - Direct-exhaust (e.g., bathrooms, trashrooms, 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 (e.g., pool heaters, hot tub/spa heaters, space conditioning systems outside the thermal envelope)
    - Dehumidification energy of an unconditioned crawlspace outside of the thermal and airtight envelope.

Exceptions: Back-up or auxiliary space conditioning systems **within** the thermal envelope of the building should **not** be modeled as auxiliary devices. Review the `Coverage` section under `System 1 (User Defined) > General Tab`.

Systems that do **not** operate on a regular basis need **not** be accounted for. (ie. back-up generators, sump pumps, ejector pumps, fire pumps)

Process Tip: If there are multiple cooling systems present due to a total system capacity >682 kBtu/hr, be sure to **uncheck** the `Use Default Values` box for the additional systems.

When this box is unchecked, only the ventilation system fan energy and defrost energy are retained. Any pump entries for DHW recirculation are removed and must be added back to the model manually. (Note: These devices appear in the WUFI Passive reports under Auxiliary Energy).

- `Ventilation Winter`: This auto-calculated value accounts for the fan power of the ventilation system for months that require heating.
- `Ventilation Summer`: This auto-calculated value accounts for the fan power of the ventilation system for months that require cooling.
- `Ventilation Defrost`: This auto-calculated value accounts for energy associated with the ventilation device staying frost-free.

Next, add devices to the table by clicking `New`. Then, define the device type according to the guidance below:

- **`Device Type`:** Select the device type for each auxiliary device from the two options below:
    1. **`DHW Circulating Pump`:** Select this option for DHW recirculation pumps. Proceed to DHW Circulating Pumps to complete the remaining inputs.
    2. **`Other`:** Select this option for all other auxiliary equipment. Proceed to Other (Misc.) Equipment to complete the remaining inputs.

Process Tip: The following device types should **not** be used:

- **`Heating Circulating Pump`**
    - Any pumps or fans associated with the space conditioning systems (ie. air handling units, fan coil units, cooling towers, pumps associated with a GSHP etc..) should be accounted for using the Phius Heat Pump Performance Estimator.
- **`DHW Storage Load Pump`**
    - This device is not required for Phius Certification.

DHW Circulating Pumps

Projects that provide active DHW recirculation must include the associated pump(s) in the WUFI Passive model. This includes continuous, time-based, temperature controlled, on-demand and "smart" recirculation pumps. After adding a new device to the table, complete the inputs as follows:

- **`Device Type`:** Select `DHW Circulating Pump`
- **`Quantity`:** Input the quantity of regularly-operating recirculation pumps.

  Process Tip: The quantity should not include pumps that are installed as backup to the main pump(s).

- ☑ **`In Conditioned Space`:** Check this box for DHW recirculation pumps that are within the thermal envelope.
- **`Energy Demand (rated) [W]`:** As a default, input a value based on the following calculation[44]:
    - Wattage = (0.00007249 **x** Gross Volume ft^3) **+** 27W

  Exception: Manufacturer data may be used in lieu of this accepted default. When data is provided in horsepower (HP), convert to watts using the following calculation:
    - Wattage = HP * 745.7
- **`Runtime [khr/yr]`:** For DHW Circulating Pumps, WUFI Passive automatically estimates a run-time based on the gross volume of the building.[45]

[44] 0.00007249 **=** 0.008 **x** 0.32 **x** 0.028317 m^3/ft^3

[45] WUFI Passive Runtime for DHW Circulating Pumps **=** (10 **+** (1 **/** (0.07 **+** 50 **/** (Gross Volume **x** 0.028317 m^3 **/** ft^3 **x** 0.32)))) **x** 365

Other (Misc.) Equipment

For all other miscellaneous auxiliary systems or devices, after adding a new device to the table, complete the inputs as follows:

- **`Device Type`:** Select `Other`
- **`Quantity`:** Input the quantity of each auxiliary device.
- ☑ **`In Conditioned Space`:** Check this box for devices within the thermal envelope.
- **`Energy Demand (rated) [W]`:** The energy estimation calculations in the tables below may be used for all Phius projects and may be supplemented or replaced with project-specific calculations or manufacturer data (if available).
- **`Runtime [khr/yr]`:** For devices that operate continuously, input 8.76. For all others, refer to the calculations in the tables below or provide alternative supporting documentation to verify this input.

Table 1.4.4.21.0 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		50.8 x F_{scale}[46]	
Pool Pump		Pool Energy Use Estimator v26.2.0	
Hot tub/spa Pump		59.5 kWh/yr x F_{scale}	

Table 1.4.4.21.1 Other Devices: Fans

Device	Quantity	Energy demand (rated) [W]	Period of Operation [khr/yr]
Makeup Air	# Fans	W/cfm x cfm	Varies
Bathroom Exhaust[47]			0.365
Trash Room Exhaust			8.76
Transfer			Varies
Heating / Cooling AHU[48]			8.76

[46] F_{scale} = 0.5 **+** (Nbr **/** 12) **+** (iCFA **/** 7,680)

[47] 0.3 W/cfm may be used as a placeholder if fan power is **not** available.

[48] 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 1.4.4.21.2 Other Devices: Miscellaneous Electric

Device	Quantity	Energy demand (rated) [W]	Period of Operation [khr/yr]
Snow Melt / Frost Protection[49]	1	Snow Melt Energy Estimator	1
Pool Heater		Pool Energy Use Estimator v26.2.0	1
Hot tub/spa Heater (electric)		49 x F_{scale}	1
Exterior Dehumidifier[37]		Varies	Varies

Table 1.4.4.21.3 Other Devices: Miscellaneous Gas

Device	Quantity	Energy demand (rated) [W]	Period of Operation [khr/yr]
Hot tub/spa Heater (gas)	1	14 x F_{scale}	1
Fireplace (gas)		31.4 x F_{scale}	
Grill (gas)		14 x F_{scale}	
Lighting (gas)		3.5 x F_{scale}	

[49] Contact Us for estimating the energy use of this system type.

1.4.5 METr Energy Modeling Software

METr (Modeled Energy Transfer) is a cloud-based energy modeling platform developed by Phius and C3RRO® for passive and high-performance building projects. Building on concepts familiar to WUFI Passive users, METr offers an updated modeling environment with enhanced functionality, improved workflow efficiency, and greater accessibility through its web-based platform.

1.4.5.1 Accepted Modeling Software

For Phius CORE 2021 and 2024, & Phius ZERO 2021 and 2024:

- METr: Version 1.92/2.74 or later approved release

METr Version Updates

For information on the latest METr releases, software enhancements, and bug fixes, refer to the C3RRO Software Update Notes.

Process Tip: METr is regularly updated to improve functionality, address software issues, and support ongoing program requirements. Projects may be started and completed using different METr versions.

New software releases do not impact projects stored in the cloud, and existing project files remain accessible.

Exception: METr includes older Phius certification programs (Phius + 2015 and Phius + 2018) that should only be used for projects originally registered under those programs and are returning to complete certification. New projects are not eligible to certify under these certification programs. Prior approval from Phius is required before selecting older certificate criteria.

File Format Compatibility

METr utilizes *.json* project files and supports the import of WUFI Passive (*.mwp*) files generated in WUFI Passive. For certification submissions, the METr *.json* file must be uploaded to the project Dropbox folder, as Phius cannot access projects stored in individual METr cloud accounts.

1.4.5.2 METr Online Resources

Stay up-to-date by visiting the METr webpage on the Phius website.

Bug Reporting / Feature Requests

Any software issues, bug reports, or feature requests should be submitted through the METr Request Form. For questions regarding subscriptions, licensing, or account access, contact C3RRO Support: support@c3rro.com.

1.4.5.3 METr Settings

Table 1.4.5.3.0 METr Settings

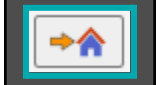
Settings	Selections	Instructions and Descriptions
User-Settings	Language	Select the language used throughout the software.
	Units	Select the preferred unit system used throughout the software.
	Show hints	Check the box to ensure the proper hover-over hints are visible.
	Thermal conductivity as R per inch	Check the box to enter thermal properties as R-value per inch (R/inch) instead of thermal conductivity (k-value).
	Paper size (report)	Select the paper size used when generating reports.
	Load Last Project at Start	When enabled, the last project you worked on will automatically open when the application starts. When disabled, a new project will be opened instead.
Assign Component Colors Automatically	☑ On/Off	Enabling this automatically assigns default component colors. When disabled, users can manually adjust colors as needed.
Store & Sync in the cloud	☑ On/Off	Enabling this automatically syncs your project files to the cloud so you can access them from any internet-connected device.
Automatic data checking	☑ On/Off	Automatically validates data and updates results after model changes. When disabled, updates must be run manually.

Process tip: Where applicable, input settings default to `User Defined`. When the setting is changed to `Calculated`, additional fields will populate (similar to the `[...]` button in WUFI Passive) that allow the user to input data for METr to calculate automatically.

Shared Action Buttons

METr features a standardized set of action buttons for managing list items. Table 1.4.5.3.1 below outlines how to use them.

Table 1.4.5.3.1 Shared Action Buttons

Action Buttons	Name	Description
	Add	Adds a new line item to a list. A new line must be added in order for the `Get from Database` and `Assign to All` buttons to be used.
	Delete	Removes the selected line item from the active list.
	Get from Database	Opens the databases to select pre-defined elements and assign them to the active item.
	Assign to All	Applies the selected assembly to all like-components (i.e., all transparent components, or all opaque components with the same `Assignment` setting.

File Management: Local & Cloud

Local Storage

METr supports saving files locally as *.json* files. To load or save files locally:

1. Click `Project` in the top blue ribbon.
2. Hover over `Locally ➤` to open the sub-menu options:
    a. **`Load`**: Import existing *.mwp* or *.json* files into METr.
    b. **`Save`**: Save your current project as a *.json* file to your default Downloads folder.

> **Process tip:** The saved file takes its name directly from the `Project Name` field under `Project` > `Data` tab.

Cloud Storage

METr also supports saving and opening files from the user's cloud-based account. These files are **only** accessible from the individual user's account. To load or save files to the cloud:

1. **To save:** Check the box for `Store & Sync in the Cloud` to ensure files are saved to the cloud and are regularly auto-saving.
2. **To open:** Click `Project` in the top blue ribbon and select `Stored Projects` from the dropdown menu.
    a. This opens the `Stored Projects` window. Select the desired project and click `Import Project` to make changes to that file. Selecting `Import Project as New` will create a copy of the existing file.

1.4.5.4 METr Databases

By default, METr includes populated databases for materials, assemblies, and windows. One of the databases is the Fraunhofer Institute for Building Physics, which is the same as in WUFI Passive. There are now also Phius databases for:

- Phius Certified Windows & Doors
- Phius default materials (per Appendix I-3.8)
- Pre-defined Phius assemblies (refer to Building Elements > Assemblies)

Accessing Databases

The Phius and Fraunhofer databases are **only** accessible by using the `Get from Database` button (refer to Shared Action Buttons above). Clicking the `Database` button in the blue ribbon at the top of the window opens the `User` database, where new materials, assemblies, and HVAC devices can be added or modified. Importing custom climate data will automatically add it to the `User` database.

> **Process Tip:** Be sure to click `Save Changes Into Database` after making edits to or adding new elements to the `User` database.

Importing Existing WUFI Databases

WUFI Passive users transitioning to METr that have existing databases can now import them. The WUFI Passive database **must** have user-defined database items in order to export.

1. In WUFI Passive, navigate to `Database` and select `Export into XML-file` from the dropdown menu.
2. Select the databases to be exported.
3. Click `Save & Exit`. Name and save the file.
4. Open METr. Navigate to `Database` and select `Import WUFI DB Data (XML)`. Navigate to where the file was saved in Step 3 and click `Open`.

1.4.5.5 Dynamic Modeling in METr

Dynamic energy modeling is not currently supported in METr. METr uses a monthly energy balance methodology rather than hour-by-hour simulation.

1.4.6 Phius Energy Modeling Protocol for METr

Energy Model Defaults

The accepted software versions agree on default input values for several input parameters. Most pre-filled fields in METr 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 core calculations are now built directly into METr. However, external calculations methods and protocol documents are still used as new modeling situations arise. Where external Phius Excel-based tools are required, they are linked in their respective sections throughout this document and under Additional Calculators above. Any external calculator used to support modeling inputs must be uploaded to the Project Dropbox folder for review.

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

Using SketchUp with METr

In this version of the guidebook, METr supports geometry imports exclusively from SketchUp. For guidance, tips and best practices for using METr in tandem with SketchUp and for other general modeling guidance review the SketchUp to METr Guide.

METr SketchUp Plug-In

Visit the METr webpage on the C3RRO® website to download the free SketchUp Plugin for METr.

Process Tip: The SketchUp plugin will need to be added to the cart and 'purchased' for $0.

Note: This section follows the structure of the METr project tree. Sections highlighted in tan below should follow the exact same protocol as in WUFI Passive in Section 1.4.4 above.

Table 1.4.6.0 Modeling Protocol Table of Contents	
1.4.6.1 Shared Objects	Building Elements
	Utilization Patterns
1.4.6.2 Cases	Cases / Variants
1.4.6.3 Localization / Climate	Localization / Climate
	Weather Data
1.4.6.4 PH Cases	Certificate Criteria
	General
	Additional Data
	Source energy/CO2-Factor
	Target Data
1.4.6.5 Building	Orientation
	Geometry
	View
	Simulated Zones; Refer to Section 1.4.4.5
1.4.6.6 Zone 1	General
	Foundation Interface
1.4.6.7 Visualized Components	General; Refer to Section 1.4.4.6
	Assembly
	Surface
	View
1.4.6.8 Thermal Bridges	Refer to Section 1.4.4.7

Table 1.4.6.0 Modeling Protocol TOC (continued)	
1.4.6.9 Internal Loads	[R] Residential
	[NR] Non-Residential
	[UF] Unfinished
1.4.6.10 Ventilation / Rooms	[R] Residential
	[NR] Non-Residential
	[UF] Unfinished
1.4.6.11 Attached Zones	Refer to Section 1.4.4.14
1.4.6.12 Remaining Elements	Refer to Section 1.4.4.15
1.4.6.13 - 1.4.6.18 Systems	Systems Set-Up
	Mechanical Ventilation Systems; See Section 1.4.4.17
	Space Conditioning Systems; See Section 1.4.4.18
	Domestic Hot Water (DHW) Systems
	Renewable Energy Systems; Refer to Section 1.4.4.20
	Supportive Devices / Auxiliary Energy; Refer to Section 1.4.4.21

1.4.6.1 Shared Objects

The `Shared Objects` section serves as a centralized library for reusable buildings elements and utilization patterns used throughout the project.

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

Shared Objects > Building Elements Tab

This tab includes building elements such as materials, assemblies, windows, and shading devices.

Building Elements > Materials Tab

This contains all the materials available for use within the opaque assemblies. Materials can be created from scratch or selected from the material databases. Available databases include:

Process tip: Materials **not** used in assemblies should be deleted from the model for project review submissions.

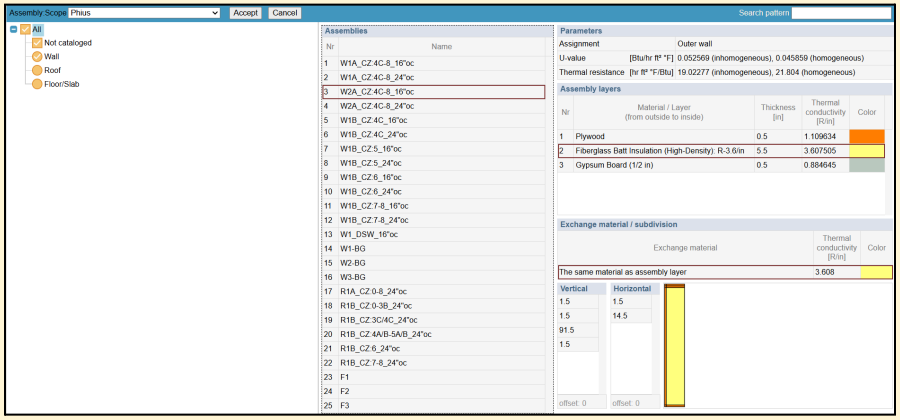
Building Elements > Assemblies Tab

All opaque assemblies used within the project are created, stored, and managed in the `Assemblies` tab. Assemblies can be created from scratch or selected from the assembly databases. Once created, assemblies can be assigned to opaque geometry components. Refer to Opaque Assemblies for modeling protocol.

The Phius assembly database contains pre-defined, Appendix B-compliant assemblies for walls, roofs, and floors that can serve as a starting point for assembly development.

Process tip: Pre-defined assemblies in MET follow a standardized naming convention to identify the assembly, climate zone applicability, and framing spacing. This convention allows users to quickly locate assemblies appropriate for their project.

Examples:
[Assembly Type][Assembly ID]_CZ:[Climate zone]_[Spacing]



Example A: *W2A_CZ:4C-8_16"oc*

- W2 = Wall Assembly - Type 2
- A = Assembly type according to Appendix B
- CZ:4C-8 = Climate Zone range (4C through 8)
- 16"oc = 16" On Center

Example B: *R1A_CZ:0-8_24" oc*

- R1 = Roof Assembly - Type 1
- A = Assembly type according to Appendix B
- CZ:0-8 = Climate Zone range (0 through 8)
- 24"oc = 24" On Center

Note: Predefined assembly names are intended to provide key assembly characteristics at a glance. Users should verify that the selected assembly type, climate zone designation, and framing spacing align with project-specific requirements before use.

- **`Assignment`**: Assemblies in METr must be assigned to a specific construction category (e.g., `Outer wall`, `Wall to Ground`, `Flat Roof`, etc). This input influences the interior and exterior surface films applied to the assembly.

  Process tip: Assembly assignments may be overridden by the `Type/Attachment` setting of the components to which the assembly is assigned. Keep assembly assignments aligned with their intended application for consistency.

Building Elements > Windows Tab

All transparent assemblies used within the project are created, stored, and managed in the `Windows` tab. Assemblies can be created from scratch or selected from the assembly databases. Once created, assemblies can be assigned to transparent geometry components. Refer to Transparent Assemblies for modeling protocol.

Process tip: The Phius Certified Window Database is built into METr allowing users to select the pre-defined assemblies rather than build them from scratch.

Building Elements > Shading Device Tab

All shading devices (i.e., interior and exterior blinds) used within the project are created, stored, and managed in the `Shading Device` tab. Shading devices can then be assigned to transparent geometry components throughout the model. Refer to Solar Protection for additional guidance.

- **`Solar Exposure for Shading Device`**: Input the solar transmittance (Ts) of the shading device.
- ☑ **`Derated Manually Operation`**: Check this box when using manufacturer data for the input above. When enabled, METr automatically calculates the effective shading factor using the deration method outlined in Appendix N-6 which accounts for occupant behavior.
- **`Position`**: Specify whether the shading device is located on the interior or exterior side of the window.

Process tip: For interior blinds, use 0.85 as a default for the `Solar Exposure for Shading Device` input. Do **not** check the box for `Derated Manually Operation` when using this default.

Building Elements > Window Overhang Tab

All overhangs used within the project are created, stored, and managed in the `Window Overhang` tab. Overhangs can then be assigned to transparent geometry components throughout the model. Refer to Solar Protection for modeling protocol.

Shared Objects > Utilization Patterns Tab

This tab is used to create and manage ventilation utilization patterns as well as utilization patterns for non-residential projects.

