ETHOS BUILDERS

Phius Core 2021 Construction Curriculum

Project R.271 — Kapicka Residence

2735 N Vista Road, Arlington Heights, IL 60004
Architect: Tom Bassett-Dilley Architects (TBDA)

AUDIENCE

This curriculum is written for two audiences: Ethos Builders internal staff (superintendent, lead carpenter, project manager) and external trade partners working on this project (framing, insulation, mechanical, electrical, concrete). The content is shared because Phius work requires every party to understand the building-science logic behind the details, not just execute them. Role-specific modules in Phase 4 are designed to be excerpted and distributed to subs as standalone training materials.

Version 1.0 | May 2026 | Prepared by Ethos Builders Preconstruction

About This Curriculum

Purpose

Phius Core 2021 certification is not a checklist. It is a building-science discipline that demands every trade understand how the assembly works as a system. A framer who taps a nail through the air barrier without thinking — a mechanical sub who pulls a wire through an unsealed grommet — a concrete sub who tears the sub-slab vapor barrier and patches it with the wrong tape — any of these will compromise the certification. This curriculum exists so that every person on the R.271 project has the foundation to recognize a problem before it becomes a problem.

This is Ethos Builders' first Phius Core 2021 project. The investment in training pays back across this project and every Phius project that follows.

How to Use This Document

If you are Ethos internal staff (Superintendent, Lead Carpenter, PM)

Read all five phases. The building-science foundations in Phase 1 are the basis for every field decision you will make on this project. Your role module in Phase 4 lists the specific QA responsibilities that fall to you.

If you are a trade partner (subcontractor or trade lead)

You should read Phases 1, 2, and 3 to understand what Phius is, why this project is different from your typical work, and how the assembly is designed. Then read your role-specific module in Phase 4 (Section 4.3 framing, 4.4 insulation, etc.). The Phase 5 resources point you to deeper training when you want it.

If you have not done Phius work before

That is normal — Phius is a small but growing segment of residential construction. The expectation is not prior experience, it is willingness to learn and apply the details correctly. Phase 1 is intentionally written from first principles. Take the time.

Why Building Science First

The decision to write this curriculum from a foundational building-science standpoint — rather than as a series of "do this, don't do that" task lists — is deliberate. Building science is not academic. It is the explanation for every detail on the plans. Once you understand why a smart vapor membrane exists, you understand why we cannot substitute regular poly. Once you understand how a wall dries, you understand why we cannot trap moisture between two impermeable layers. Once you understand convective looping in fiberglass batt, you understand why dense-pack cellulose is specified instead. The why makes the what stick.

> **Time Investment:** Plan for 6–10 hours of reading to work through this curriculum carefully. For Ethos lead staff, budget an additional 30–40 hours of self-study using Phase 5 resources (Phius Builder's Track, BSC papers, 475.supply training). This is professional development that compounds across every future high-performance project.

Phase 1: Building Science Foundations

This phase covers the physics that govern how buildings work. Every other phase of this curriculum — every detail on the plans, every product on the schedule — is an application of these principles. Read this phase in order. The sections build on each other.

1.1 The Four Control Layers

Every building envelope must control four flows: water (bulk liquid water), air (mass movement of air carrying heat and moisture), vapor (water in gas form, which moves by diffusion), and thermal energy (heat). These are the four control layers. Building-science orthodoxy, formalized by Joseph Lstiburek of Building Science Corporation, holds that every component of the envelope serves one or more of these functions. A successful envelope addresses all four — but importantly, treats them as separate problems with separate physics.

Why this matters for Phius

Code-minimum construction can be sloppy about distinguishing these layers because the performance targets are low enough that overlapping deficiencies cancel out. Phius performance targets are five to ten times tighter than code, so each control layer must be designed and built with intention. A vapor strategy that is also accidentally an air barrier is not acceptable on a Phius job; the air barrier needs to be the air barrier, and the vapor strategy needs to be the vapor strategy.