Utilization Patterns > Room Ventilation Tab

The `Room Ventilation` tab is used to create and manage room ventilation utilization patterns within METr. Refer to the following sections for modeling protocol according to the project type:

- **[R] Residential:** Section 1.4.4.9
- **[NR] Non-Residential:** Section 1.4.4.11
- **[UF] Unfinished:** Section 1.4.4.13

Utilization Patterns > Internal Loads Tab

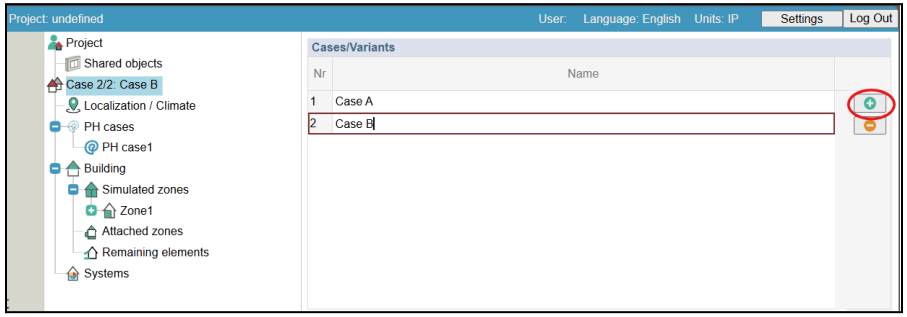
The `Internal Loads` tab is used to create and manage utilization patterns for internal loads and occupancy for non-residential projects **only**. Refer to the following sections for modeling protocol according to the project type:

- **[R] Residential:** Do not input anything on this tab.
- **[NR] Non-Residential:** Section 1.4.4.10
- **[UF] Unfinished:** Section 1.4.4.12

1.4.6.2 Cases

Case #/# > Cases / Variants Table

METr allows for quick creation of multiple `Cases` within a single project file. Refer to Section 1.4.4.1 for guidance on case management, comparisons, and mixed-use projects.



Process tip: Creating a new case in METr will duplicate the currently selected case and retain the original case name. Rename additional case(s) to easily distinguish them from each other.

1.4.6.3 Localization / Climate

Localization / Climate > Location Tab

Refer to Section 1.4.4.2 for general information about Phius' available climate datasets and criteria for selecting an appropriate location from the map outlined below.

- **`Selection`:** Set to `From Map (Database)` by default, which is appropriate for projects using one of Phius' standard climate data sets. For projects using custom climate data, refer to Uploading Custom Climate Data into METr below.

- **`Find and Select Climate Data Near Building`:** Click this button to open the map, then follow the steps below to find and select the climate data location:

    1. Locate the building on the map and **right-click** to specify the building location, which will be represented by a brown pin with a house icon. Alternatively, the latitude and longitude of the building site may be input.

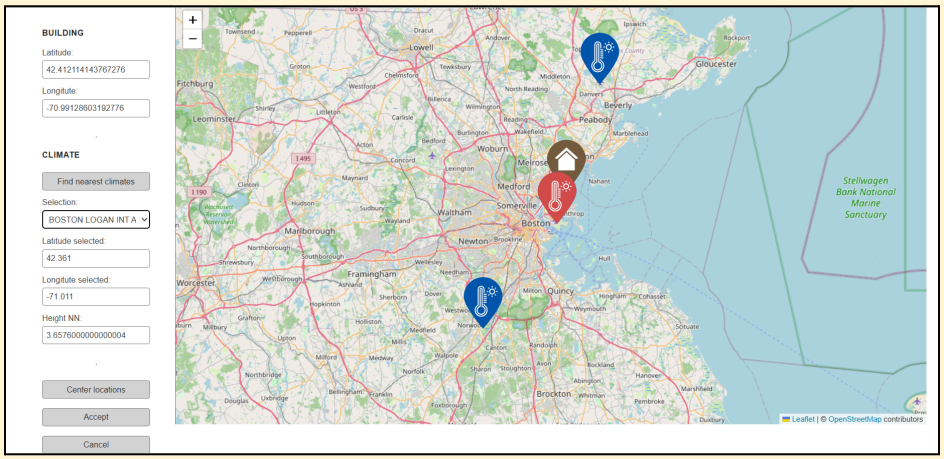
        Process tip: To navigate the map:
        - *Zoom in/out:* Scroll (wheel or touch pad) or use the [+]/[-] buttons in the top left corner of the map
        - *Pan:* Left click (or mouse wheel click) + drag

    2. Click `Find Nearest Climates`.
        - METr will display the nearest available climate datasets, represented by blue pins with a thermometer icon.

    3. Select the appropriate climate dataset and click `Accept` to import into METr.
        - The pin color will turn red when selected
        - Be sure to review the `Height NN` field, which is the weather station altitude, to verify that the data set falls within the limits established in Section 1.4.4.2.

    4. **Always** verify that the following `Building` data fields are accurate, which are auto-filled after the climate dataset is selected:
        - `Latitude` / `Longitude`
        - `Height NN` (building altitude)
        - `Time Zone`

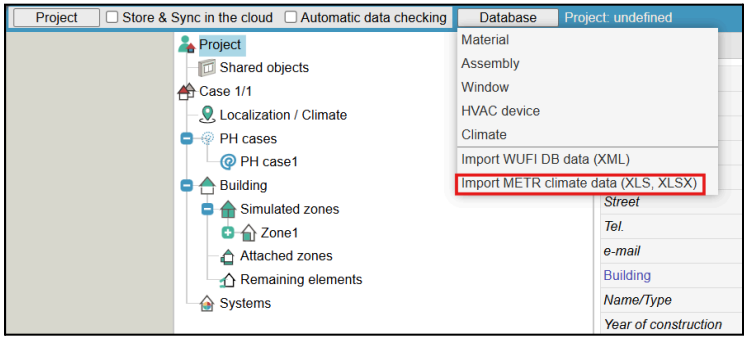
Example: `From Map (Database)` selection window



Uploading Custom Climate Data into METr

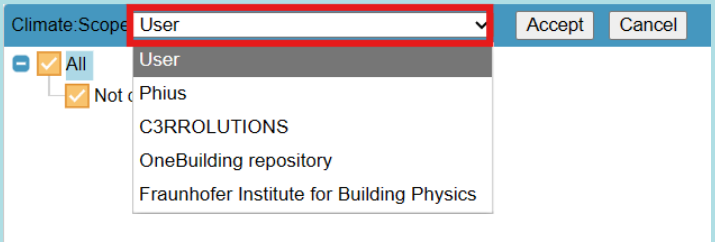
To import custom climate data into METr and use it in the model, follow the steps below:

1. Click `Database` in the blue ribbon at the top of the application.
2. From the dropdown menu, select `Import METR climate data (XLS, XLSX)`. A confirmation message will be displayed when the climate dataset has been successfully imported.
    - Supported file formats include Legacy Excel format (*.xls*) and Current Excel format (*.xlsx*)



3. Navigate to `Localization / Climate` > `Location` tab.
    - **`Selection`:** Set to `User-defined`
    - Click `Get from Database`
    - Select the climate dataset imported in Step 2

> **Process Tip:** Climate datasets are imported to the `User` database. Make sure the `Scope` is set accordingly.



4. Complete the following inputs:
    - `Building` data:
        - `Latitude` / `Longitude`
        - `Height NN` (building altitude)
        - `Time Zone`
    - `Climate Station` data:
        - `Time Zone`
    - `Additional Data`:
        - `Climate Zone`
        - `Heating Degree-Days, Base 65°F`
        - `Cooling Degree-Days, base 50°F`
        - `Electricity price, marginal, state average`

> **Process Tip:** Phius will provide these values along with the custom climate dataset.

Localization / Climate > Weather Data Tab

This tab is automatically populated upon selection or import of climate data. See Localization / Climate > Climate Tab.

1.4.6.4 PH Cases

☑ **`Use detailed 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 Mean Month Shading` button will appear (in the `Status` window directly to the left of where the results will populate), prompting the shading calculation to be re-run.

PH Cases > Certificate Criteria

METr includes the following options:

- Phius CORE 2021
- Phius CORE 2024
- Phius ZERO 2021
- Phius ZERO 2024

The selected `Certificate Criteria` influences the following:

- Automatic calculation of the Performance Criteria Targets
- Source energy / CO_2 factors
- Default performance data for appliances. Refer to Section 1.4.4.8.
- WaterSense DHW pipe volume limits

PH Case 1 > General Tab

Refer to PH Case > General Tab for modeling protocol.

> **Exception:** Unfinished (UF) projects do **not** need to set the `Certificate Criteria` to `PHIUS+ 2018` in order to set the `Occupancy Type` to `Undefined/Unfinished`.

PH Case 1 > Additional Data Tab

Refer to PH Case > Additional Data Tab for modeling protocol.

> **Exception:** Projects with ventilators outside of the thermal and airtight envelope (**not** in conditioned or semi-conditioned spaces) may set the `Mechanical Room Temperature` to `Calculated` which will automatically populate a value based on the selected climate dataset.

PH Case 1 > Source Energy / CO_2-Factor Tab

Refer to Localization / Climate > Source Energy / CO2 Factors Tab for general information.

- **`Selection`**: Select `Standard According to Location/Country`

  > **Exception:** For projects located outside the United States and Canada, and Japan the selection should be set to `User Defined`.

PH Case 1 > Target Data Tab

The Performance Criteria Targets are automatically calculated based on the selected `Certificate Criteria`. Review Section 1.4.2.6 for information about which factors influence this calculation. The geometry and inputs in the model must be accurate in order for the targets to be accurate.

- **`Space Conditioning Target Data`:** For all projects, set to `Calculate from Climate Data`

  > **Temporary Exception:** While software functionality is in development, projects with Custom Climate Data should choose `User Defined` and input the targets according to the Google Sheets-based calculator received along with the custom climate dataset.

1.4.6.5 Building

Building > Orientation Tab

The orientation of the building 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).

Building > Geometry Tab

When importing geometry into METr the following importing parameters should be defined prior to importing.

- **`Dimensions, Visualized Geometry`:** Do not change from the default selection `Outer, Extern Partitions Included`.

  Process Tip: Do not use the `Inner, Outer Partitions Not Included` option.

Import Options

Refer to the SketchUp to METr Guide for guidance on using the C3RRO® SketchUp Plug-in for METr and importing geometry.

- **`Import From`:**
  - SketchUp (recommended): Selected by default.
  - `Building Wizard`: Refer to Building Wizard

☑ **`Merge Imported with Existing Data`**: Check this box when importing geometry to retain existing data/assembly assignments in the model.

☑ **`Set Zone Volume/Floor Area calculated from Geometry`**: Selected by default. Allows METr to estimate building volume based on imported geometry.

Building > View Tab

METr has the ability to center the geometry automatically, eliminating the need for centering circles to be modeled in the 3D geometry. Centering the model improves navigation within the geometry window. Set the `Center Point` according to the guidance below:

- **`Gravity Of:`**
  - `Simulated Zones` (Recommended): Centers the model relative to the geometry components in the `Simulated Zones` (`Zone 1`).
  - `All zones`: Centers the model relative to the geometry components in both `Zone 1` and the `Attached Zones`.
  - `All components/Vertices`: Centers the model relative to **all** geometry components, including `Remaining Elements` (i.e., shading geometry).
- **`Move` (`S-N`, `E-W`, `Up/Down`):** Relocates the center point manually by entering the desired distance along each axis.
- **`Rerender 3D View`:** Click to apply new center point settings.

Building > Simulated Zones

Single-Zone modeling is required for Phius Certification. Refer to Section 1.4.4.5 for additional guidance.

1.4.6.6 Zone 1

Zone 1 > General Tab

Refer to Section 1.4.4.5 for modeling protocol.

Zone 1 > Foundation Interface Tab

The `Setting` for each foundation interface modeled should be set to `User Defined` for most projects. Refer to PH Case > Foundation Interface Tab for modeling protocol.

Exception: Projects with a slab on grade as the only foundation type and very simple geometry may use `Detect Automatically`. The calculated values should be reviewed for accuracy.

Process tip: The `Related to Zone` selection under `Parameters` should be set to `Not Related to Zone` until further testing is conducted on the functionality of this setting.

1.4.6.7 Visualized Components

Visualized Components > General Tab

See Section 1.4.4.6 for guidance on `Name` / `Type` / `Attachment` settings for geometry components.

Visualized Components > Assembly Tab

- **`Selection` > `Assembly`:** Select the appropriate assembly created in Shared Objects for each component.

Visualized Components > Surface Tab

Default values for radiation balance and solar absorption/emission are applied for all components according to the component type in METr. No user inputs are needed in this section unless white finish materials are used specifically to reflect radiation heat gains.

Visualized Components > View

- ☐ **`Not Visible/Selectable in 3D View`:** Checking this box hides the selected component and renders it unselectable within the 3D geometry window.
- **`Make all components visible/selectable`:** This button is only clickable if components are hidden using the checkbox above. It will unhide all hidden components.

1.4.6.8 Thermal Bridges

Refer to Section 1.4.4.7 for modeling protocol.

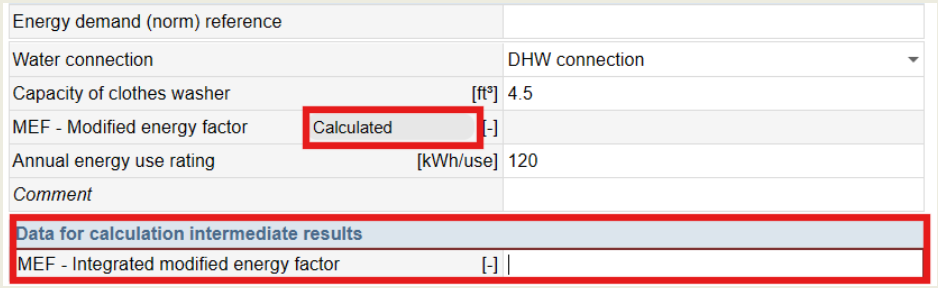
1.4.6.9 Internal Loads

[R] Residential - Internal Loads

Refer to Section 1.4.4.8 for modeling protocol.

Process tip: The median Energy Star appliance data (Tables 1.4.4.8.0 - 1.4.4.8.5) is automatically populated and aligns with the acceptable values for each certification standard year, defined by the Certification Criteria setting.

Exception: For clothes washers with IMEF data, instead of completing a manual calculation, revise the dropdown in the `MEF - Modified Energy Factor` line to `Calculated` and input the IMEF in the corresponding field that appears below:



Energy demand (norm) reference			
Water connection			DHW connection
Capacity of clothes washer		[ft³]	4.5
MEF - Modified energy factor	Calculated	[-]	
Annual energy use rating		[kWh/use]	120
Comment			
Data for calculation intermediate results			
MEF - Integrated modified energy factor		[-]	

[NR] Non-Residential - Internal Loads

Refer to Section 1.4.4.10 for modeling protocol.

Exception: Utilization patterns are defined under Shared Objects.

[UF] Unfinished - Internal Loads

Refer to Section 1.4.4.12 for modeling protocol.

Exception: Utilization patterns are defined under Shared Objects.

1.4.6.10 Ventilation / Rooms

[R] Residential - Ventilation / Rooms

Refer to Section 1.4.4.9 for modeling protocol.

Exception: Utilization patterns are defined under Shared Objects.

[NR] Non-Residential - Ventilation / Rooms

Refer to Section 1.4.4.11 for modeling protocol.

Exception: Utilization patterns are defined under Shared Objects.

[UF] Unfinished - Ventilation / Rooms

Refer to Section 1.4.4.13 for modeling protocol.

Exception: Utilization patterns are defined under Shared Objects.

1.4.6.11 Attached Zones

Refer to Section 1.4.4.14 for modeling protocol.

1.4.6.12 Remaining Elements

Refer to Section 1.4.4.15 for modeling protocol.

1.4.6.13 Systems Set-Up

In METr, one system will consist of a set of devices. Only one system is needed per building.

Process tip: METr supports modeled cooling system capacities >682 kBtu/sf.yr (~56 tons of cooling), unlike the threshold previously set in WUFI Passive.

Within the `Systems` branch, click the `[+]` button to add a system to the energy model.

Process tip: The `System Type` should not be changed from the default selection `User Defined (ideal system)`.

The table of contents to the right outlines the structure of the remaining modeling protocol sections, which provide guidance on completing the inputs for mechanical systems.

Note: 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.

Table 1.4.6.13.0 Systems Table of Contents

1.4.6.13 Systems Set-Up	System 1 (User Defined): General Tab
	System 1 (User Defined): Distribution Tab
1.4.6.14 Mechanical Ventilation Systems	Mechanical Ventilation Devices
	Mechanical Ventilation Ducts
1.4.6.15 Space Conditioning (Heating/Cooling) Systems	Heat Pumps: Heating
	Heat Pumps: Cooling
	Electric Resistance heaters
	Boiler or Furnace (Space Heating)
	Wood or Pellet Stove
	Hydronic Heating
1.4.6.16 Domestic Hot Water (DHW) Systems	Heat Pump Water Heaters: (Inside/Outside)
	Tankless Water Heaters
	Tanked Water Heaters (except heat pumps)
	Hot Water Storage
	Swing Tanks
	Solar Collector
	Drain Water Heat Recovery
	Hot Water Piping
1.4.6.17 Renewable Energy Systems	On-Site Renewable Energy
	Off-Site Renewable Energy
1.4.6.18 Supportive Devices / Auxiliary Energy	DHW Circulating Pumps
	Other (Misc.) Equipment

System 1: (User defined) > General Tab

Once a system is created, navigate to:

- `Systems`
  - `System 1 (User defined)`
    - `General` (tab)

On the `General` tab, add devices to the `Device/Usage/Coverage Within the System` table for the following systems:

- Heating / Cooling
- Domestic hot water (DHW)
  - Water Heater
  - Storage Tanks (if applicable)
- Mechanical Ventilation
- Photovoltaics / Renewable energy

Exception: For Unfinished (UF) spaces, the **only** device that should be included in the model is the mechanical ventilation device (E/HRV). This is the only device that impacts the space conditioning results.

The following inputs are required on the `General` tab for each device:

- **`Type`**: Select from the dropdown menu. See system-specific sections below for appropriate `Type` selections for each piece of equipment.
- **`Usage/Coverage`**: Define what each device is used for and assign coverage by entering values (between 0-1) in the column corresponding to each usage category. The total coverage in each column must sum to 1.

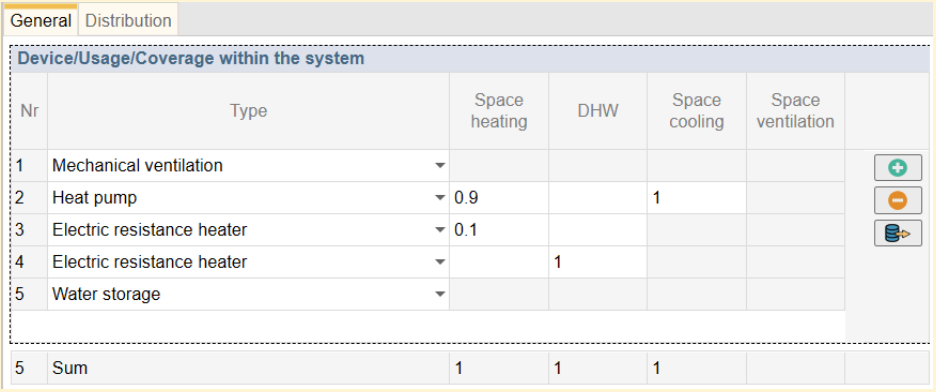
Exception: Assigning coverage is **not** necessary for the following device types:

- `Mechanical Ventilation`
- `Photovoltaic / Renewable Energy`
- `Drain Water Heat Recovery`

Example: A project team is using the following system in their project:

- Mechanical Ventilation: ERV
- Primary Space Conditioning: Mini-split heat pump
- Supplemental Space Conditioning: Electric unit heaters
- Domestic Hot Water: Electric resistance water heater (with tank)

The `DeviceUsage/Coverage Within the System` is set up as follows:


General | Distribution

Device/Usage/Coverage within the system

Nr	Type	Space heating	DHW	Space cooling	Space ventilation
1	Mechanical ventilation				
2	Heat pump	0.9		1	
3	Electric resistance heater	0.1			
4	Electric resistance heater		1		
5	Water storage				
5	Sum	1	1	1	

System 1: (User defined) > Distribution Tab

Unlike in WUFI Passive, the `Distribution` tab sub-sections are always present and do not require devices to be added on the General tab to appear. Refer to the following sections for modeling guidance:

Distribution > Hydronic Heating

Refer to Hydronic Heating for modeling protocol.

Distribution > DHW

Refer to the Phius DHW Piping Protocol document for guidance on modeling hot water piping. This document covers the modeling protocol for the `General` and `Hot Water Piping` tabs. These tabs can be found by navigating to:

- `Systems`
  - `System 1: (User Defined)`
    - `Distribution` (tab)
      - `DHW` (tab)

Process tip: Do not leave cells blank. Input '0' as the length for unused trunks, branches, or twigs so METr can correctly calculate the heat capacity, volume and check compliance with WaterSense requirements.