The four layers, in order of priority

Water (highest priority)

Liquid water — rain, snowmelt, splashback, plumbing leaks. Water is the most destructive force on any building. The water control layer is typically the housewrap (or in our case the ZIP System sheathing) on the exterior, with flashing details at every penetration, window, door, and transition. Water control is so dominant that if a detail is in conflict between water and air, water wins.

Air

Bulk movement of air through the envelope. Air carries heat (a one-square-inch hole in an air barrier can move as much moisture as a 32-square-foot area of vapor diffusion) and creates the energy losses that drive heating and cooling demand. The air control layer must be continuous around the entire envelope — six sides, sealed at every transition.

Vapor

Water in gas form, moving by diffusion. Vapor moves from warm-and-humid to cool-and-dry, regardless of pressure or wind. The vapor control strategy is not a single layer but an assembly logic: the wall must be able to dry in at least one direction, and ideally both. "Vapor open" and "vapor closed" are relative terms — there is no truly impermeable material in residential construction (even glass is slightly permeable), and there is no truly vapor-open material either.

Thermal

Heat flow by conduction (through solids), convection (through air movement), and radiation (between surfaces). The thermal control layer — your insulation — only works if the air and water layers are doing their jobs. Wet insulation does not insulate. Air-leaking insulation does not insulate.

> **Lstiburek's Rule:** If any one of these four control layers is interrupted, the others cannot compensate. A perfect air barrier with a leaking roof is a failed envelope. A perfect water control system with a leaky air barrier is a failed envelope.

1.2 Heat Transfer — The Three Modes

Heat moves three ways. Different materials and assemblies address different modes. Understanding which mode you are fighting changes which product you choose.

Conduction

Heat moving through a solid. A steel stud is a thermal bridge — heat conducts through it from the warm side to the cold side, regardless of how much fiberglass surrounds it. Wood is also conductive (less than steel, more than insulation). This is why exterior continuous insulation matters — it breaks the conductive path through framing. R-value is primarily a measure of resistance to conduction.

Convection

Heat moving via air movement. Hot air rises, cold air falls. Inside a fiberglass batt that is not perfectly fit, air loops within the cavity — warm air rises along the inside face, cools at the top, falls along the outside face, warms at the bottom. This convective loop transfers heat far faster than conduction through the fiber. Dense-pack cellulose stops this loop by filling every void. Closed-cell spray foam stops it by being a closed-cell material. This is one of several reasons Phius walls do not use batts.

Radiation

Heat moving between surfaces without contact, via infrared. Two surfaces of different temperatures will exchange radiant heat across an air gap. Low-e coatings on window glazing reflect radiant heat. Radiant barriers in attics reflect summer heat. In a Phius wall, radiation is a minor factor — the dominant thermal modes in a heavily insulated assembly are conduction (through framing) and convection (within cavities, if not properly filled).

1.3 Air and Vapor Are Different Problems

This is the single most-misunderstood concept in residential construction. Many builders treat "air barrier" and "vapor barrier" as synonyms. They are not.

Air moves by pressure

Wind pushes air against the windward side of a house. The stack effect (warm air rising inside) creates pressure differentials between bottom and top. Mechanical systems (range hoods, clothes dryers, bath fans) create pressure differences. Air follows pressure gradients through any hole, crack, or gap. Air moves quickly — at Phius airtightness levels, a hole the size of a quarter measurably moves the blower-door number.

Vapor moves by diffusion

Water vapor moves from warm-and-humid to cool-and-dry, independent of air movement. It moves through materials, not just through holes. Even continuous, well-sealed materials like drywall and OSB are slightly vapor-open. Vapor diffusion is slow — orders of magnitude slower than air movement.

Why this distinction matters

In Phius construction, the air barrier must be continuous and tight (Phius Core 2021: 0.05 CFM50/ft^2 or 0.69 ACH50). The vapor strategy, by contrast, is intentionally non-uniform — we use a smart vapor membrane (Pro Clima Intello Plus or Rothoblaas ClimaControl 80) on the interior that is variable permeability: tight in winter when vapor is moving outward, open in summer when vapor is moving inward. The membrane responds to ambient humidity. This is why we cannot substitute regular 6-mil poly — poly is a fixed vapor barrier and will trap moisture in summer, leading to mold and rot.

The double air barrier on R.271

This project uses a dual air barrier strategy: the exterior ZIP System sheathing (with seams taped per Huber spec) serves as the primary air control layer, and the interior Intello Plus membrane (with seams taped per Pro Clima spec) serves as the secondary air control layer. Both must be continuous. The redundancy is intentional — at Phius airtightness targets, single-layer strategies are too easily defeated by a single missed detail.

1.4 Hygrothermal Behavior — Why Walls Dry

Every wall assembly must be able to dry. Materials get wet from many sources — bulk water infiltration during construction, vapor diffusion, air-leakage-carried moisture, even moisture in the lumber as it dries to equilibrium with the indoor humidity over the first year. If the wall cannot dry in either direction, that moisture is trapped, and you grow mold or rot wood.

Drying directions

A wall can dry inward (into the conditioned space) or outward (to the outdoors). In Chicago Climate Zone 5, heating-dominated, walls primarily dry outward in winter (because the outdoors is colder and drier than the indoor space) and inward in summer (because indoor air is cooler and drier than humid outdoor air, especially when air-conditioned). A wall that can only dry in one direction will work in some seasons and fail in others.

WUFI — what it is and why TBDA does it

WUFI (Wärme-Und-Feuchte-Instationär — heat and moisture, transient) is the industry-standard hygrothermal simulation software. It models how heat and moisture move through a wall assembly over time, accounting for climate, indoor conditions, and material properties. For Phius work, WUFI analysis is typically performed by the architect or Phius rater on critical wall sections to verify the assembly will not accumulate moisture over time. TBDA likely performed this analysis on R.271 — confirm with the project architect.

What this means in the field

Every detail on this project is designed assuming the WUFI model holds. If a sub installs a vapor barrier on the wrong side, or substitutes a less-permeable membrane for the smart membrane spec, the WUFI model no longer applies, and the wall may not dry. This is one of the reasons substitution requires Phius rater approval — small changes can break the hygrothermal logic of the assembly.

> **Field Translation:** Substituting a product is not a value-engineering decision in Phius work. Every product on this project's BOD (Basis of Design) was selected to work in a specific assembly with specific climate inputs. Substitutions require written approval from the Phius rater. No exceptions.

1.5 Phius vs. Code Minimum — The Performance Gap

Illinois has adopted the 2021 International Energy Conservation Code (IECC) for residential construction. The IECC requires R-21 in walls, R-49 in ceilings, R-30 in floors over unconditioned space, and an air infiltration target of 3.0 ACH50 (Climate Zone 5). These targets, while meaningful improvements over older code cycles, are still significantly below Phius performance.

The Phius Core 2021 standard for R.271:

Performance Metric	Value
Wall R-value	R-43.7 (double-stud, dense-pack cellulose)
Roof R-value	R-84 (raised-heel scissor truss, loose-fill cellulose)

Sub-slab R-value	R-20 (4" XPS or EPS continuous under slab)
Airtightness target	0.05 CFM50/ft² of envelope area, or 0.69 ACH50
Windows	Triple-pane uPVC (Zola Thermo) — U ≈ 0.14
Ventilation	CERV2 ERV with smart climate response
Heating/cooling	Geothermal heat pump — all-electric

What the performance gap means in practice

At code-minimum 3.0 ACH50, a 30,000 cubic-foot house leaks 1,500 cubic feet of air per minute at test pressure. At Phius 0.69 ACH50, the same house leaks 345 cubic feet per minute — about four times less. This is the difference between "reasonably tight" and "actually controlled." At code-minimum air leakage levels, mechanical ventilation systems struggle to deliver consistent fresh air because uncontrolled infiltration overwhelms them. At Phius airtightness, the ventilation system actually controls indoor air quality — which is what it was designed to do.