Distribution > Cooling

Refer to Heat Pumps: Cooling for modeling protocol.

Distribution > Ventilation

Refer to Mechanical Ventilation Ducts for modeling protocol.

Distribution > Supportive Device / Auxiliary Energy

Refer to Section 1.4.4.21 for modeling protocol.

1.4.6.14 Mechanical Ventilation Systems

Refer to Section 1.4.4.17 for protocol on setting up the `System 1: (User Defined)` > `General` tab.

Mechanical Ventilation Device

Refer to Mechanical Ventilation Device for modeling protocol.

Exception: METr supports modeling ventilation devices both inside and outside of the thermal envelope. The Exception box in the WUFI Passive protocol under `HRV/ERV in Conditioned Space` does **not** apply to METr projects.

Mechanical Ventilation Ducts

Refer to Mechanical Ventilation Ducts for modeling protocol.

1.4.6.15 Space Conditioning (Heating/Cooling) Systems

Refer to Section 1.4.4.18 for protocol on setting up the `System 1: (User Defined)` > `General` tab.

Exception: Coverage inputs for cooling systems do not apply to METr projects.

Heat Pumps: Heating

Refer to Heat Pumps: Heating for modeling protocol.

Heat Pumps: Cooling

Refer to Heat Pumps: Cooling for modeling protocol.

Exception: To input the Energy Factor (L/kWh) for stand-alone dehumidifiers, change the dropdown in-line with `Dehumidification COP` to `Calculated` and input value in the field that appears below:

Dehumidification COP	Calculated	[-]	
Panel cooling COP		[-]	
Data for calculation intermediate results			
Dehumidification		[Liter/kWh]	

Electric Resistance Heaters

Refer to Electric Resistance Heaters for modeling protocol.

Boiler or Furnace (Space Heating)

Refer to Boiler or Furnace (Space Heating) for modeling protocol.

Wood or Pellet Stove

Refer to Wood or Pellet Stove for modeling protocol.

Hydronic Heating

Refer to Hydronic Heating for modeling protocol.

Exception: To input values to auto-calculate `Heat Loss Coefficient per ft Pipe`, change the dropdown in-line to `Calculated`, then input values in the fields that appear below:

Heat loss coef. per unit length	Calculated	[Btu/hr ft °F]			
Temperature of the room the pipes pass through		[°F]	68	32	32
Design system heating load		[kBtu/hr]			
Flow temperature controlled			☐	☐	☐
Data for calculation intermediate results					
Nominal diameter		[in]			
Insulation thickness		[in]			
Thermal conductivity		[R/in]			
Is reflective			☐	☐	☐

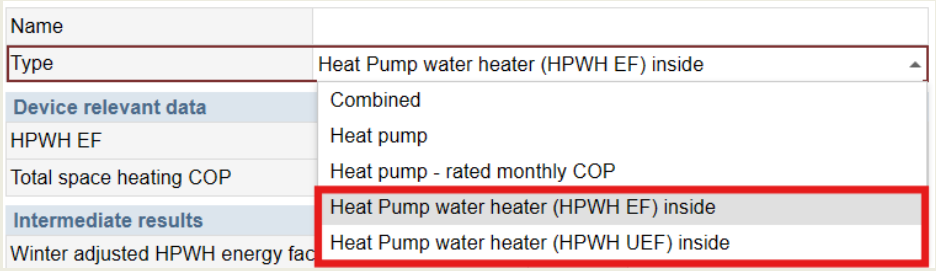
1.4.6.16 Domestic Hot Water (DHW) Systems

Refer to Section 1.4.4.19 for protocol on setting up the `System 1: (User Defined)` > `General` tab.

Heat Pump Water Heaters: Inside

Refer to Heat Pump Water Heaters: Inside section above for completing inputs.

Exceptions: METr allows for either Energy Factor (EF) or Uniform Energy Factor (UEF) inputs, eliminating the need for manual conversion calculations. Select the heat pump `Type` according to the type of data available:



The `Annual Heating Coefficient of Performance (COP)` and `Total System Performance Ratio of Heat Generator` fields have changed. METr is capable of automatically calculating the average COP of the space heating system. To do so, set the dropdown in-line with `Total Space Heating COP` to `Calculated`:



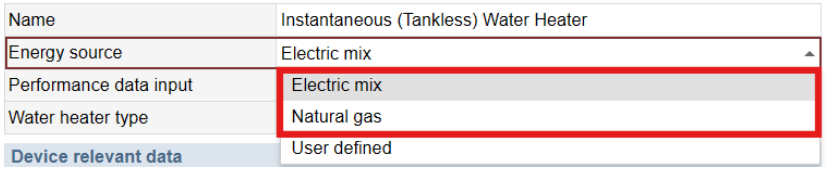
Heat Pump Water Heaters: Outside

Refer to Heat Pump Water Heaters: Outside for modeling protocol.

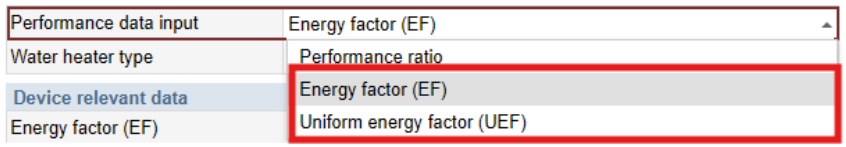
Tankless Water Heaters

Click into the `Device #: (User Defined)` sub-branch. Then, complete the inputs as follows:

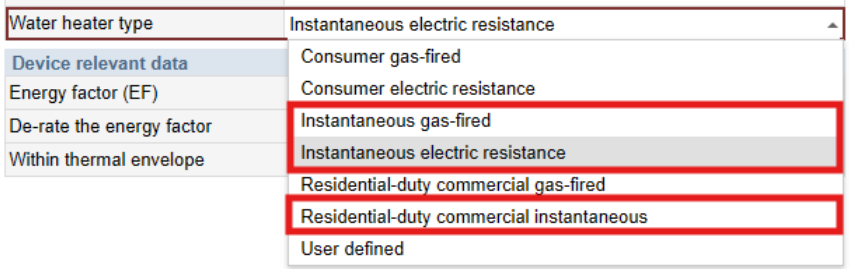
- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer and model number.
- **`Energy Source`:** Select according to fuel type



- **`Performance Data Input`:** Select according to the type of performance data (EF or UEF)



- **`Water Heater Type`:** Select from the available options



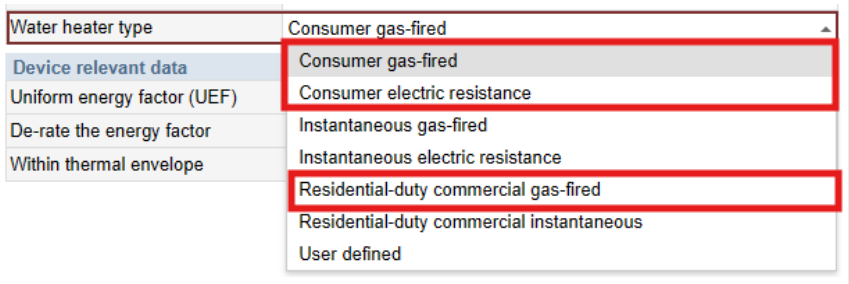
- **`Device Relevant Data`:** Complete the inputs as follows
  - **`Energy Factor (EF)`** or **`Uniform Energy Factor (UEF)`:** Input value according to datasheet.
  - ☐ **`De-rate the Energy Factor`:** Optional. Review Process Tip in Section 1.4.4.19.
  - ☐ **`Within Thermal Envelope`**: Check this box for devices within the thermal envelope.

Tanked Water Heaters (except heat pumps)

If a tanked water heater is used for water heating, the modeling method depends on the fuel type and performance data available. Review the appropriate `Type` settings at the beginning of Section 1.4.4.19, then complete the inputs for each device as follows:

- **`Name`:** Give the device a clear, descriptive name that indicates the device tag, manufacturer, and/or model number.
- **For devices *with* EF or UEF performance data:** Follow the instructions for Tankless Water Heaters

  Exception: The `Water Heater Type` should be either:
  - `Consumer Gas-Fired`
  - `Consumer Electric Resistance`
  - `Residential-duty Commercial Gas-Fired`



- **For devices *without* EF or UEF performance data:**
  - **Electric resistance water heater:** No efficiency inputs are required for the `Electric Resistance Space Heat / DHW` device type.
  - **Natural gas (`User Defined`) water heater:** Follow the modeling protocol for a Boiler or Furnace**.**
  - **All systems:** Complete `Water Storage` device inputs.

Hot Water Storage

Refer to Hot Water Storage for modeling protocol.

Swing Tanks

Refer to Swing Tanks for modeling protocol.

Solar Collector

Refer to Solar Collector for modeling protocol.

Drain Water Heat Recovery

Refer to Drain Water Heat Recovery for modeling protocol.

Hot Water Piping

Refer to Hot Water Piping for modeling protocol.

1.4.6.17 Renewable Energy Systems

Refer to Section 1.4.4.20 for protocol on setting up the `System 1: (User Defined)` > `General` tab.

On-Site Renewable Energy Systems

Refer to On-Site Renewable Energy Systems for modeling protocol.

Off-Site Renewable Energy Systems

Refer to Off-Site Renewable Energy Systems for modeling protocol.

1.4.6.18 Supportive Devices / Auxiliary Energy

Refer to Section 1.4.4.21 for modeling protocol.

DHW Circulating Pumps

Refer to DHW Circulating Pumps for modeling protocol.

Other (Misc.) Equipment

Refer to Other (Misc.) Equipment for modeling protocol.

1.5 On-Site Review

This section is generally written for Raters and Verifiers to review and understand the 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.

Table 1.5.0 Performance Path: On-Site Review	
Required Documentation	Refer to Section 1.5.1 for the documentation needed for the 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.

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 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			
DOE Energy Star	DOE 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 Efficient New Homes	DOE Efficient New Homes certificate	Phius Annotated: DOE Efficient New Homes Multifamily National Rater Checklist	
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 Efficient New Homes 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	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 systems)	

1.5.2 Performance Path: QA/QC Requirements

It is imperative to the 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

		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		
	Building Envelope	Compartmentalization	Duplexes & Townhouses must meet 0.3 cfm50/sf	Multifamily and residential portions of Mixed-Use projects projects must meet 0.3 cfm50/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		
	Appliances & Electrical	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		
	Renewables & Electrification	Electric Vehicle	Electric Vehicle Readiness and Capability		

1.5.2.1 Key Documents

Phius Quality Control Field Checklist

New to the Phius 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 the Phius Quality Assurance webpage to download the most recent documents.

The Phius Quality Control Field Checklist should be taken on site by the Phius Rater or Verifier and uploaded to Dropbox once complete. It can be downloaded on mobile devices, such as phones or tablets, and the boxes can be checked with various PDF viewing platforms, internet access should not be required. It has also been formatted appropriately to be printed out for a paper version to be taken on-site.

Process Tip: If a paper copy is taken on site, the Phius Rater or Verifier should either (a) upload a scanned version to Dropbox, or (b) replicate the checked items and notes in a digital version to be uploaded to Dropbox.

[C] 1 - Building Envelope

[C] 1.0.1 Insulated Assemblies

Photos of all insulated assemblies (footings, foundation walls, slabs, framed floors, above grade walls, and ceilings/attics) should be captured and uploaded to the project's Dropbox folder in their respective folders. These photos should include measured insulation thickness, material type, and installation quality.

Process Tip: In the 'Notes' line item at the bottom of this section, the rater/verifier should make a note about any assemblies where a photo could not be captured. Visual confirmation, or confirmation with the builders on-site, should be provided in lieu of the photo documentation.

[C] 1.0.2 Windows & Doors

Take a photo of the NFRC label, if available. Include photos that show window installed, U-value, and SHGC, and upload to the project's Dropbox folder in the respective folder(s).

Process Tip: Note that providing as-built shop drawings and/or a purchase order is preferred to NFRC stickers. These documents allow for a more comprehensive verification of all windows and doors that were installed.

[C] 1.0.3 Infrared Photos

Perform a thorough IR scan of the building thermal envelope and provide representative photos, including but not limited to: areas of walls, corners, window frames, suspended floors, overhangs, and roofs. Include photos that indicate any thermal bridges.

[C] 1.0.4 General Exterior

Take exterior photos of each elevation and significant architectural features including window placement, balconies, overhangs and shading devices. Take photos of the areas surrounding, and adjacent to the building. Include photos that show any nearby structures, natural features or vegetation that can cause shading on the building.

[C] 1.1.1 Architectural Features, Insulation, and Thermal Bridging

The Phius Rater/Verifier is responsible for verifying the information below and uploading supporting documentation as needed:

- Provide as-built drawings and describe any significant variations in construction from the drawings and specifications (insulation type/thickness, window sizes, window performance, fixed shading etc.)
- Ensure that framing matches architectural plans (depth & spacing, e.g., 2x6 16” O.C.)
- If operable shading has been installed, describe operable shading in the notes section
- Ensure that all insulation R-values match those listed on architectural plans. If not, please describe in notes section below.
- Ensure that all insulated assemblies have achieved a RESNET Grade I cavity insulation level, or alternatively Grade II with continuous insulation.
- Confirm the material of fasteners used to install exterior insulation (aluminum, mild steel, stainless steel, plastic, etc.)
- Note any thermal bridges in the assembly observed on the project and strategies used for mitigation. Describe and provide photo documentation where such details are missed.

[C] 1.1.2 Whole Building Airtightness Testing

Mid-construction airtightness testing is recommended, but not required, for performance path projects. Raters/Verifiers should conduct multi-point blower door tests for depressurization and pressurization, following building set-up per Phius Certification Guidebook & ANSI/RESNET/ICC Std 380-2022.

Process Tip: For multifamily buildings, it is recommended to provide Phius with a whole building blower door testing plan.

[C] 2 - Ventilation

[C] 2.0.1 Site Photos of Ventilation Systems

Take photos of each installed ventilation system and auxiliary ventilation system defrost equipment (electric, hot water loop from DHW tank, and ground loop) and nameplate (manufacturer, model number).

Process Tip: Include photos that show context of where the systems are installed i.e., rooftop, mechanical room, etc.

The Phius Rater/Verifier is responsible for verifying the information below and uploading supporting documentation as needed:

[C] 2.1.1 General

- Confirm that ventilation air inlets for projects in Climate Zones 4-8 are installed ≥ 4' above grade and/or roof deck
- Confirm that ventilation air comes directly from outdoors, not from adjacent dwelling units, common spaces, garages, crawlspaces, or attics.
- Confirm that outside supply air passes through a minimum MERV 8 filter prior to distribution.

  Process Tip: Alternate filtration ratings that demonstrate equivalency to the MERV 8 rating may be accepted at Phius' discretion (e.g., Class G4 per EN 779).

- Confirm that the filter is located to facilitate regular service by the occupant and/or building superintendent.
- Confirm that a class 1 vapor retarder is installed over all air-permeable insulation (such as fiberglass duct wrap) on ventilation ducts connected to outside.
  - Confirm that the vapor retarder is continuous and sealed to the building air barrier and ventilation unit with no gaps, breaks or holes.

[C] 2.1.2 Kitchens

- Confirm that the ERV/HRV exhaust register is installed ≥ 6' from the nearest edge of the cooktop. ("stretched-string distance")
- Designate whether a MERV 3+ filter or a washable mesh filter (for trapping grease) was installed.
- Confirm whether a recirculating or direct exhaust rangehood was installed.
- Confirm that the measured kitchen direct exhaust rates meet Energy Star, Indoor AirPlus, and Efficient New Homes minimum requirements.

[C] 2.1.3 Bedrooms

- Confirm whether dedicated outdoor air supply ventilation ductwork is installed to all bedrooms or outdoor air supply ventilation ductwork integrated with heating/cooling ductwork and is connected directly to the return plenum of the air handler. See Integrated Heating/Cooling & Ventilation System Testing.
- Confirm that bedrooms are pressure balanced to achieve a Rater/Verifier measured pressure difference of +/- 1 Pa with respect to the main body of the dwelling unit when all

bedroom doors are closed and only the ventilation system is operating at design speed.

[C] 2.1.4 Bathrooms

- Confirm that measured bathroom exhaust rates meet either ≥20cfm continuous, or ≥50cfm intermittent.

[C] 2.1.5 Ventilation Auxiliary Systems

- Where applicable, enter the type of ERV/HRV defrost - electric, hot water loop from DHW tank, ground loop into the Ventilation tab of the Workbook.
- Demonstrate that the defrost control logic is set up properly.

[C] 2.1.6 Ventilation System Airflow Testing

ERV/HRV Ventilation System Airflow Testing

- Conduct ventilation system airflow testing, enter data into the Ventilation tab of the QA Workbook, and provide testing reports into the project folder.

Auxiliary Exhaust Ventilation System Airflow Testing

- Conduct ventilation system airflow testing, enter data into the Ventilation tab of the QA Workbook, and provide testing reports into the project folder.
- If a direct exhaust kitchen range hood is installed, enter the measured median exhaust airflow into the Appliances & Electrical tab of the QA Workbook.

Integrated Heating/Cooling & Ventilation System Testing

If the ventilation ductwork is integrated with the heating/cooling ductwork, ensure that:

1) The ERV/HRV remains in balance under all fan speeds of the heating/cooling air handler.
2) The air handler fan is designed to run continuously by default.
3) The sum of the air handler fan power and ventilation fan power meets DOE ENH efficacy requirements.

[C] 3 - Heating & Cooling

[C] 3.0.1 Site Photos of Heating & Cooling Systems

Take photos of each installed system that clearly shows the nameplate (including manufacturer and model number). If the system is a heat pump, take a photo of the outdoor component of the system. Only one photo is required per model number.

[C] 3.1.1 Combustion Equipment

- If combustion equipment for space heating is included in the project, provide a dedicated branch circuit, in compliance with DOE ZERH v2 NPR Exhibit 1, Item 11. The branch circuit shall be labeled “For Future Heat Pump Space Conditioning.”
- Confirm that combustion furnaces, boilers and/or water heaters located within the buildings' pressure boundary are sealed combustion, direct-vent appliances.
- Confirm that natural draft fireplaces are not installed in the project.
- Confirm that installed woodstoves have a combustion air inlet connected to the firebox.

[C] 3.1.2 Controls

Heating/Cooling System Fan

- Confirm that air flow is produced when the thermostat is set to "fan on"
- Confirm that heated air flow is produced when the thermostat is set to "Heat"
- Confirm that cooling air flow is produced when the thermostat is set to "Cool"

[C] 3.1.3 Condensation Management

- Confirm that the condensate drain provided for the cooling system evaporator coil or a condensate drain is located within 3 feet.
- Confirm that the corrosion-resistant drain pan is properly sloped to the drainage system and is included with each HVAC component that produces condensate.

[C] 3.1.4 Distribution System Layout

- Confirm that the duct installation reasonably matches the design layout.

[C] 3.1.5 Heating/Cooling Distribution System Testing

Ducted Heating/Cooling Distribution System Testing

- Confirm that Section 4: Air Balancing of Supply Registers & Return Grilles of the HVAC Functional Checklist is uploaded to the project’s Dropbox folder.
- Confirm that a testing and balancing (TAB) report is uploaded to the project’s Dropbox folder for multifamily and non-residential projects.

Hydronic Heating/Cooling Distribution System Testing

- Collect documentation of the testing of the hydronic heating/cooling distribution system.
- Confirm that a testing and balancing (TAB) report is uploaded to the project’s Dropbox folder for multifamily and non-residential projects.

[C] 4 - Domestic Hot Water

The Domestic Hot Water Section ensures that all site photos and field verification items have been documented and uploaded.

[C] 4.0.1 Site Photos of Domestic Hot Water System

Take photos of each installed domestic hot water system (domestic hot water heaters, recirculation pumps and controls, storage tanks, etc.) that clearly show the nameplate (including the manufacturer and model number).

Process Tip: Include photos that show context of where the systems are installed i.e., mechanical room, mechanical closets, etc.

[C] 4.1.1 Domestic Hot Water System

- Confirm that the pipe installation and insulation reasonably matches the design layout.
- Confirm that any on-demand DHW recirculation system was installed per the Phius Annotated: DOE Efficient New Homes Multifamily National Rater Checklist.
- Confirm that any domestic hot water systems located outside of dwelling units complies with Appendix E.

[C] 5 – Appliances & Electrical Loads

The Appliances & Electrical Loads Section ensures that all site photos and field verification items have been documented and uploaded.

[C] 5.0.1 Site Photos of Appliances

- Take photos of each installed appliance (refrigerators, dishwashers, clothes washers and dryers, etc.) that clearly show the nameplate (including the manufacturer and model number).

  Process Tip: Include photos that show context of where the appliances are installed i.e., dwelling units vs common areas.

- Upload Energy Star datasheets for each appliance installed.

  Process Tip: If Energy Star datasheets are not available, upload a manufacturer datasheet that includes data inputs laid out in the QA Workbook. If manufacturer datasheets don't include the necessary data, use the values laid out in Appendix I-3.15 Non-Rated Appliances.

[C] 5.1.1 Combustion Appliances & Equipment

Combustion Clothes Dryer

- Confirm that a dedicated 240-volt branch circuit with a minimum capacity of 30A shall terminate within 6' of natural gas clothes dryers and shall be accessible with no obstructions.
- Confirm that both ends of the branch circuit are labeled with the words "For Future Electric Clothes Drying" and are electrically isolated.

Combustion Cooking

- Confirm that a dedicated 240-Volt, 40A branch circuit is terminated within 6’ of natural gas ranges, cooktops and ovens and is accessible with no obstructions.
- Confirm that both ends of the branch circuit shall be labeled with the words “For Future Electric Range" and are electrically isolated.

Other Combustion Equipment

- Confirm that all other combustion equipment is provided with a branch circuit sized for an electric appliance, equipment or end use with an equivalent capacity that terminates within 6’ of the appliance or equipment.

[C] 5.1.2 All Other Appliances & Electrical Equipment

Appliances

- Record Manufacturer and Model Number in the Appliances & Electrical tab of the QA Workbook.

Direct Exhaust Range Hood

- Measure the exhaust cfm and record this value in the Ventilation tab of the QA Workbook.

Electrical

- Record any other significant energy use loads in the Appliances & Electrical Loads tab of the QA Workbook.

[C] 5.1.3 Lighting

- Confirm that all installed lighting matches the designed lighting plan, or confirm if there are variations.

[C] 6 – Renewables & Electricification

The Renewables & Electricification Section ensures that all site photos and field verification items have been documented and uploaded.

[C] 6.0.1 Site Photos of Appliances

- Take photos of all solar PV installed (inverters and panels) and upload to the project’s Dropbox folder.
- Take photos confirming electric vehicle readiness, including the electric service panel that identifies the branch circuit as “Electric Vehicle Charging.”
- Take photos of electric vehicle supply equipment (EVSE) including the EV charger(s) and charging station(s).

[C] 6.1.1 Renewable Energy Systems

Solar Thermal System

- Confirm that the installed solar thermal system corresponds with shop drawings or purchase order.
- Document appropriate information in the Renewables & Electrification tab of the QA Workbook.

Solar Photovoltaic System

- Confirm that the installed solar PV system corresponds with shop drawings or purchase order.
- Document appropriate information in the Renewables & Electrification tab of the QA Workbook.

[C] 6.1.2 Electric Vehicle (EV) Charging Infrastructure

- Where parking spaces are provided, confirm that installed electric vehicle infrastructure corresponds with shop drawings and achieves the requirements listed in Section 1.3.4.4.

- For non-residential projects and non-residential parts of mixed-use projects, document EV Charging Infrastructure in the Renewables & Electrification tab of the QA Workbook.

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 either the WUFI Passive or METr model. For more information on who should make as-built changes to this model, refer to Section 1.1.6.

On-Site Photos

Refer to the Phius Quality Control Field Checklist for a non-exhaustive list of required photo documentation.

Process Tip: Use the Phius Quality Control Site Photos DON'Ts and DO's Guide as a visual guide for Phius Certified Raters and Verifiers on how to take clear and effective site photos.

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.

Process Tip:

- For projects with multiple buildings, create a Workbook for **each building** in the project

- For projects with multiple non-residential buildings, or comprised of a combination of non-residential and residential portions, complete a Phius QA Non-Residential Workbook for each non-residential building or portion of the project
    - Complete a Phius QA MF Workbook for each residential building or residential portion of the project

Phius Single-Family Quality Assurance Workbook

"Single-family" refers to single-family detached homes. Detached Dwellings (e.g., single family homes and duplexes) and Townhouses 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.

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.

Process Tip: The Phius Certified Rater or Verifier is responsible for verifying all items input into the QA Workbook. Any additional content needed for clarification of the building and its construction shall be added to Rater Notes sections in the QA Workbook.

1.5.2.2 HERS Building Summary or Other External Documentation

Single-Family, Duplexes, and Townhouses

Provide one Building Summary for each dwelling unit, 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 per each unique boundary condition in the project, and upload as a PDF.

Process Tip: These will likely show up in different dwelling units depending on how many units have exposure to the exterior assemblies. If there is a dwelling unit in contact with an interior space that is not a dwelling unit, or not part of the thermal envelope, this should be included as a separate building summary.

Prescriptive Path through Energy Star:

Provide Energy Star, IAP, and DOE Efficient New Homes 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

ASHRAE Path through Energy Star:

Provide Energy Star, IAP, and DOE Efficient New Homes checklists for every dwelling unit. Refer to Section 1.5.3.2 for more information.

Process Tip: If a WUFI Passive or METr model is being used as the sole modeling software for projects pursuing this ASHRAE Path through Energy Star, certification through Energy Star and Efficient New Homes cannot be achieved until the final source energy result, after all as-built changes have been made, from the WUFI Passive or METr model is determined.

Non-Residential

DOE Energy Star MFNC, IAP and DOE Efficient New Homes 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

When determining the maximum allowed cfm50, the 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.

For townhouses, multifamily, and non-residential projects, development of a Blower Door Testing Plan is highly encouraged.

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 (Operational - Mandatory)

The operational test result must be used for the energy model in order to meet the space conditioning and source energy targets.

Process Tip: If building airtightness passes during an operational test, a durability test is **not** required.

Exception: The results of the durability test described below may be used for the energy model.

Where only direct exhaust range hoods and air moving equipment that operates continuously (more than 8000 hours per year) with barometric or spring loaded dampers are sealed in the direction of the test that they will be force-failed open. Thus, fresh air intake dampers may be sealed during depressurization, while exhaust dampers may be sealed during pressurization.

Review ANSI/RESNET/ICC Standard 380-2022 or ABAA Standard Method for Building Enclosure Airtightness Compliance Testing for further guidance.

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 the WUFI Passive or METr model.

Final Test (Durability - if necessary)

In addition to the requirements outlined in the Operational section above, refer to Appendix C-2.2 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

Process Tip: Projects with commercial kitchens / un-dampered range hoods due to fire code requirements should first perform a durability test with **only** the range hood taped. Refer to the Phius Guidance and Testing Rules for Commercial Kitchens document. Refer to Appendix I-3.17.2 for as-built modeling protocol.

Compartmentalization

For Duplexes, Townhouses, Multifamily projects, and residential portions of Mixed-Use 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.

Compartmentalization testing shall be performed to test air tightness of individual dwelling units in accordance with ANSI/RESNET/ICC Std 380-2022. The test threshold shall be 0.3 CFM50 / sq ft of unit Shell/Envelope (ES MFNC Prescriptive Path = 0.27 CFM/SF) area expressed in CFM/SF. Testing may be performed

using RESNET Chapter 6 and MINHERS Addendum 46 sampling protocols. Please discuss SAMPLING with your RESNET QA Provider and Phius PRIOR TO initiating sampling to ensure they will support sampling being applied to the project. Please document compartmentalization results below.

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 with flow straightener and capture hood
    - For flows under 100 CFM
- 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)

Exceptions:
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.

In the scenario where an E/HRV is ducted to an Air Handling Unit (AHU) or Fan Coil Unit (FCU) and the two systems are then used to distribute the outdoor air to individual supply rooms, outdoor distribution should be confirmed through testing as described in Appendix C-4.

In the scenario where a project incorporates constant airflow volume devices (also known as CAR Dampers), refer to the Phius Outdoor Air Mechanical Systems Memo.

Individual room supply and exhaust airflows: This is automatically calculated within the QA Workbook once design and measured values are input.

Process Tip: 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.

Ventilator fan power measurements are **not** required for the CERV from Build Equinox or the PentaCare V12 from Minotair.

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 about Phius' sampling protocol.

1.5.2.5 Heating & Cooling

Heating & Cooling QA Workbook Instructions

The Phius Certified Verifier is responsible for verifying all items on this worksheet. Any additional content needed for clarification of the building and its construction shall be added to Verifier Notes in this worksheet. Please follow instructions as noted below:

- **Step 1:** Enter the Outdoor portion of the Heating/Cooling System In Section 3.0.
- **Step 2:** If the heating/cooling system is a split system, in Section 3.0 enter the tag name, manufacturer, model, etc.
- of the compressor located Outdoors and in Section 3.1 enter the portion of the system located Indoors.
- **Step 3:** For each Air Source Heat Pump (ASHP) enter pump tag name, manufacture, model, quantity, etc. in Section 3.2 and for each Ground Source Heat Pump (GSHP) enter pump information in Section 3.3.

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 DOE's Efficient New Homes 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 Efficient New Homes PV-Ready Checklist. Refer to DOE Efficient New Homes Program Requirements for more information.

1.5.2.9 Electric Vehicle (EV) Charging Infrastructure

Refer to Section 1.3.4.4.

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 Efficient New Homes Program.

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 Certification process. Phius program requirements include partner programs such as the DOE ENERGY STAR Single-Family Homes, DOE ENERGY STAR Multifamily New Construction Program, EPA Indoor AirPlus and DOE Efficient New 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
DOE 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[50]	Version 1, Rev. 4	Version 1, Rev. 4	
DOE Efficient New Homes	Single-Family Version 2, Rev. 1	Multifamily Version 2[51]	

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.

[50] Version 2 is now available, but **not** required until permits after 1/1/2027.

[51] Phius 2024 Multifamily projects are **not** required to obtain ENH Certification, however the meeting the intent of all requirements within this program **is** required

Energy Star MFNC Eligibility Criteria

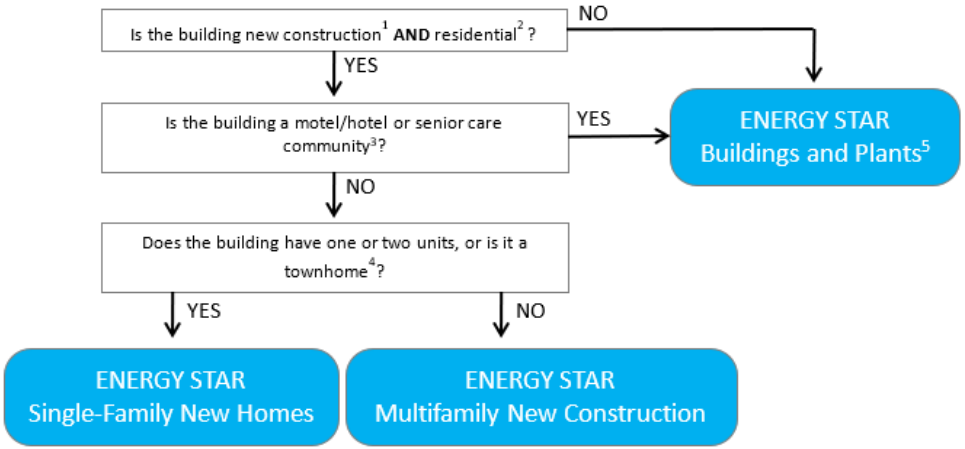
The ENERGY STAR Multifamily New Construction Program (MFNC) program is available for all residential new construction, except single-family detached homes, duplexes, and townhouses. Follow the decision tree below to determine which program your multifamily building can use to earn ENERGY STAR certification. 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.

DOE 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 Efficient New Homes Eligibility Criteria

Single-Family Version 2

Detached single-family homes, Duplexes and Townhouses[52]

For further clarification refer to the DOE Efficient New Homes Single-Family Version 2 Specifications.

[52] 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.

Multifamily Version 2

Multifamily buildings with any number of stories, Mixed-use buildings[53] with dwelling or sleeping units with any number of stories.

Exception: ENH Certification is **not** required for Phius 2024 Certification, however projects must meet the intent of **all** requirements according to the Phius Annotated documents below:

- Phius Annotated: DOE Efficient New Homes Multifamily National Program Requirements
- Phius Annotated: DOE Efficient New Homes Multifamily National Rater Checklist

For further clarification refer to the DOE Efficient New Homes Multifamily Version 2 Specifications.

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

Non-Eligible Buildings

Generally, the only cases where a Phius project does **not** need to earn ENERGY STAR or EPA Indoor AirPlus certifications are:

- Non-residential buildings
- Existing (retrofit) buildings
- Projects located outside of the United States

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.

[53] Where the dwelling units, sleeping units, and common space exceed 50% of the building's square footage.

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 Efficient New Homes 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 or METr 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 DOE's Efficient New Homes standards shall be based on the permit date of the project. For more information on these programs, please see the following links:

- DOE Energy Star Program Requirements
- EPA Indoor AirPlus Requirements
- DOE Efficient New Homes 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 Phase	Phase Summary
Pre-Design (PD) / Schematic Design (SD)	**Phase 0** Prescriptive Snapshot (Optional)	-Project teams may quickly establish technical design limits with this free online tool. -See **Section 2.1.1**
	Phase 1 Paperwork	-Project team requests a quote, invoice, & contract. -See **Section 2.1.2**
	Milestone 1 Project Registered	-Project team signs the contract and pays the invoice. -Phius creates a project number, makes the project publicly visible on Phius' Certified Project Database, and shares a project Dropbox folder with the project team -See **Section 2.1.3**
Design Development (DD) / Construction Drawings (CD)	**Phase 2** Design Review	-Submitter/CPHC uploads project documents. -Phius reviews the documents and provides feedback. -Project team responds to Phius' feedback and revises the project documents. -Repeat until all comments are resolved. -See **Section 2.1.4**
Bidding & Procurement	**Milestone 2** Design Certification	-Phius certifies the design and sends an official letter of Design Certification to the project team. -See **Section 2.1.5**

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	-Rater/Verifier performs site visits and communicates all changes to the Submitter/CPHC -Submitter records all changes in the Phius Prescriptive Checklist -See **Section 2.1.6**
	Phase 3.2 Final Review	-Rater/Verifier uploads all documentation -Phius reviews the documents and provides feedback -Rater/Verifier responds to Phius' feedback and revises the project documents. -Repeat until all comments are resolved. -See **Section 2.1.6**
Post-Construction (PC)	**Milestone 3** Certification	-Phius certifies the as-built project. -Phius sends a plaque to the project owner and a digital certificate to the project team. -See **Section 2.1.7**

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 or METr energy model and the Phius Certification Feedback Document.

2.1.7 Milestone 3: 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	$1,500
Attached Single-Family & Townhouses	$1,500 per unique dwelling unit $1,125 per duplicate unit type
Expedited Review	Available for an additional cost equal to 50% of the base certification fee (subject to Phius approval).

2.2.1 Prescriptive Path Certification Fees

Certification fees are a flat rate, based on project type as outlined in the table above.

2.2.2 Discounts

No discounts are available for the Prescriptive path.

2.2.3 Expedite Fee

Refer to Section 1.2.3

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
DOE ENERGY STAR	Single-Family New Homes Version 3.2 Refer to Section 1.4.1.1 & Section 1.5.3
DOE Efficient New 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

The prescriptive path is reserved for new construction single-family, duplex and townhouse projects located within the United States or Canada only. Because renewable energy is not credited for prescriptive path projects, only CORE projects are eligible for this Certification path.

Process Tip: Duplexes and townhouses must be vertically partitioned (side-by-side). Horizontally partitioned units are not eligible for this Certification path.

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 for general guidance. The airtightness limit for prescriptive path projects is outlined in Table 2.3.3.1.0 below. For more information, refer to Section [C] 2 Airtightness.

Table 2.3.3.1.0 Prescriptive Path Airtightness Limits

Building Type	50 Pa	75 Pa
Single family, duplexes & townhouses	≤ 0.04 CFM_{50}/ft^2	≤ 0.053 CFM_{75}/ft^2

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, Appliances & Fireplaces

Fossil-fuel based equipment and appliances are **not** allowed in Prescriptive path projects.

Biomass-burning fireplace inserts or wood stoves are allowed under the following two conditions. Refer to Section 1.3.6.3 for further information.

- They must be vented to the outside
- The fireplace or stove must be airtight

2.4 Design Guidance

Table 2.4.0 Prescriptive Path: Design Guidance	
Co-Requisite Programs	Refer to Section 1.4.1.1 for design requirements that stem from the co-requisite programs.
Required Documentation	Refer to Section 2.4.2 for all required documentation.
Compliance Tool	Phius CORE Prescriptive 2024 Checklist v24.1.0 (or newer)
Compliance Tool Protocol	Refer to Section 2.4.3 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 Section 2.4.2.6
Letter of Intent	Refer to Section 0.4.5

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 1.4.2.2

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 Section [C] 0 Project Information and Section [C] 3 Compactness.

- Section [C] 0.6 Project Specifics
- Section [C] 3.1 Building Enclosure Area

Glazed Fenestration Area

Refer to Section [C] 4 Solar Protection.

- Section [C] 4.2.1 Window-to-Wall (WWR) Area Ratio
- Section [C] 4.2.2 Skylight-to-Roof (SRR) Area Ratio

Fixed Overhang Dimensions

Applicable to climate zones 0-3. Refer to Section [C] 4 Solar Protection.

- Section [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

The approved compliance tool for the Phius Prescriptive path is the 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

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, 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. There are fields 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 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. The weather station chosen must meet the following criteria:

- ≤50 linear miles from the project location
- ≤400' difference in elevation from the project location

Exception: Projects located outside of these parameters are ineligible for the prescriptive path and should instead follow the performance path. Custom climate data noted in Section 1.4.4.2 is **not** permitted for Prescriptive Path projects.

Process Tip: 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. See Section 1.4.2.6 for iCFA definition. The following requirements are determined by this input:

- Occupant density & Compactness limit
- Duct length limit
- Window-to-floor area ratio

Exterior Enclosure Area

The reference exterior enclosure area. This value is used to demonstrate compliance with the compactness limit.

Process Tip: The exterior enclosure area is similar to the envelope area found in Section 1.4.2.6. 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). The following requirements are determined by this input:

- Compactness limit
- Duct length limit

Number of Bedrooms

The total number of bedrooms should be input here, see Section 1.4.2.6 for more information.

Process Tip: 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 Project eligibility

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 Maximum bedroom size

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-10.1 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-10.2.1.1 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-10.2.1.2 outlines the logic behind the net gain requirement.

Process Tip: For partially glazed doors, the following protocol can be used:

- ⅓ Lite doors should be treated as opaque and need to be included in this calculation
- ½ - ⅔ Lite doors should be treated as half-sized doors and half the area of the whole door should be counted as glazing in this calculation
- ⅔ Lite doors should be treated as full-sized doors and the area of the whole door should be counted as glazing in this calculation

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. Follow the steps below:

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 (outlined to the right) 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 makeup.

[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.

Process Tip: 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, outlines Energy Star requirements for ventilation fans and humidifiers, and confirms that no heating equipment or heated spaces are 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 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 is 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 preliminary blower door test is required for the prescriptive path and must be included in the scope of work of the Rater or Verifier.

2.5.3 Co-Requisite Programs

Refer to the Single-Family, Duplex and Townhouse portions of Section 1.5.3

3 - Retrofit - REVIVE 2024

3.0 REVIVE 2024 Pilot

The REVIVE 2024 Pilot program is not currently accepting submissions. Teams with pilot projects currently pursuing this certification path should refer to Appendix R for guidance.

New retrofit projects must instead follow the Phius CORE 2024 Certification path according to Section 3.1 below.