1.6 Climate Zone 5 — What Chicago Means for Wall Design

Arlington Heights, Illinois is in IECC Climate Zone 5A — cold and humid. Phius designations refer to the same climate using ASHRAE classification. What this means for envelope design:

- Heating-dominated climate. Approximately 6,000 heating degree days (base 65°F), roughly 700 cooling degree days. The envelope is engineered primarily to retain heat in winter.
- Cold winter design temperature: −4°F per ASHRAE 99% (the temperature exceeded 99% of winter hours). The plans show this as the design condition for HVAC sizing.
- Humid summer. Latent loads (humidity) are substantial in July and August. The ventilation system must address dehumidification.
- Risk of summer inward vapor drive. Air conditioning cools and dries interior air, creating a vapor gradient that drives outdoor humidity inward through the wall. This is why interior vapor strategies must be smart (variable permeability), not fixed.
- Snow loading: 25 psf ground snow per plans. Affects roof framing, eaves, and ice/water shield extent.
- Frost depth: 42 inches in Cook County. Foundations must extend below frost line.

Why this climate makes Phius work harder

Climate Zone 5A is harder than Zone 4 (warmer winters, less heating load) and harder than Zone 6 (drier summers, lower latent load). The combination of cold winters and humid summers requires assemblies that perform in both directions — dry to the outside in winter, resist inward vapor drive in summer. The smart membrane strategy is the response to this dual challenge.

Phase 2: The Phius Core 2021 Standard

This phase covers what Phius is, what it certifies, and how certification is verified. Understanding the certification framework is important for every party on the project — it explains why we test, why we document, and why the Phius rater has authority over substitutions.

2.1 What Phius Certifies

Phius (formerly the Passive House Institute US) certifies building performance, not products or specific construction methods. The standard sets performance targets — annual heating demand, annual cooling demand, peak heating load, peak cooling load, source energy, and airtightness — and verifies that the as-built project meets those targets. The path to those targets is open; assembly types, products, and construction techniques are tools, not requirements.

This is an important distinction from prescriptive codes (like the IECC, which specifies R-values and U-values directly). Phius lets the designer trade off, for example, slightly less insulation in exchange for better windows, as long as the overall energy model still meets the targets. The energy model is the gatekeeper.

2.2 The Phius Core 2021 Targets

Phius Core 2021 (the current standard, adopted September 2021) sets the following performance targets for a project of R.271's climate and floor area:

Metric	Target	Verification
Annual heating demand	≤ 5.7 kBTU/ft²·yr (climate-adjusted)	WUFI Passive energy model
Annual cooling demand	≤ 5.7 kBTU/ft²·yr (climate-adjusted)	WUFI Passive energy model
Peak heating load	≤ 4.7 BTU/h·ft²	WUFI Passive energy model
Peak cooling load	≤ 4.7 BTU/h·ft²	WUFI Passive energy model
Source energy demand	≤ 6,200 kWh/person·yr	Annual energy model + occupancy
Airtightness	≤ 0.05 CFM50/ft² envelope or ≤ 0.69 ACH50 (use stricter)	Blower door test, mid-construction + final

All targets must be met for certification. The exact numerical targets vary slightly by climate zone, floor area, and occupancy — TBDA's energy model captures the project-specific values. Confirm with the architect or rater for the exact R.271 targets.

2.3 The Verification Path

Phius certification is verified at several stages of design and construction. The builder's responsibility is to understand each gate and prepare for it.

Stage 1: Pre-construction energy model

The architect (or sometimes the rater) builds a WUFI Passive energy model of the project. This model accounts for envelope assemblies, windows, mechanical systems, climate, and orientation. The model must show all performance targets are met before construction begins. If the model fails, the design is iterated — typically with envelope upgrades, window upgrades, or mechanical adjustments — until it passes.

Stage 2: Pre-construction meeting

Phius best practice (and the rater's typical contract requirement) is a pre-construction meeting with the builder, key subs, architect, and rater. This is where the assembly logic, critical details, product specifications, and certification process are reviewed. For R.271, this meeting should be scheduled before framing begins and should include the framing, insulation, and mechanical leads.