3.1 Process

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

Refer to Section 1.1.1

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: Design Review

Refer to Section 1.1.4

3.1.5 Milestone 2: Design Certification

Refer to Section 1.1.5

3.1.6 Phase 3: Construction & Final Review

Refer to Section 1.1.6

3.1.7 Milestone 3: Certification

Refer to Section 1.1.7

3.1.8 Phius Certification Feedback Document

Refer to Section 1.1.8

3.1.9 Review Timeline

Refer to Section 1.1.9

3.2 Fee Schedule

Refer to Section 1.2

3.3 Performance Path Requirements

Refer to Section 1.3

Exception to Section 1.3.1: The Phius CORE 2024 & Phius ZERO 2024 Certification Programs are applicable to construction that falls within the following parameters:

- Stand-alone retrofit projects
- Retrofits with new construction additions of any size

3.4 Design Guidance

Refer to Section 1.4

Exception: Thermal Bridge Allowance
A case-by-case allowance on the Performance Criteria Targets may be made for difficult or impossible-to-fix structural thermal bridges that cannot be mitigated, but have low risk from a moisture point of view (Refer to Section 1.3.3.3). Contact Us for the Phius REVIVE 2024 Allowance Calculator.

The allowance may also apply to existing assemblies that cannot be altered. To determine the allowance in WUFI Passive, the prescriptive path minimum R-value for the associated location should be modeled. The difference in modeled performance results is equivalent to the allowance that may be applied.

Required Documentation: Documentation must be provided describing each condition and the circumstances that prevent it from being altered. Phius will either approve or decline the allowance upon review of the narrative and detail provided.

Example: The allowance above may apply to uninsulated basement conditions where the slab cannot be removed because the foundation/structure cannot be changed and the floor-to-ceiling height is such that insulation above the slab cannot be installed.

3.5 On-Site Review

Refer to Section 1.5

3.5.1 Required Documentation

Refer to Section 1.5.1

3.5.2 Performance Path: QA/QC Requirements

Refer to Section 1.5.2

3.5.3 Co-Requisite Programs

Refer to Section 1.5.3

Exception: Retrofit projects are **not** eligible for certification to the programs outlined in Section 1.5.3. The certification checklist criteria for these programs shall be completed “as if” they will be certified.

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). The following iCFA and EnvFlr ratios were used in the optimization models to establish the Performance Criteria Targets. Buildings that exceed these ratios may have difficulty meeting the project-specific targets.

Building Type	iCFA [ft^2]	EnvFlr [ft^2/ft^2]
Tiny House	146-229	5.87-9.19
Single-Family (small)	997	3.07
Single-Family (typical)	1,803	2.54
Townhouses	15,073	1.52
Multifamily (midrise)	32,920	1.02
Multifamily (highrise)	82,300	0.71

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 of the ratio of the floor area 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 of the number of occupants per square foot of floor area.

> ***Residential:*** The number of occupants equals the number of bedrooms + 1 per dwelling unit. Calculation range limits based on the buildings studied are incorporated with a minimum iCFA/person of 86 and a maximum iCFA/person of 750.
>
> ***Non-Residential:*** 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 following figures.

A-1.1 Annual Heating Demand [kBtu/ft^2.yr]

A-1.1.1 Buildings (>1,000 sf iCFA)

$$
\begin{aligned}
&2.5457921063 \\
&+ 0.0006964273 \cdot \text{HDD65} \\
&+ -0.001754102 \cdot \text{IGA} \\
&+ -12.84284075 \cdot \$\text{elec} \\
&+ 2.0656632454 \cdot \text{EnvFlr} \\
&+ 1566.1974476 \cdot \text{UnitDens} \\
&+ (\text{HDD65} - 5674.3866667) \cdot ((\text{HDD65} - 5674.3866667) \cdot -8.222261e\text{-}8) \\
&+ (\text{HDD65} - 5674.3866667) \cdot ((\text{IGA} - 1451.0633333) \cdot -3.521982e\text{-}7) \\
&+ (\text{HDD65} - 5674.3866667) \cdot ((\$\text{elec} - 0.2029193333) \cdot -0.002089994) \\
&+ (\text{HDD65} - 5674.3866667) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.0003487784) \\
&+ (\$\text{elec} - 0.2029193333) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot -3.472274709)
\end{aligned}
$$

Rsq = 0.88, min. results of 1.0.

A-1.1.2 Buildings (<200 sf iCFA)

$$
\begin{aligned}
&6.3652258193 \\
&+ 0.0038587347 \cdot \text{HDD65 [F.days]} \\
&+ (\text{HDD65 [F.days]} - 4880.725) \cdot ((\text{THD-1 [F]} - 21.5575) \cdot 0.0000322794)
\end{aligned}
$$

Rsq = 0.92, min. 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)

$$
\begin{aligned}
&-2.891826273 \\
&+ 0.0016600925 \bullet \text{CDD50} \\
&+ 2.7134372315 \bullet \text{DDD} \\
&+ -1.072883835 \bullet \text{EnvFlr} \\
&+ 3347.3086058 \bullet \text{UnitDens} \\
&+ (\text{CDD50} - 3785.076) \bullet ((\text{CDD50} - 3785.076) \bullet 1.5194385\text{e-}7) \\
&+ (\text{IGA} - 1451.0633333) \bullet ((\text{DDD} - 0.3233057482) \bullet 0.0075130061) \\
&+ (\text{CDD50} - 3785.076) \bullet ((\$\text{elec} - 0.2029193333) \bullet -0.002710065) \\
&+ (\text{IGA} - 1451.0633333) \bullet ((\text{EnvFlr} - 1.7740848024) \bullet 0.0021353042) \\
&+ (\text{EnvFlr} - 1.7740848024) \bullet ((\text{EnvFlr} - 1.7740848024) \bullet 2.1308341827) \\
&+ (\text{DDD} - 0.3233057482) \bullet ((\text{UnitDens} - 0.0009781131) \bullet 7123.3552616) \\
&+ (\text{EnvFlr} - 1.7740848024) \bullet ((\text{UnitDens} - 0.0009781131) \bullet -1680.206998)
\end{aligned}
$$

Rsq = 0.93, Inclusivity adjustment of +2.0768, min. result of 1.0

A-1.2.2 Buildings (<200 sf iCFA)

$$
\begin{aligned}
&-4.511787896 \\
&+ 0.0053698658 \bullet \text{CDD50 [F.days]} \\
&+ (\text{IGA [kWh/m2.yr]} - 1493.525) \bullet ((\text{DDD [lb/lb.days]} - 0.3829363138) \bullet 0.0179690723)
\end{aligned}
$$

Rsq = 0.96, Inclusivity adjustment of +3.5806, min. 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, min. 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, min. 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)

$$
\begin{aligned}
&-7.799196768 \\
&+ 160.56676643 \cdot \text{Occ} \\
&+ -0.000064641 \cdot \text{CDD50} \\
&+ 0.1087419716 \cdot \text{TCD} \\
&+ 0.0114553286 \cdot \text{IGCL} \\
&+ -0.144119045 \cdot \text{EnvFlr} \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{CDD50} - 3785.076) \cdot 3.108567e\text{-}8) \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{TCD} - 78.127) \cdot 5.7628526e\text{-}6) \\
&+ (\text{CDD50} - 3785.076) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.0000487234) \\
&+ (\text{TCD} - 78.127) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.0112936538) \\
&+ (\text{EnvFlr} - 1.7740848024) \cdot ((\text{EnvFlr} - 1.7740848024) \cdot 0.893136984) \\
&+ (\text{TCD} - 78.127) \cdot ((\text{UnitDens} - 0.0009781131) \cdot 41.014256753)
\end{aligned}
$$

Rsq = 0.91, Inclusivity adjustment of +0.3616, min. 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, min. 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]

$$
\begin{aligned}
&-2857.033962 \\
&+ 12.109301597 \bullet \text{iCFA/p} \\
&+ 2674374.9714 \bullet \text{UnitDens} \\
&+ \left(\text{iCFA/p} - 474.68053023\right) \bullet \left(\left(\text{UnitDens} - 0.0014444453\right) \bullet 6165.3716584\right)
\end{aligned}
$$

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 • HDD65 [F.days]
+ 59.886974326 • $elec [$/kWh]
+ (HDD65 [F.days] − 5520.8545455) • ($elec [$/kWh] − 0.2016890909) • 0.0111932731

Rsq = 0.88, Conservative fit adjustment +5.3792

A-3.2 Roofs

33.972385485
+ 2.1434846549 • EnvFlr
+ 0.0025310881 • HDD65 [F.days]
+ -0.276768354 • THD99 [F]
+ 66.938407603 • $elec [$/kWh]
+ (EnvFlr − 3.14219615) • (EnvFlr − 3.14219615) • -1.607593659
+ (THD99 [F] − 12.486818182) • ($elec [$/kWh] − 0.2016890909) • -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 • EnvFlr
+ 0.0026621341 • HDD65 [F.days]
+ 38.923653317 • $elec [$/kWh]
+ (CDD50 [F.days] − 3890.5772727) • (TCD [F] − 78.59) • 0.0000576588
+ (HDD65 [F.days] − 5520.8545455) • ($elec [$/kWh] − 0.2016890909) • 0.0060470435

Rsq = 0.84

A-3.4 Ceilings of unconditioned basements or crawl spaces and pier and beam floors

-18.64576148
+ 5.9003677205 • EnvFlr
+ 0.0026621341 • HDD65 [F.days]
+ 38.923653317 • $elec [$/kWh]
+ (CDD50 [F.days] − 3890.5772727) • (TCD [F] − 78.59) • 0.0000576588
+ (HDD65 [F.days] − 5520.8545455) • ($elec [$/kWh] − 0.2016890909) • 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.[54]

B-1 General 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)

Plywood, OSB, 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)

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

[54] Lstiburek, Joseph. BSI-028: Energy Flow Across Enclosures. Building Science Corporation, 1 Dec. 2009. Web. 13 May 2016.

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)

   Exceptions: Path 2 outlined above is **not** available for:
   - Buildings pursuing the Phius Prescriptive Path
   - Non-residential projects

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 issues
   c. Outline that the potential hygrothermal or moisture risk of the assembly as designed is acceptably low

Best Practice Recommendations

Mid-wall is the best place for the air barrier. Exterior/interior placement is more vulnerable.

Keep in mind the "perfect wall" concept - structure to the inside, insulation to the outside.[55],[56]

Polyisocyanurate (PolyIso) insulation is typically **not** to be used below grade.[57] Thoroughly follow the application guidance of the manufacturer's warranty and any ICC Evaluation Service report that pertains.

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?

[55] Lstiburek, Joseph. BSI-001: The Perfect Wall. Building Science Corporation, 15 July 2010. Web. 16 May 2016.
[56] BSI-091: Flow-Through Assemblies. Building Science Corporation, 13 Jan. 2016. Web. 16 May 2016.
[57] 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.

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.

[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.

Double-Stud Wall Assemblies

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:

- 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 (PIR) 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.

Zones 0, 1, 2, 3, 4A and 4B

- No interior vapor control layer is required.

Zones 4C, 5, 6, 7 and 8

- Class III vapor control layer is required on the interior of framed walls
- The sheathing-to-cavity ratios for each climate zone outlined below must be met

Process Tip: The ratios below should be calculated using the homogeneous (i.e. non-derated) R-values, rather than the effective R-values (i.e. insulation derated for fasteners/framing).

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.

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 minimum 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 minimum 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 minimum 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 minimum insulated sheathing**

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.[60,61,62,63] 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.
[63] Lstiburek, Joseph. BSI-105: Avoiding Mass Failures. Building Science Corporation, 24 June 2018. Web.

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.

e) Vented, framed assemblies with both vapor permeable cavity and continuous insulation

a) Vented, framed roof assemblies with only vapor permeable cavity insulation.

Well-Vented Compact Roof

If well-vented[64] above the insulation **or** 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.[65]

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:

> **Exception:** Comply with the ventilation requirements outlined in the IRC, R806.1-3. The exception found in R806.2 does **not** apply.

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.

[64] Well-vented: Soffit and ridge vents connected by an open air-space of 1.5”/38mm or more.

[65] The climate zones noted here are defined by the Building America Zoning system.

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:

Process Tip: The ratios below should be calculated using the homogeneous (i.e. non-derated) R-values, rather than the effective R-values (i.e. insulation derated for fasteners/framing).

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 III 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 Tip: 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.

e) Vented, framed roof assemblies with both vapor permeable cavity and continuous insulation

This roof type applies to assemblies with vapor permeable insulation used in the cavity and as the continuous insulation layer (e.g., mineral wool batt + mineral wool board).

All Climate Zones

- Meet the venting and vapor control requirements for a Well Vented Compact Roof
- Meet the hygrothermal ratios for Roof Type B

B-4 Floor Moisture Control Guidelines

Process Tip: It is recommended to install a vapor-open water-resisting layer, e.g. housewrap, directly below the finish flooring, to protect against beverage spills and the like for all floors containing vapor-permeable insulation or acoustic material.

B-4.1 At-Grade Floor Assemblies

Slab-on-Grade[66] floor assemblies shall comply with the following:

- Provide a minimum 10-mil vapor retarder between the floor assembly and ground.
- Contain no structural wood framing.
- Contain no vapor-permeable insulation.

Exception: Mineral wool board products warranted by the manufacturer for below-grade application.

Process Tip: Refer to BSI-003: Concrete Floor Problems. The 2021 IRC requires ASTM E1745 Class A vapor retarder.

B-4.2 Overhang Floor Assemblies

Requirements in B-4.2.1 **and** B-4.2.2 apply to **all** floor assemblies over outside air, unconditioned and semi-conditioned[67] spaces.

B-4.2.1 Comply with A, B or C:

A. Limit materials vulnerable to wetting.

1. There shall be no structural wood framing above the most water resistive layer.
2. There shall be no vapor permeable insulation below the water-resistive layer.

B. Make it repairable in the event of bulk water intrusion from above.

1. Floors shall be accessible from below for repair, with the height of the space below being at least 36" (inches) everywhere.
2. There shall be no structural wood framing above the most water-resistive layer.
3. There shall be at most 2-½" of vapor-permeable insulation above the most water-resistive layer.

C. Provide floor drains compliant with the applicable local code.

B-4.2.2 Climate-Specific Requirements

Floors shall comply with the general requirements in B-1, and the prescriptive requirements for walls outlined in B-2.1. Additionally, the requirements outlined below should be met based on the climate zone in which the building is located.

Zones 0A, 1A, 2A and 3A below the warm-humid line

Provide a maximum 1.5 perm (or less) vapor retarder on the bottom face of the assembly.

Process Tip: Refer to BSI-009: New Light in Crawlspaces and Indoor AirPlus Version 2 requirements for crawlspaces.

[66] Includes "slabless" or "concrete-free".
[67] Semi-conditioned: **Not** heated/cooled to typical indoor setpoints, but may be freeze-protected by a mechanical heating system.

B-4.3 Below-Grade Floor Assemblies

Below-grade floor assemblies shall comply with the following:

- Locate the insulation below the structure.
- Provide Class I vapor control between the structure and insulation.

Process Tip: It is recommended to review the following related documents:

- Indoor AirPlus Version 2 requirements for drains.
- 2021 IRC, Third version:
  - Flood protection - Section R322
  - Frost protection - Sections R403.1.4.1, R403.3
  - Drainage - Section R405
  - Dampproofing / waterproofing - Section R406

Appendix C - Additional Information for Raters & Verifiers

C-1 Phius Certified Rater and Verifier General Information

C-1.1 Definitions

Please visit Appendix D - Definitions & Glossary of Terms for helpful terminology related to raters and verifiers.

C-1.2 Third Party Status

Phius Certified Raters and Phius Certified Verifiers cannot serve as the Phius Certified Consultant (CPHC), builder or as a member of the design team (designer, architect, engineer etc..) on a project in which they are performing verification.

Exception: 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 the Phius webpage on maintaining 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 or Verifier for each detached building in the certification project. Testing shall be conducted using multi-point infiltration procedures as specified in this appendix, as well as additional guidance specific to multifamily building testing included in the RESNET Guidelines for Multifamily Energy Ratings document.

C-2.1.1 Single Blower Door Fan Testing

If a single blower door fan is utilized for testing, the Rater or Verifier shall use an automated multi-point testing software such as The Energy Conservatory TECTITE or Retrotec Fantestic software.

C-2.1.2 Multiple Blower Door Fan Testing

If multiple fans are utilized for testing, the Rater of Verifier shall use a multi-fan control testing software such as The Energy Conservatory TECLOG software. A proposed Testing Plan shall be provided to Phius by the Rater of Verifier in advance of testing using the Contact Us form.

Exception: Alternative test methods proposed by the Rater or Verifier will be considered on a case-by-case basis.

C-2.1.2.1 Attached Housing (Duplexes and Townhouses)

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. In such cases, multi-zone whole building testing shall be required. This necessitates the use of multiple fans in multiple testing locations to achieve uniform testing pressure throughout all building zones. Multi-fan control testing software must be utilized or sufficient fan operators must be employed to achieve accurate testing results.

If 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, the project shall use one of the following testing protocols:

Example: A 20-unit attached townhouse development, which would require 20 simultaneously running blower door tests to create a uniform result.

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.

Individual zone, "guarded" testing

Process Tip: 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 the outdoors of an individual dwelling unit.

The "guarded" testing strategy described below shall be allowed if an appropriate whole-building test is unable to be performed, and where dwelling units achieve the prescriptive measures noted:

- Blower doors are installed in individual dwelling units to be tested and in each directly adjacent building zone surrounding the dwelling unit.

  Examples:
  - 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.
  - 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.

Required Prescriptive Measures to perform "guarded" testing:

- All penetrations in the dwelling unit enclosure shall be sealed, including pipes, wires, light fixtures, vent fans, duct/ventilation boots, light switches, electrical outlets, etc.
- 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. 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 top and bottom plates shall be sealed using appropriate sealing products.
- Partition walls between dwelling units shall be capped at the top of the wall. Solid blocking material shall be installed above partition walls for the entire perimeter of 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, a fully sealed partition wall shall extend from the attic floor to the roofline so as to isolate the attic space of each dwelling unit.

  Exception: Where this is **not** possible or practical, the Rater or 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.

Zone Linking Method

This strategy shall be allowed 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:

- Use of well sealed flex duct and taped transitions into windows of adjacent spaces.
- Use of duct work of central ventilation systems.

Process Tip: 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 or additional fans may be required for testing to achieve consistent pressure.

C-2.1.2.2 Large Building Infiltration Testing

Verifiers may use experienced testing professionals provided they supervise and witness the building preparation and testing.

The building must 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.

Exception: Alternative test methods proposed by the Rater or Verifier will be considered on a case-by-case basis.

C-2.2 Non-Threatening Air Leakage

Exception, for non-threatening air leakage:

If the operational 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 durability airtightness criterion.

Projects with commercial kitchens/un-dampered range hoods due to fire code:

Review the Phius Guidance and Testing Rules for Commercial Kitchens document.

Non-threatening leakage elements that may be taped upon Phius approval:

- Fire rated entry doors: operable components
- Entry doors with panic hardware requirements: operable components
- Entry door thresholds with universal accessibility requirements: threshold/sweep
- Elevator doors: operable components into shaft
- Dampers: seal
- Trash chutes and compactor systems, code required dampened openings like elevator shaft vents, gas meter room vents, coiling doors
- Direct vent gas fireplace: firebox
- Window or through-wall space conditioning units:
    - Leakage through unit itself
    - Window-only: Gasket inset in window glazing or window frame

Exceptions: Projects with openings **not** listed above may request approval by using the Contact Us form to tape such items off prior to the airtightness test.

For window space conditioning units, some frames present durability risk and Phius has discretion to decline the request for taping.

Non-threatening leakage elements already accounted for in the cfm/ft^2 gross envelope limit. May not be taped:

- Standard operable windows: operable components
- Standard lift and slide doors: operable components
- Standard Balcony/French doors: operable components
- Duct/vent leakage if fully exposed and in conditioned space

Threatening leakage sources. May not be taped.

- Window or door installation: rough opening
- Duct/vent/wiring: penetration of exterior wall
- Duct or vent: inside assembly
- Exterior wall mounted space conditioning unit installation: rough opening

Process Tip: The following paper is used as the basis for durability airtightness threshold: Acceptable Airtightness of Walls in Passive Houses – Salonvaara and Karagiozis 2015

Additional background on Phius' use of CFM_{50}/ft2 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-2.3 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-2.3.1 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...), detail 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.

Example: If a waiver is being requested for the airtightness requirement not being met, please be sure to include the following (and all other items that may be relevant):

- A testing plan
- A narrative of all testing done to date
- A narrative outlining any mitigation strategies that were implemented
- All test reports
- Verification reports

C-2.3.2 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..), detail the nature of the waiver or allowance and document 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, the project Sampling plan must be submitted to Phius' QA/QC Manager for review 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. See below for step-by-step instructions on how to determine a proper sample set. 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.

C-3.1 Centralized Ventilation Systems

This tab of the QA Workbook shall be completed for centralized E/HRV systems servicing multiple dwelling units (DU) and/or common spaces. The airflow rates at the ventilation unit and at the individual registers shall be measured at the design 24/7 ventilation rate. The Phius Certified Verifier is responsible for verifying airflows[68] in accordance with the steps below:

- **Step 1:** Count the number of centralized ventilation units.
- **Step 2:** For each centralized ventilation unit, enter the requested ventilator data at the design 24/7 airflow speed setting in section 2.1.1.
- **Step 3:** Next, count the number of DU types served by each centralized ventilator.
- **Step 4:** For each DU type, enter the measured airflows for all registers in a minimum of 3 of each DU type per centralized ventilator in section 2.1.2.[69]
- **Step 5:** Enter additional verified measured airflows at registers in a DU in section 2.2.2, until no fewer than 10% of the DUs in the building (among all Ventilation Tabs) have been measured.
- **Step 6:** Complete the remaining sections 2.1.3 - 2.1.4.
- **Step 7:** Add any additional content needed for clarification in the Verifier Notes.

[68] Measured airflows, or verified airflows, must be directly measured or observed by the Phius Verifier.
[69] If there are fewer than three (3) of any dwelling unit type, measure airflows in all dwelling units of that type.

C-3.2 Decentralized Ventilation Systems

This tab of the QA Workbook shall be completed for decentralized E/HRVs serving individual dwelling units (DU) only. The airflow rates at the ventilation unit and at the individual registers shall be measured at the design 24/7 ventilation rate. The Phius Certified Verifier is responsible for verifying airflows[68] in accordance with the steps below:

- **Step 1:** Review the architectural drawings to determine the number of DU types (studio, 1 bed, 2 bed, etc.).
- **Step 2:** Complete the corresponding ventilation tab for each DU type.

  Process Tip: For decentralized ventilation systems, the QA Workbook has separate tabs laid out to correspond with various bedroom types. The Phius Rater or Verifier may remove tabs that are not applicable to that specific project or add tabs as necessary.

- **Step 3:** Within a minimum of three (3) DUs, enter the requested ERV/HRV ventilator data at the design 24/7 airflow rate in section 2.2.1.
- **Step 4:** Within these same three (3) DUs, enter the measured airflow at each register within the DU in section 2.2.2.[69]
- **Step 5:** Sample additional DUs, recording data in sections 2.2.1 and 2.2.2, until no fewer than 10% of the DUs in the building (among all Ventilation Tabs) have been measured.

  Exception: If the ventilation system is a Minotair, sample units following the instructions above, complete section 2.2.1 (through column: "Type of ERV/HRV Defrost"), record all other measurements in the Phius Minotair Calculator, skip section 2.2.2, and complete section 2.2.3.

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 a third-party air volume measurement and balancing professional other than the Rater/MF Verifier is hired 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.
- DOE's Efficient New Homes 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

Process Tip: 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.

C-4 Testing Procedure for Integrated Outdoor Air Ventilation and Space Conditioning Air Handling Units

The Air Handling Unit (AHU) or Fan Coil Unit (FCU) shall be set to the fan speed that will be programmed when there is no call for space conditioning. The required tests are noted below in order of run:

1. **Test 1:** The AHU should be turned off so as not to provide any fan assistance in the distribution of the outdoor air from the E/HRV. Measure the outdoor airflow from the E/HRV entering the FCU and then measure the individual registers. If the design airflow rates are not met at the individual registers, proceed to Test 2.
    a. Note: Proceed to Test 2 and forego Test 1 if it is clear and obvious to the onsite QA/QC professional that the outdoor airflows would never be met without AHU fan assist.
2. **Test 2:** The AHU shall be set to the lowest programmable fan speed to provide assistance in the distribution of the outdoor air from the E/HRV. Measure the outdoor airflow from the E/HRV entering the AHU and then measure the individual registers. Assuming well-mixing of the outdoor air with the recirculation air from the AHU, the following estimation can be used to determine if adequate outdoor air is being distributed per the mechanical designer's intentions. Multiply the E/HRV airflow entering the AHU by the airflow at each individual register divided by the sum of the register airflows. If the design airflows are **not** met using this method, follow Option A or Option B below.
    a. **Option A:** Have the mechanical designer review the estimated outdoor airflows per register and sign-off to align the design airflows. If no sign-off can be provided, proceed to Option B.
    b. **Option B:** Re-balance/commission the system to bring it up to the design requirements.

Appendix D - Definitions & Glossary of Terms

D-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.

Durability Airtightness Test: Previously referred to as the 'taped test,' this version of the airtightness test may be conducted if the airtightness criterion is initially missed and non-threatening leakage elements have been taped. See Appendix C-2.2 Non-Threatening Air Leakage for more information.

Non-Certified Inspector: 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. For more information, see the Phius Certified Rater or Verifier Mentorship Letter of Attestation.

Process Tip: Raters / Verifiers more than 200 miles from the project may employ or contract a local non-Phius certified professional to do portions of the on-site verification. Important notes to keep in mind:

- The local non-Phius certified professional must at minimum be a RESNET Rater or RFI, and have demonstrated knowledge of Energy Star, IAP, and DOE's Efficient New Homes programs
    - It is recommended, but **not** required, for the local non-Phius certified professional to be a partner of the three co-requisite programs mentioned above.
- There shall be no distinction between the remote Rater / Verifier and local non-Phius certified professional acting on their behalf.
- The remote Rater / Verifier is still accountable for providing all the deliverables to Phius and ensuring all co-requisite program requirements are met.
- Phius requires a disclosure letter naming the non-Phius certified professional providing field services.
- The remote Rater / Verifier is responsible for vetting the local non-Phius certified professional's qualifications and training.

Operational Airtightness Test: Previously referred to as the 'un-taped test,' this version of the airtightness test is what is used for the energy model, regardless if an operational test is conducted or not. For this version of the airtightness test, only E/HRV intake and exhaust ducts may be taped.

Phius Certified Raters and Verifiers: 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 to learn more about becoming a Rater or 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.

Process loads: Energy consumed for services being provided to a customer or client in the building, excluding space conditioning and maintaining comfort and amenities for the occupants. Whether it is the customer or client using the energy (e.g., arcade, gym) or if the energy is used on their behalf (e.g., commercial kitchen in a restaurant), both situations may qualify as process loads.

Appendix E - Electrification Readiness for Combustion Equipment

Combustion equipment shall comply with the section below.

Combustion Water Heating:

Systems 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 using the appropriate subfolders.
    - Files should be named in a logical manner (i.e. v1, v2, etc.). Avoid uploading files with file names 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'
- Old files should **not** be deleted, rather they should be placed in the 'Archive' folder.
- 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.

Process Tip: How to Ace the New Phius Portal

Contact Us for any questions regarding Phius Portal access.

I-1.3 Editing Project Public Listing

Project editing can be done through the Phius Portal under the 'My Projects & Products' tab. Please review this blog post for additional information.

- 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.

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 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-2.3 Tips on Ventilation

Exhaust Ventilation Devices

Consider moving an exhaust dryer to the mudroom or outside the thermal envelope.

Makeup air for a directly vented range hood is acceptable as long as the total meets the source energy requirements. If a makeup 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[70]

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.

[70] Selecting Ventilation Air Filters to Reduce PM2.5 Of Outdoor Origin. ASHRAE Journal. September 2016.

I-2.4 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 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 Z-Girts	Any	Derate R/in by 8%
Plastic or Thermally Broken Point Fasteners	No fastener correction required	
Aluminum	Fastener Correction Calculator required.	

Process Tip:

- 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 Passive or METr 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 NLR'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.

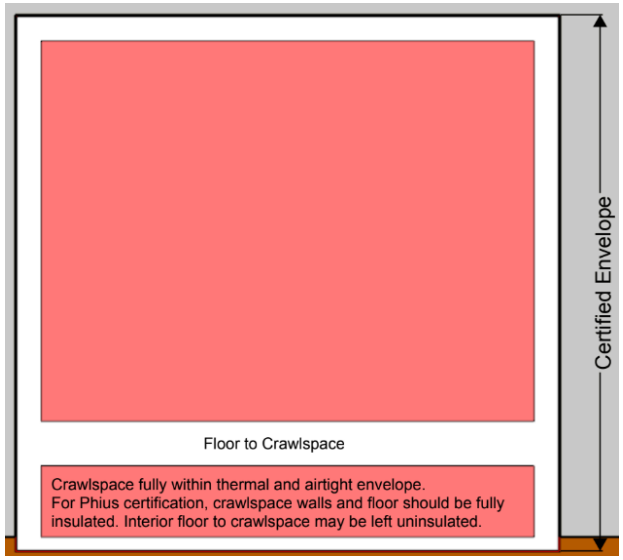
I-3.5 Domestic Hot Water Use Per Person

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):



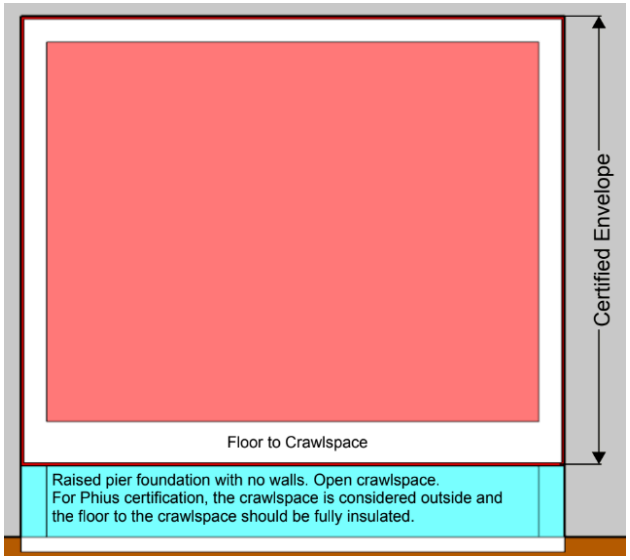
`Foundation Interface` Settings (for WUFI Passive/METr):

- `Slab on Grade`
- `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):



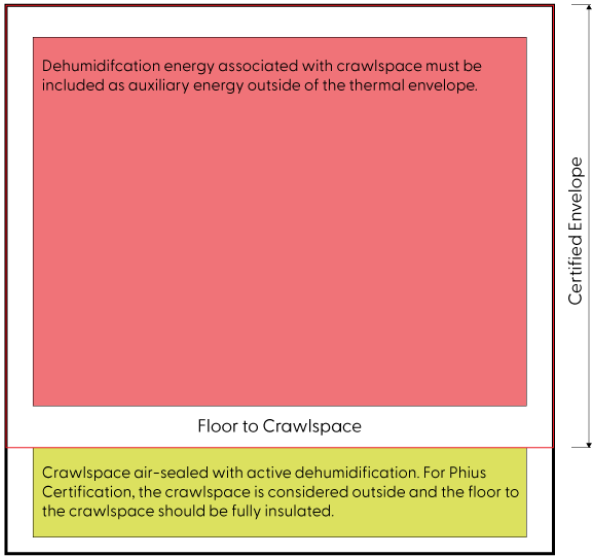
`Foundation Interface` Settings (for WUFI Passive/METr):

- `None`
- The `Outer Side Attachment` for the floor component in WUFI Passive/METr 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)](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*

Crawlspace Option 3 (IAP Additional Exceptions):



`Foundation Interface` Settings (for WUFI Passive/METr):

- `Suspended Floor`

Indoor AirPlus Version 1 (rev. 04):

- *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.*

I-3.7 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.

Definitions

- **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.

I-3.8 Default Materials Database

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.

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
Soil / Dirt / Earth / Ground	0.0721	13.87

I-3.9 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-3.10 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-3.11 Method for Evaluating when a Cooling System is Recommended

Some designers are against the use of cooling systems. The "cooling-is-a-luxury" perspective survived the introduction of air-conditioning in North America, where building codes do **not** require a cooling system in any climate, nor does the DOE Energy Star program which is a co-requisite to Phius' certification programs.

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/formula, 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 (Top) is:

Top = 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 slightly warmer than the 70.2°F maximum in the monthly file.

This makes the upper operative temperature limit (Top):

- Top = 0.31 * 70.2 + 60.5 = 82.2°F, by the monthly data maximum
- Top = 0.31 * 73.9 + 60.5 = 83.4°F, by the 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-3.11.1 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 or METr 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 or METr 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 1.4.4.9.

The conditions on the representative occupants might always be assumed true for residential but might **not** be for non-residential. 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-3.11.2 Passive Cooling Protocol when no Active Cooling System is Provided

Use the following protocol when no active cooling system is provided. If natural ventilation is **not** sufficient to meet the cooling demand of the project (as indicated by the warning: "Cooling: The cooling system does **not** cover the cooling demand."), then occupant installed cooling (e.g. window A/C) shall be modeled as indicated in the process tip following the protocol below and no natural ventilation may be accounted for in the model.

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 `[...]` button in the far right of the cell in WUFI Passive to expand the built-in calculator required to complete this section. Input 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 `[...]` button in the far right of the cell in WUFI Passive to expand the built-in calculator required to complete this section. Input 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-3.12 DHW Uniform Energy Factor (UEF) Conversion Formulas

UEF, or *Uniform Energy Factor*, is an AHRI metric for water heaters. The EF, or *Energy Factor*, is calculated based on regression analysis of EF conversion equations found in the Federal Register, based on differing hot water draw patterns, with support from the California Energy Commission (CEC). The calculation to convert UEF to EF (energy factor) depends on the type of heat pump water heater being used. Refer to the equations below for each type.

Table I-3.12.0 DHW UEF Conversion Formulas

Water Heater Type	Conversion Formula
Consumer Gas-Fired Water Heater	EF = 0.9066 **x** UEF **+** 0.0711
Consumer Electric Water Heater (Electric Resistance)	EF = 2.4029 **x** UEF **-** 1.2844 *Use the minimum of 0.96 and the calculated EF.*
Consumer Electric Water Heater (Heat-Pump)	EF = 1.2101 **x** UEF **-** 0.6052
Instantaneous Gas-Fired or Electric Water Heater	EF = UEF
Residential-Duty Commercial Gas-Fired Water Heater	EF = 1.0005 **x** UEF **+** 0.0019
Residential-Duty Commercial Electric Instantaneous Water Heater	EF = 1.0219 **x** UEF **-** 0.0025 *Use the maximum of 1.0 and the calculated EF.*

I-3.13 Early Design DHW Modeling Method

Within the `System 1 (User Defined)` > `Distribution` > `DHW` > `General` tab, set the `Calculation Method` to `Simplified hot Water Piping Calculator`. This setting may be used early in design, but is **not** accepted for design nor final Certification. Input values noted below on the `Hot Water Piping` tab:

- **`Pipe Material`:** Select the pipe material used.
- **`Pipe Diameter`:** Select the nominal pipe diameter in inches.
- **`Number of Bathrooms`:** Input the sum of all bathrooms in a building covered by the DHW device.

I-3.14 Auxiliary Heating Systems

Cabinet Unit Heaters / Electric Unit Heaters

If an electric heater serves a space within the certified envelope, the coverage of service should be calculated in one of two ways:

1. Area weighted coverage.
    a. Calculate the iCFA of the spaces served by the electric heater and divide by the total iCFA of the building.

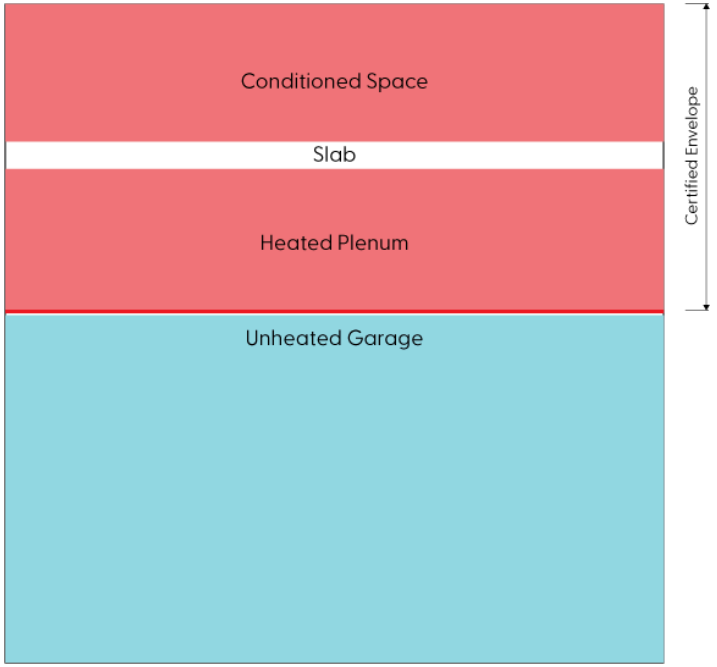
> **Example:** The stairwells in a multifamily building are served by cabinet unit heaters (CUHs) with no distribution from the main air source heat pump system. The iCFA of the stairwells sums to 1,600 ft^2 and the total iCFA of the building is 60,000 ft^2. The area-weighted coverage of the electric resistance system would be calculated as 1,600 / 60,000 = 2.7% (0.027 input for WUFI Passive / METr)

2. Capacity weighted coverage.
    a. Calculate the capacity of the electric heater(s) and divide by the total heating capacity of all heating systems (including the electric resistance system) in the building. If capacities are available at multiple temperatures, use the capacity at 47 °F.

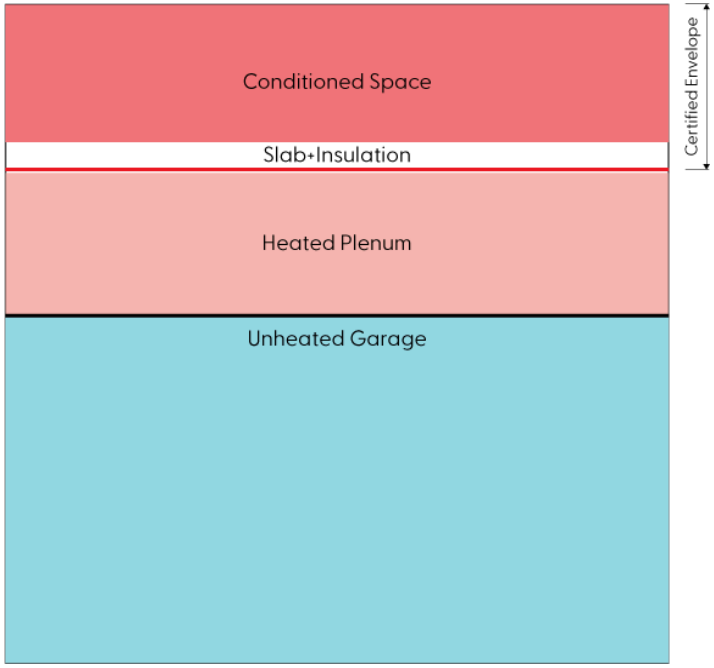
> **Example:** The stairwells in a multifamily building are served by cabinet unit heaters (CUHs) with no distribution from the main air source heat pump system. Four heaters are provided, each with a capacity of 5 kW. The rest of the building is served by an air source heat pump system with a combined capacity of 960 kBtu/hr. The capacity-weighted coverage of the electric resistance system would be calculated as:
> 4 x 5 kW x 3.412 Btu/hr / [(4 x 5 kW x 3.412) + 960 kBtu/hr] =
> 68 kBtu/hr / 1,028 kBtu/hr= 6.6% (0.066 input for WUFI Passive / METr)

Heated Plenums

Plenums that contain piping or other mechanical distribution systems may need to be freeze protected. Phius has seen two typical approaches to modeling this scenario. Follow the examples below for guidance.



1. Continuous insulation is provided below the plenum and it is considered to be within the thermal and airtight envelope of the building.
    - The heating system serving the plenum must be accounted for as an additional heating system under the devices within WUFI Passive or METr and assigned a coverage based on the capacity of the system
    - When modeling the assembly in WUFI Passive or METr, only model the exterior continuous insulation and finish material below the plenum (ignore air gap and interior floor/structure)



2. The insulation and air/vapor control are tight against the slab with the tempered plenum below
    - The plenum is considered to be outside of the thermal and airtight envelope of the building and requires the Phius Temperature Reduction Factor & Auxiliary Space Heating Estimator to determine the attached zone reduction factor and auxiliary energy associated with heating the plenum

> **Process Tip:** In this scenario, it is still important for the system hung below the plenum to be insulated and relatively well air-sealed to reduce energy loss

Duct Heaters

Preheat

A heating system in-line with the E/HRV **before** the ventilation air passes through heat recovery. Frost protection is accounted for automatically for mechanical ventilation equipment by checking the boxes for `Equipped with Frost Protection` and `Defrost Active`.

Post-Heat

A heating system in-line with the E/HRV **after** the ventilation air passes through heat recovery. Contact Us to receive an estimator to account for the coverage of this type of heating system.

I-3.15 Non-Rated Appliances

US Federal Standards are used where available, for all other defaults, an assumed 15% increase in energy use was assumed. These values are accepted as placeholders through Design Certification or until the appliance is selected. Project specific appliances should be confirmed for Certification.

Table I-3.15.0 Dishwasher

Water Connection	Reference Quantity	Energy Demand	Capacity
DHW	PH case occupants	307 kWh/yr	Standard (12)

Table I-3.15.1 Fridge / Freezer Combo

Size (cu ft)	Reference Quantity	Energy Demand Reference	Energy Demand
<10	PH Case Units or User Defined	Year	288 kWh/yr
15-20			504 kWh/yr
>20			766 kWh/yr

Table I-3.15.2 Freezer

Reference Quantity	Energy Demand Reference	Energy Demand
PH Case Units or User Defined	Year	438 kWh/yr

Table I-3.15.3 Clothes Dryers

Type	When Applicable?	Reference Quantity	CEF
Condensation	Ventless	PH case occupants	2.28
	Heat Pump		3.34
Exhaust Air	Electric		2.93
	Natural Gas		2.96

Table I-3.15.4 Clothes Washer

Reference Quantity	Energy Demand	Utilization Factor	Capacity	MEF
PH case occupants	127 kWh/yr	1	4.5 ft	2.25

I-3.16 Dynamic Modeling in WUFI Plus

Consider 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.

I-3.17 Commercial Kitchen Range Hoods

Due to fire code, range hoods in commercial kitchens must be un-dampered. Commercial kitchens also typically require a high volume of exhaust while cooking appliances are in use. Both of these conditions have an impact on whole-building airtightness and generally lead to an increase in space conditioning energy use.

Rather than compartmentalizing the commercial kitchen from the rest of the certified space, which requires additional detailing and construction sequencing considerations, the entire kitchen should be kept within the certification boundary. Allowances are available for projects that include commercial kitchen range hoods. Review the Phius Guidance and Testing Rules for Commercial Kitchens document for more information on whole-building airtightness testing protocol.

The following protocol is applicable for Occupancy Classes A-2, B and F-1. Approval of the method outlined below for other occupancy classes may be granted on a per-project basis. Contact Us early in design to request approval.

I-3.17.1 Design Certification Model

Follow the steps below during Design Certification review:

1. `Rooms / Ventilation` > `Exhaust Ventilation`: add a new line item and complete the following inputs:
    - **`Device Type`:** Set to `Other`
    - **`Exhaust Volume Flow Rate [cfm]`:** Enter the design airflow rate of the commercial range hood
    - **`Run Time per Year [min]`:** Calculate based on the daily operation schedule.

2. `Systems` > `System 1` > `Distribution` > `Supportive Device / Auxiliary Energy`: add a new line item and complete the following inputs:
    - **`Device Type`:** Set to `Other`
    - **`Quantity`:** Enter the quantity of range hoods
    - **`In Conditioned Space`:** Check this box
    - **`Energy Demand (rated) [W]`):** Enter the wattage of the range hood fan
    - **`Period of Operation [khr/yr]`:** Calculate based on the daily operation schedule

3. Determine if a make-up air system is required using the Phius Intermittent Exhaust & Make-Up Air Estimator. If an active system is planned refer to Section 1.4.4.21.

4. Duplicate the case. Remove inputs created in Steps 1 and 2 from the duplicated case.

5. Complete the Phius Commercial Kitchen Range Hood Allowance Estimator[71].
    - Update targets in WUFI Passive / METr

[71] Contact Us for this calculator.

I-3.17.2 As-Built Certification Model

Process Tip: Two cases should be included in the model from Design Certification. Remove Case 2, complete all as-built updates to Case 1, duplicate the case again, then follow the steps below.

Three whole-building airtightness tests should have been performed per the Phius Guidance and Testing Rules for Commercial Kitchens document. In the WUFI Passive/METr energy model, follow the steps below:

1. In Case 1, input the result from the **Operational** test.
    - This case should include the exhaust ventilation and auxiliary energy devices noted in Steps 1-3 for the Design Certification model above.

2. In Case 2, input the result from **Durability Test 1**.
    - This case should be treated as if the range hood and makeup air system (if applicable) do not exist. There should not be any exhaust ventilation or auxiliary devices associated with the commercial kitchen exhaust system

3. Update the Phius Commercial Kitchen Range Hood Allowance Estimator.
    - Update targets in WUFI Passive/METr

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.[72]

Maximum temperature difference (ΔT) =

6.0 °F for double-height spaces (≥16');

$14.7°\text{F} - (0.742\ x\ HHS(ft))$ for window head-height-from-sill HHS of 10 feet or less,

or $13.3°\text{F}$, whichever is less;

where the whole-window U is calculated as:

$$U = \frac{\Delta T}{\left[R_{si}\left(T_{air,inside} - T_d\right)\right]}$$

$$R_{si} = 0.74\ \frac{hrft^2°\text{F}}{BTU}$$

[72]The Efficient Windows Collaborative provides an easy-to-understand explanation of this concept here: Control Comfort - Efficient Windows Collaborative

$T_{air,\,inside} = 68°\text{F}$

$T_d = ASHRAE\ 99\%\ Design\ Temperature$ °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-2.2.
  - 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.
  - The location of the perimeter heating is an important consideration and must be located within 3' in plan (1 meter) of the window.
  - Perimeter heating may be provided from two distinct sources:
    a. Primary heat source **or**
    b. Supplementary heat source
       - Include the room with non-compliant windows in the capacity–weighted coverage calculation for multiple heating systems as outlined in Section 1.4.4.18

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[73]	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

[73] 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' 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" (z = Ts = solar transmittance), 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 & MELs 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". [74] 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). [75] 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:

$MEL = MEL_{DWELL} + MEL_{COMM} + MEL_{YARD}$ (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.
- $units_{k}$ 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.* [76]

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.

[74] RESNET, op.cit., Section 303.4.

[75] Wilson, E. et al. *2014 Building America House Simulation Protocols* (BAHSP). Golden, CO: National Renewable Energy Laboratory, 2014. Print. House Simulation Protocols Report - Buildings

[76] RESNET, op. cit., clause 303.4.1.7.2.1 "Residual MELs" and 303.4.1.7.2.6 "Televisions".

For itemization by floor *n*:

$$MEL_{DWELL} = \sum_{n}\left(units_{n} * 413 + 69 * Nbr_{n} + 0.91 * iCFA_{DWELL,n}\right) * 0.8$$

- *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.

Table N-7.0 Multifamily Common Space MELs [77]

Room Type	Electricity (kWh/yr)
Office	3.2 x iCFA
Workout room	9.8 x iCFA
Corridor / Restroom / Mechanical	0
Elevator	Varies[78,79]

[77] 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.

[78] 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.

[79] Alternate for elevators: More detailed calculations may be made using the following resource TKE 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.

Table N-7.1 Large Uncommon Electric & Gas Loads [80]

Appliance	Electricity [kWh/yr]	Natural Gas [therms/yr]
Pool heater (gas)	-	3 × Fscale
Pool heater (electric)	10.1 × Fscale	-
Pool pump	158.5 × Fscale	-
Hot tub/spa heater (gas)	-	0.87 × Fscale
Hot tub/spa heater (electric)	49 × Fscale	-
Hot tub/spa pump	59.5 × Fscale	-
Well pump	50.8 × Fscale	-
Gas fireplace	-	1.95 × Fscale
Gas grill	-	0.87 × Fscale
Gas lighting	-	0.22 × Fscale

- F_{scale} = (0.5 + 0.25 Nbr/3 + 0.25 iCFA/1920)
- 1 therm = 100 kBTU / [3.412 kBTU/kWh] = 29.3 kWh

[80] BAHSP, op. cit., Table 26.

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. [81]or light fixtures controlled by a photocell and motion sensor, are all considered high-efficacy.

Interior Lighting

For whole-building certification:

$LIGHTS_{INT} = LIGHTS_{INT,DWELL} + LIGHTS_{INT,COMM}$ (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*:

$$LIGHTS_{INT,DWELL} = \sum_{n}(0.2 + 0.8 * (4 - 3 * qFFIL)/3.7) * \left(units_{n} * 455 + 0.8 * iCFA_{DWELL,n}\right) * 0.8$$

[81] 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.

Table N-7.2 Multifamily Common Space Lighting[82]

Room Type	Operating Hours [hrs/day]	W/ft²
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/ft².
- $iCFA_{COMM}$ 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). Projects may also complete a custom calculation for

[82] Building America B10 Analysis – New Construction 2011-01-26 workbook, Detailed Lighting tab, C89:D101 and C120:L132

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

For whole-building certification:

$LIGHTS_{EXT} = LIGHTS_{EXT,DWELL} + LIGHTS_{EXT,COMM} + LIGHTS_{GAR}$ (kWh/yr)

- $LIGHTS_{EXT,DWELL}$ pertains to exterior lighting for the dwelling units (balcony/porch or general building lights). [83]
- $LIGHTS_{EXT,COMM}$ 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*:

$LIGHTS_{EXT,DWELL}$ =

$$\sum_n (1 - 0.75 * FFEL) * (units_n * 100 + 0.05 * iCFA_n) * 0.8$$

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.

[83] RESNET, op. cit., clause 303.4.1.7.2.3 Exterior Lighting, and equation 6.

Table N-7.3 Exterior Lighting[84]		
Room Type	**Operating Hours [hrs/day]**	**W/ft²**
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/ft².
- $iCFA_{COMM}$ 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 [85], 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.

Table N-7.4 Garage Lighting[86]		
Room Type	**Operating Hours [hrs/day]**	**W/ft²**
Parking Garage	24	0.2

[84] B10 Analysis workbook, op. cit.
[85] RESNET, op. cit., clause 303.4.1.7.2.4 Garage lighting, and equation 7.
[86] 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.

1. Duplicate the existing case, create a new 'test' case.

2. Add the dryers to the Exhaust Appliances tab in WUFI Passive or METr.

3. 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.)

4. Convert that to source energy using the COP and SE factor of the dryer. Divide by the source energy factor for electricity and input the result as an auxiliary electric load outside the thermal envelope.

5. 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.)

6. 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 Prescriptive Path

N-10.1 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-10.2 Solar Protection Criteria

Glazed fenestration solar heat gain coefficient:
Requirements vary by climate zone and align with DOE Efficient New Homes.

Fixed overhangs:
Required for south windows in hot climate zones, with a depth that depends on the latitude and window height.

N-10.2.1 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-10.2.1.1 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.

Process Tip: 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). [87]

N-10.2.1.2 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

[87] 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.

fits were all over 0.98. The general pattern was that some North 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.[88]

[88] 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

N-10.3 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-10.4 Mechanical Ventilation

N-10.4.1 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.)

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-10.4.1.0 Cooling Season Minimum Requirements

Climate Zone	Total Recovery Efficiency (TRE)
0A – 3A	60%
3B – 3C	NR
4A	50%
4B - 8	NR

N-10.4.2 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-10.4.3 Fan Efficiency

A limit on ventilation fan power was set based on the DOE Efficient New Homes 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-10.5 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-10.5.0 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 @ 5ºF ≥ 1.75 SEER ≥ 15	

N-10.6 Lighting, Appliances & Water Heating

N-10.6.1 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-10.6.2 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-10.6.3 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-10.6.4 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.
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 N-10.6.4.0 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[89] / 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	

[89] Amenity = 6.6 gal/person.day at 90F temperature rise * 1.25 operational waste factor, in kWh/person.yr.

N-11 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

$$E_{CHP} = \begin{cases} \text{the intended amount, for E-priority} \\ D_{HEAT}K_{COVG}\cdot\dfrac{\eta_{ELEC}}{\eta_{HEAT}}, \text{ for H-priority} \end{cases}$$

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

$$F_{H,CHP} = \begin{cases} 0, & \text{for E-priority} \\ F_{FUEL}/\eta_{HEAT}, & \text{for H-priority} \end{cases}$$

Appendix R - REVIVE 2024 Pilot

R-1 Process

Table R-1.0 Phius REVIVE 2024 Pilot Process Matrix

AIA Project Phases	Phius Benchmarks	Phase Summary
Pre-Design (PD)	**Phase 0** Programming	**R-1.1 Rationale for Retrofit** -Use the 'Program Plan' & 'Rationale for Retrofit' tabs within the Assessment & Investigation Workbook to determine whether retrofitting is the best choice for the building. **Multi-Facility Planning** -Project team creates initial Program Plan and establishes general scope of work to be completed
	Phase 1 Paperwork	**R-1.2 Inquiry** -Project team requests a contract.
	Milestone 1 Project Registered	**R-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	**R-1.4 Assessment & Investigation** -CPHC conducts existing building assessment and investigation, including the completion of the baseline energy model **R-1.4 Assessment & Investigation Review** -CPHC submits Assessment & Investigation deliverables to Phius -Phius Review & Feedback -CPHC Revisions & Response -Repeat (as needed)
	Milestone 2 Assessment & Investigation Approval	**R-1.5 Assessment & Investigation Approval** -Phius approves the Assessment & Investigation deliverables. An official letter of approval is sent to the design team.

Table R-1.0 Phius REVIVE 2024 Pilot Process Matrix (continued)

AIA Project Phases	Phius Benchmarks	Phase Summary
Design Development (DD) / Construction Drawings (CD)	**Phase 3** Design & Review	**R-1.6 Design** -CPHC completes the post-retrofit energy model & Design Workbook, iterating through multiple scenarios until the resilience criteria is met **R-1.6 Design Review** -CPHC document upload -Phius Review & Feedback -CPHC Revisions & Response -Repeat (as needed)
Bidding & Procurement	**Milestone 3** Design Certification	**R-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	**R-1.8 Onsite Review** -Rater/Verifier performs site visits and communicates all changes to the Submitter/CPHC -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	**R-1.8 Final Review** -Rater/Verifier Provider document upload -Phius Review & Feedback -Rater/Verifier Provider Response -Repeat (as needed)
	Milestone 4 Certification	**R-1.9 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 R-1.0 Phius REVIVE 2024 Pilot Process Matrix (continued)		
AIA Project Phases	**Phius Benchmarks**	**Phase Summary**
On-going Commissioning (OCx)	**Phase 5.1** Monitoring	**R-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)	**R-1.10 Ongoing Commissioning (OCx) & Monitoring Electives** -Additional monitoring and commissioning electives are encouraged for all projects, but **not** required

R-1.0 Note from Phius

The goal of the Phius REVIVE 2024 Pilot standard is to set requirements on the design and formalize the process by which project teams retrofit existing buildings. Many of these written-out processes are likely already part of the normal architectural process for existing buildings, but are expanded upon to include non-typical activities that are necessary to achieve the stringent quality assurance goals of the REVIVE 2024 Pilot Standard.

R-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 Pilot Standard for more detailed information and guidance on the programming phase.

R-1.1.1 Rationale to Retrofit

The Rationale for Retrofit tool is built-in to the Phius REVIVE 2024 Pilot 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[90] (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 Pilot Standard document for more detailed information on making this determination, and alternate pathways for buildings that may **not** be appropriate to retrofit.

[90] Shaw, Al, Abrahm Lustgarten, and Jeremy W Goldsmith. "New Climate Maps Show a Transformed United States." ProPublica, September 15, 2020.

R-1.1.2 Multiple-Facility Planning (optional)

Review Section 4.5.2 of the Phius REVIVE 2024 Pilot 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

R-1.2 Phase 1: Paperwork

Refer to Section 1.1.2

Exception: Where a habitable attic or habitable space in a basement is created in an existing building, ceiling height shall **not** be less than 6'-8". Bathrooms, toilet rooms, and laundry rooms shall have a ceiling height of **not** less than 6'-4"[91]

R-1.3 Milestone 1: Project Registered

Refer to Section 1.1.3

R-1.4 Phase 2: Assessment, Investigation & Review

R-1.4.1 Assessment & Investigation

Complete the Phius REVIVE 2024 Pilot Assessment & Investigation Workbook and compile all required documentation for Phase 2. Review Sections 8.6 and 8.7 of the Phius REVIVE 2024 Pilot Standard document for detailed requirements and additional recommendations.

R-1.4.2 Phius Review

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.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 Pilot 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 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 made by the Reviewer and may need to provide new or updated documentation.
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.

[91] Per 2024 IRC Section R313.1.2

7. When no remaining items need to be addressed for Assessment & Investigation Approval, the project moves to Phase 3: Design Review.

R-1.5 Milestone 2: Assessment & Investigation Approval

The CPHC 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 Pilot Standard document for more detailed information.

R-1.6 Phase 3: Design Review

R-1.6.1 Design

Complete the Phius REVIVE 2024 Pilot Design Workbook and compile all required documentation for Phase 3. Review Section 8.8 of the Phius REVIVE 2024 Pilot Standard document for detailed requirements and additional recommendations.

NOTE: The Phius REVIVE 2024 Pilot Design Workbook is still in development at this time. Check back regularly for when this document is released and available for use.

R-1.6.2 Phius Review

Refer to Section 1.1.4

Exception: The Phius REVIVE 2024 Pilot Design Workbook will act as the main form of communication between the Submitter/CPHC and Phius.

R-1.7 Milestone 3: Design Certification

Refer to Section 1.1.5

R-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 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 R-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 CPHC.
- The Submitter and/or CPHC 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 Pilot Implementation Workbook & Documentation Requirements are still in development at this time. Check back regularly for when this document is released and available for use.

R-1.9 Milestone 4: Certification

Refer to Section 1.1.7

R-1.10 Phase 5: Monitoring & Ongoing Commissioning (OCx)

The project is officially handed-off to the Owner by the project team. The project team should deliver and review the Ongoing Commissioning (OCx) Plan. Review Section 8.11 of the Phius REVIVE 2024 Pilot Standard document for more detailed information on process requirements and recommendations.

Process Tip: Ongoing Commissioning (OCx) is a continuation of Commissioning (Cx) well into occupancy and operations to continually improve the operation and performance of a facility to meet current and evolving Current Facility Requirements (CFR). Ongoing Cx activities occur throughout the life of the facility; some of these will be close to continuous in implementation, and others will be either scheduled or unscheduled as needed.

R-1.11 The Phius REVIVE 2024 Pilot Workbooks

The Phius REVIVE 2024 Pilot Workbooks will act as the main channel of communication between Phius and the project Submitter/CPHC 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/CPHC 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.

R-1.12 Review Timeline

Refer to Section 1.1.9

R-2 Fee Schedule

Refer to Section 1.2

R-3 Requirements

Table R-3.0 Phius REVIVE 2024 Pilot: 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 R-3.2.3
Hazard Mitigation[92]			
Earthquake	Refer to Section R-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 R-3.4.3		
Airtightness	Blower door testing is required to show compliance with limits outlined in Section R-3.4.2		
Moisture Risk Mitigation & Comfort[93]	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 R-3.4.4		

[92] Where geographically relevant.

[93] Once available, 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 R-3.1 Phius REVIVE 2024 Pilot: 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.**[94]
Off-Site Renewables	**Not credited.**	**Credited with utilization factors applied as outlined in Appendix N-4.**
Battery Storage	**Battery readiness required.**	**Required.**[95]
Combustion Equipment, Appliances & Fireplaces		
Space Heating (natural gas furnace, boiler etc...)	**Not Allowed**[96]	**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.	

[94] **Exception: 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.

[95] **Exception:** Alternative non-fuel-based and electrically-interacting energy storage is also permitted, such as electrochemical or gravity batteries, flywheels, compressed air, pumped hydroelectric, etc.

[96] **Exception:** On-site stored combustion fuel is permitted for emergency backup electricity generation and/or outdoor cooking only.

R-3.1 Scope Limitations

The Phius REVIVE CORE 2024 & Phius REVIVE ZERO 2024 Certification Programs are applicable to retrofit existing buildings with new construction additions less than or equal to 20% of the floor area of the existing building.

Exceptions:
Refer to Section 1.3.1 for retrofit of existing buildings with additions greater than 20% of the floor area of the existing building.

Garages are **not** permitted to be included in the Certification scope or within the Certified enclosure.

Process Tip: Refer to Section 1.3.1 for general rules about spaces included/excluded from Certification.

R-3.2 Co-Requisite Requirements

All electives listed in the Phius REVIVE 2024 Pilot Standard document are entirely up to the discretion of the project team to pursue, but are outside of the scope of Phius Certification.

R-3.2.1 Personnel Required

Refer to Section 1.3.2.1.

R-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

R-3.2.3 Energy Star Portfolio Manager

Refer to Section R-3.5 above.

R-3.2.4 EPA Indoor AirPlus

Additions and expansions are required to comply with the requirements outlined in Construction Specifications Version 1 (rev. 04).

R-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.

Multifamily & Non-residential:

Multifamily New Construction (MFNC) Version 1.2. Refer to Section 1.4.1.2 & Section 1.5.3.

R-3.3 Hazard Mitigation

Refer to Section 5.2 of the Phius REVIVE 2024 Pilot Standard for detailed requirements and available electives where geographically applicable.

Process Tip: 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.

R-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

R-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)

R-3.3.3 Hail

Roof-mounted PV modules must have passed one of the following hail tests:

- FM Approved for hail
- FM Approval Standard 4476 (Severe Hail rating)
  - For Flexible PV Modules
- FM Approval Standard 4478 (Class 4 rating) or UL 1703
  - For Rigid PV Modules
- RETC Hail Durability Test
- PVEL Hail Stress Sequence
- IEC 61215-2:2021 hail test, with:
  - 50mm diameter ice balls or larger

R-3.3.4 Structural & High Wind

Applies to single family, duplexes, and townhouses on a dry stack foundation and/or when the Ultimate design wind speed (V_{ult}) 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

R-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)

R-3.3.6 Wildfire

Applies to all projects with FEMA Risk: Relatively Moderate, Relatively High, or Very High.

- Berkeley Fire Dept Checklist

R-3.4 Performance Requirements

Refer to Section 6 of the Phius REVIVE 2024 Pilot Standard for detailed requirements.

R-3.4.1 Simulation Requirements

Refer to Section 6.1 of the Phius REVIVE 2024 Pilot Standard for detailed requirements.

All Phius projects must use the Phius REVIVEcalc for certification purposes. See Section R-4.2 for more information about the tool.

R-3.4.2 General Resilience

Enclosure Air-Sealing

Refer to Section 6.2.1 of the Phius REVIVE 2024 Pilot 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.)

R-3.4.3 Seasonal Resilience

Winter Resilience

Refer to Section 6.3 of the Phius REVIVE 2024 Pilot 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 Pilot

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 Pilot

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 Pilot 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 Pilot

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 Pilot

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

R-3.4.4 Life Cycle Cost & Impact Control

Refer to Section 6.5 of the Phius REVIVE 2024 Pilot Standard for detailed requirements and available electives.

Life Cycle Cost Limit

Per Section 6.5.1 of the Phius REVIVE 2024 Pilot 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 Pilot Standard, additional decarbonization strategies must be employed as described below.

Operational Decarbonization

Refer to Section 6.5.2.1 of the Phius REVIVE 2024 Pilot Standard for detailed requirements and available electives.

Phius ZERO REVIVE 2024 Pilot:

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 Pilot:

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 Pilot 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).

R-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 Pilot Standard document.

R-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 Pilot Standard document for more detailed information.

Process Tip: 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.

R-4 Assessment and Investigation

Table R-4.0 Required Documentation for Phius REVIVE 2024 Pilot: 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

R-4.1 Required Documentation

Every retrofit project must first begin with assessment and investigation of the existing conditions. Table R-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 Pilot Assessment & Investigation Workbook. Review the expanded sections below for detailed guidance on using and completing the Assessment & Investigation Workbook.

Table R-4.1.0 Required Documentation for Phius REVIVE 2024 Pilot: Phase 2 - Assessment & Investigation			
Compliance Tool			**Phius 2024 REVIVEcalc Results & Supporting Documentation**
Additional Documentation[97]			DOE Multifamily Building Efficiency Screening Tool (MBEST) Workbook
Phius REVIVE 2024 Pilot Assessment & Investigation Workbook	**Issues & Resolutions Log**		Feedback channel between project 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: The Commissioning Plan & Report are **not** separate documents. They will be generated in the background as the workbook sections are completed. PDFs of these will be generated by Phius upon completion of the Assessment & Investigation Phase.		
	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**[98]**)**	Regulatory, financial, & functional requirements
			On-going commissioning (OCx)
			Facility Summary
		Additional Reports	IAQ Assessment & Investigation Reports
			Initial Performance Modeling Report
			Site hazard risk report

[97] For Multifamily residential projects only
[98] New Construction equivalent → Owner's Project Requirements (OPR)

R-4.1.1 Compliance Tool

All Phius REVIVE 2024 Pilot projects must use the Phius 2024 REVIVEcalc for certification compliance. Refer to Section R-4.3 below for modeling protocol using this tool. Review Section 6 of the Phius REVIVE 2024 Pilot Standard document for detailed information on simulation requirements and calculation details.

Supporting Documentation

To confirm all inputs in Phius 2024 REVIVEcalc, the project 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
  - Assemblies
- Existing appliance information/assumptions
- Proposed design drawings (schematic)[99]

R-4.1.2 Issues & Resolutions (I&R) Log

The Issues & Resolutions log should be used by the project team to communicate and track information about issues that arise during the assessment & investigation phase. The CPHC 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.

R-4.1.3 Updated Program Plan (Multiple Facility Planning only)

Review Section 4.5.2 & 4.5.3 of the Phius REVIVE 2024 Pilot 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 project 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 Pilot 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 project team should re-evaluate the rank for each building and record the finalized order in the Multi-Facility Program Plan.

R-4.1.4 Rationale for Retrofit

Review Section 4.5.1 of the Phius REVIVE 2024 Pilot Standard document for detailed information on making the initial determination of whether a building should be excused from retrofit.

[99] Only applicable if there is a change in occupancy, dwelling units, building function, or floor area (i.e. new additions)

In the Phius REVIVE 2024 Pilot Assessment & Investigation workbook, the CPHC should complete the Rationale for Retrofit worksheet.

Process Tip: The Rationale for Retrofit worksheet will automatically generate a 'Final Consideration' statement and prompt the CPHC to acknowledge and accept the recommendation. This recommendation is based on the information provided in the Program Plan and Rationale for Retrofit worksheets, and considers maintenance needs, intended building life, and climate migration risk. The recommendation is **not** an official acceptance or rejection of the project to pursue Certification.

R-4.1.5 Site Hazard Risk Worksheet

The project team should use the Hazard Mitigation Worksheet in the Phius REVIVE 2024 Pilot 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.

R-4.1.6 Owner Worksheet

The intent of the owner worksheet is for the CPHC 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 CPHC.

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 CPHC 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.

R-4.1.7 Current Facility Requirements (CFR)

Facility Requirements

The CPHC 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 is limited to 15 Current Facility Requirements (CFR) items (5 elected requirements per category). It is at the project team's discretion to decide how many CFR items to include. 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?

Process Tip: The Current Facility Requirements (CFR) deliverables above will **not** be reviewed for Certification. They are included in the Workbook for the project team to track non-Certification deliverables that are still necessary to include in their scope of work.

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: Critical loads & occupancy for non-residential projects are required to verify the assumptions in the energy model, as it relates directly to the battery sizing requirements of the project.

Ongoing Commissioning (OCx) and Measurement & Verification Electives

The CPHC 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 for Certification, but all project teams are encouraged to review Section R-3.6 on the value of collecting project data for future development.

Exception: Non-residential projects are required to register with Energy Star Portfolio Manager and track energy and water utility meters. Access to the Portfolio Manager must be granted to Phius upon final Certification.

Facility Summary

The initial Current Facility Requirements (CFR) should be completed by creating the facility summary. The project team should review all of the project information gathered up to this point, and write a brief summary of the findings.

R-4.1.8 IAQ Assessment Worksheet

The CPHC 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 project 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 CPHC 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 project 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 CPHC 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 CPHC should then update the status of each Assessment Protocol item by marking it as resolved, requires

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 CPHC should update the Current Facility Requirements (CFR) Worksheet with new findings, record new requirements, or eliminate remediated requirements.

R-4.1.9 IAQ Investigation Worksheet

The CPHC 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 project 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 CPHC should use the 'Planning' column of the Investigation Worksheet to plan the investigation or testing methods for the remaining IAQ Assessment Protocol items that were deferred during the initial assessment. The intent of this worksheet is for the project 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 CPHC 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 CPHC 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 CPHC should update the Current Facility Requirements (CFR) Worksheet with new findings, record new requirements, or eliminate remediated requirements.

R-4.1.10 Initial Performance Modeling Worksheet

Review Section R-4.2 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 existing project documentation, then provide feedback in the form of requesting modeling revisions or documentation clarifications.

R-4.2 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[100]. 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

[100]The DOE flagship energy modeling engine

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.

R-4.3 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

R-5 Design

R-5.1 Required Documentation

Upon completion of the Assessment & Investigation phase, the project team should iterate different retrofit approaches using REVIVEcalc until the design meets all of the resilience criteria required for Certification. 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 Pilot Design Workbook, which will be issued to the project team upon Assessment & Investigation Approval.

Table R-5.1.0 Required Documentation for Phius REVIVE 2024 Pilot: Phase 3 - Design

Phius REVIVE 2024 Pilot Design Workbook		**Issues & Resolutions Log**	Feedback channel between project team members
	Existing Buildings Commissioning (Cx) Plan - Part 2	**Current Facility Requirements (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
		Retrofit Phase Plan	Complete the workbook sections relating to phased retrofits
	Existing Buildings Commissioning (Cx) Report - Part 2	**Design Review Report**	This report will be generated in the background of the Design Workbook
		Additional Documents	Refer to Section 1.4.2 for a comprehensive, but non-exhaustive list of possible required design documentation[101,102]

[101] Required documentation for retrofit projects is based on the specific selected approach. **Not** all projects will have the same documentation requirements.

[102] **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

NOTE: The Phius REVIVE 2024 Pilot Design Workbook is still in development at this time. Check back regularly for when this document is released and available for use.

R-5.1.1 Issues & Resolutions Log

The Issues & Resolutions log should be used by the project 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.

R-5.1.2 Current Facility Requirements (CFR) Deliverables Plan

Regulatory, financial, functional, and ongoing commissioning electives defined in the Current Facility Requirements (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 CPHC should report the following information in the Design Workbook:

Regulatory, Financial, & Functional Electives

- Design category
    - Envelope (assemblies, airtightness)
    - Mechanical systems (HVAC, plumbing, appliances)
    - Functional (i.e. reconfiguration of a space into a bedroom)
- Solution summary

Ongoing Commissioning (OCx) and Measurement & Verification Electives (M&V)

- Narrative describing approach to monitoring for each elected Measurement & Verification (M&V) item
- For non-residential projects, register the project with EnergyStar Portfolio Manager

R-5.1.3 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 / CPHC 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 #)

R-5.1.4 Passive Systems Plan

All Passive Systems Planning tabs in the Design Workbook will be designated with a 'P-' before the name of the section (i.e. P-Opaque Assemblies). The CPHC must complete all necessary sections related to the post-retrofit envelope, which will be cross-referenced with the REVIVEcalc Databases to confirm alignment. Refer to the bulleted list below for guidance on completing the corresponding tabs in the Design Workbook:

P-Opaque Assemblies

1. Input material name and R-value/in for opaque assemblies. Separate sections are included in the worksheet for:

a. Walls
b. Ceilings / Roofs
c. Floors / Slabs

2. Expand each section to build assemblies (similar to the process in the Prescriptive Checklist) by following the steps below:
    a. Name the assembly
        i. The naming convention used in the worksheet should align with the assembly name in the Construction Database for REVIVEcalc
    b. Choose the corresponding Assembly Type per Appendix B
        i. If none of the pre-defined options fit the configuration of the assembly, choose 'User Defined'
    c. Select materials for each assembly layer using the dropdown options
    d. Input layer thickness in inches
    e. Use the 'Framing & Fasteners' dropdowns in-line with each layer if applicable
3. Refer to the calculated material conductivity & thicknesses to implement the materials into the REVIVEcalc Material Database
4. Define the CO2e (kg/m^2) and cost ($\$/m^2$) for the entire assembly. Note the source of the information in the corresponding cells of the worksheet.

Process Tip: For each assembly, the total effective R-value will be calculated in-line with the assembly name. This worksheet will also determine whether the assembly meets the hygrothermal requirements outlined in Appendix B, unless a 'User defined' assembly type is selected. In this case, the assembly will require further Phius review to confirm compliance.

P-Fenestration

1. Indicate documentation location (detail / sheet #) to verify window quantities, sizes, & types
2. Indicate operable window area for each facade orientation
    a. Takeoffs should be provided for review to verify these inputs
3. For each window type, indicate where the windows are assigned in the model
4. Define construction database information
    a. CO2e/m^2 (kg/m^2)
    b. Cost ($\$/m^2$)
    c. Lifetime
    d. Labor fraction
5. Define whole-window performance values
    a. U-factor
    b. SHGC

P-Airtightness & Details

1. Define the Chi-value of all thermal bridges in the project
    a. Chi-value = TB psi-value x TB length
2. Define the target airtightness of the project
    a. Refer to Section R-3.4.2 for Certification limits
3. Provide a red-line section diagram showing the continuity of the air barrier
4. Provide detail & sheet numbers for review of critical junctions. Details may include, but are **not** limited to:
    a. Wall-to-slab
    b. Rim joists
    c. Wall-to-roof
    d. Overhang / canopy attachments

R-5.1.5 Active Systems Plan

Complete the Active Systems Plan in the Design Workbook. The CPHC must complete all sections for the post-retrofit mechanical systems and appliances, which will be cross-referenced with the REVIVEcalc Databases, Runlist and/or drawing set(s) to confirm alignment. Refer to the bulleted list below for for guidance on completing the Active Systems plan within the Design Workbook:

Ventilation System

- Define the continuous balanced ventilation airflow rate
    - Confirm minimum airflow rates for kitchens / bathrooms are met
- Define the BOD manufacturer / model number for ventilation equipment, as well as the performance data, including:
    - Sensible recovery efficiency
    - Latent recovery efficiency
- Indicate if any direct-exhaust is planned, as well as the location and airflow rate

Domestic Hot Water

- Define the BOD manufacturer / model number for water heating equipment
- Indicate whether DHW Recirculation is planned

Heating & Cooling

- Define the BOD manufacturer / model number for space conditioning equipment, as well as the performance data, including:
    - Annual heating COP
    - Annual cooling COP

Renewables

- Define the array size (W), tilt & azimuth (°) of the proposed PV system if applicable

Appliances

- Define information about the appliances if replacement is within the scope of the retrofit, including:
    - Manufacturer / model number
    - Cost of equipment ($)
    - Energy consumption (kWh/yr)
    - Lifetime (years)
    - Labor fraction of cost to install equipment

R-5.1.6 Site Hazards Mitigation Plan

Only where geographically applicable, CPHC must complete the Site Hazards Mitigation Plan Worksheet to confirm compliance with the requirements defined in Section R-3.3. To do so, the CPHC must report the following information in the Design Workbook:

- Solution summary
- Supporting documentation location, if applicable (i.e. detail / sheet / note #)

R-5.1.7 Retrofit Phase Plan

Complete the Phase Plan Worksheet. First, indicate whether the project will be completed in one phase, or over several phases. If implementation will occur in phases, indicate the timeline and scope for each phase.

R-5.1.8 Performance Modeling & Additional Documents Worksheet

Review Section R-4.2 for more information on the REVIVEcalc Modeling tool.

Complete the Additional Documents Worksheet within the Design Workbook to verify that all of the required project documentation has been collected and uploaded to the project Dropbox folder for review. This checklist includes REVIVEcalc files, LOI from the Rater/Verifier, and other applicable miscellaneous documentation needed for Design Certification.

Example: 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 project team may be asked to provide during design review to confirm design solutions will be sufficient in satisfying all project deliverables.

- 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...

R-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.

R-6 On-Site

R-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 R-6.1.0 Required Documentation for Phius REVIVE 2024 Pilot: Phase 4 - Implementation

Phius REVIVE 2024 Pilot Implementation Workbook		**Issues & Resolutions Log**	Feedback channel between project team members
	Existing Buildings Commissioning (Cx) Plan - Part 3	**Final Current Facility Requirements (CFR) Report**	Add additional CFR deliverables to the Implementation Workbook as needed
		Final Phase Report	If doing a phased retrofit, use the Phase Planner to track phase deliverables, construction schedules, completion of phases, etc.
		Final Measurement & Verification (M&V) Report[103]	Use the M&V Planner to schedule and track the completion of M&V requirements
	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 with any changes that arose 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 REVIVE 2024 Pilot QA checklist[104] to verify that all tests have been performed and that all documentation has been collected and

[103] Required for non-residential projects only (Energy Star Portfolio Manager)

[104] **NOTE:** The REVIVE 2024 QA Checklist is still in development at this time.

			provided to Phius for Final Review

NOTE: The Phius REVIVE 2024 Pilot 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 Tip:
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 CPHC 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-2.3

R-6.1.1 Issues & Resolutions Log

The Issues & Resolutions log should be used by the project 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 CPHC 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 project team will be asked to provide one, or resolve the issue.

R-6.1.2 Final Current Facility Requirements (CFR) Report

Regulatory, functional, financial, and monitoring electives addressed during design in the Current Facility Requirements (CFR) Deliverables Plan of the Design Workbook during Phase 3 should be carried over to the Final CFR. For each deliverable, the CPHC should report the following information in the Implementation Workbook:

Regulatory, Financial, & Functional Electives

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)

R-6.1.3 Final Phase Report

Applicable to phased retrofits only. The Phase Plan established during the Design Phase will be carried over to the Implementation Workbook. Use the Phase Planner tab to track the following:

- 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 project team should upload relevant documents as they become available to the project Dropbox.

R-6.1.4 Final Measurement & Verification (M&V) Report

For non-residential projects only. Provide access information to the project's Energy Star Portfolio Manager.

R-6.1.5 Executive Summary

The project team should review and summarize all of the implemented project deliverables for the executive summary.

R-6.1.6 Final Findings & Recommendations

The final findings & recommendations should include plans for possible future improvements and lessons learned during the implementation phase.

R-6.1.7 New Discovery Report

The project team should report on any new findings during implementation.

Process Tip: This may include IAQ Assessment protocol items that could **not** be addressed previously.

R-6.1.8 Final Testing & Verification Reports

The project team should complete the final Implementation Worksheets in the Phius REVIVE 2024 Pilot Workbook.

Typical Verification Reports

The following testing should be performed in compliance with the corresponding New Construction requirements described in Sections 1.5.2.3-1.5.2.9 above:

Exception: Additional blower door testing methods are outlined in Section 8.9.4.1 of the Phius REVIVE 2024 Pilot Standard. Compartmentalization requirements do **not** apply to single family or non-residential projects.

Site Hazard Verification Documentation

Where geographically applicable, the project 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)

Refer to Section R-3.3.3 Hail above.

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)

R-6.2 Co-Requisite 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 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 R-6.2.0 Co-Requisite 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[105]	Version 1, Rev. 4	
EPA Energy Star[57]	EPA ENERGY STAR Certified Homes v3.2	Multifamily New Construction (MFNC) v1.2
FEMA[106]	P-50-1, P-348 & P-804 (Sec 4.1)	-
IBHS FORTIFIED	Home (Section 3)	Commercial (Sections R-1) Commercial Silver (Sections R-2.4 & R-2.5)

[105] 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.

[106] Only where geographically applicable.

Congratulations! You've made it to the end of the Phius 2024 Certification Guidebook v26.1.2. Thank you for reading and supporting Phius. As a reward, you have earned a secret CEU code (worth 1 CEU).

Self-Report CEU Code: 26984