Stage 3: Mid-construction blower door test

Performed after the envelope is closed in and air-sealed but before drywall — typically after rough mechanical, plumbing, and electrical are complete and inspected. The mid-construction test is diagnostic: it identifies leaks while they are still accessible. Failing the mid-construction test is normal on first attempts; the test is used to find and fix leaks before they become buried. Budget for one or two iterations.

Stage 4: Mechanical commissioning

The ERV (CERV2), heat pump, and any other mechanical systems are commissioned per manufacturer and rater requirements. Static pressure is verified against design. Airflow at each register is measured. Documentation is collected for the certification file.

Stage 5: Final blower door test

Performed after drywall and finishes are complete. This is the certification test. The result is reported in the certification package.

Stage 6: Certification submission and approval

The rater compiles the final documentation — energy model, photo log, product confirmations, blower door results, commissioning reports — and submits to Phius for certification. Phius reviews and issues the certificate.

> **Builder Implication:** The verification path requires that the builder maintain a continuous documentation trail throughout construction. Photo logs of air sealing, insulation, and penetrations are not optional. The certification cannot be reconstructed after the fact — every key install moment must be documented as it happens.

2.4 Roles in a Phius Project

Role	Responsibility
Architect (TBDA)	Design, assembly selection, energy model (typically), specifications, WUFI hygrothermal analysis on critical sections
Phius Rater	Independent verification — pre-construction review, mid-construction blower door, final blower door, certification submission. Has authority over substitutions affecting performance.
Builder (Ethos)	Construction, sub coordination, in-house QA, photo documentation, sub training, scheduling of inspections and tests, RFI process for field conditions
Energy Modeler (often Architect or Rater)	Builds and maintains WUFI Passive model, updates for any design changes, confirms updated model still meets targets
Trade Subs	Execute specified details, request RFIs for any conflict or unclear condition, support photo documentation, attend pre-construction meeting
Owner	Selects design path, approves any cost-impacting substitutions, ultimately owns the completed certified building

2.5 Phius+ vs. Phius Core 2021 — Why This Matters for Plan Review

Phius rebranded and restructured its standards in 2021. Older project specifications may use the legacy terminology "PHIUS+ 2018" or simply "PHIUS+," which refers to the prior standard. Phius Core 2021 is the current standard and has different targets, verification methods, and certification language.

For R.271, the plans should reference Phius Core 2021 throughout. If you encounter language referencing PHIUS+ 2018 or older standards in the construction documents, flag this to the architect for clarification. The targets are similar but not identical, and certification requires the current standard.

Phase 3: R.271 Project Walkthrough

This phase walks through the specific assemblies, details, and systems on R.271. Reference the construction documents — particularly the PH.1 air sealing details, A4 series wall sections, A5 schedules, and M1 mechanical plans — as you read.

3.1 Project Overview

Item	Detail
Project	R.271 Kapicka Residence — new construction
Site	2735 N Vista Road, Arlington Heights, IL 60004
Buildings	Main house (5,514 SF gross) + detached garage (668 SF) + studio (325 SF)
Stories	2 stories + full basement
Structural system	Wood-framed, dimensional lumber + engineered components
Foundation	Full basement, poured concrete walls, conditioned slab
Certification target	Phius Core 2021 — main house
Climate	IECC Zone 5A — Cook County, IL
Snow load	25 psf ground snow
Wind load	115 mph
Winter design temp	−4°F (ASHRAE 99%)
Mechanical strategy	All-electric: geothermal heat pump, CERV2 ERV, HPWH
Site team	TBDA (architect), Quad Chicago (structural), Haeger (civil), Ethos (builder)

3.2 Assembly Decisions

Double-stud wall — 2x6 + 2x4, dense-pack cellulose, R-43.7

The wall assembly is two parallel stud walls with a cellulose-filled cavity between them: a 2x6 structural stud wall on the exterior (carrying load) and a 2x4 interior stud wall offset by an air gap. The total wall depth is approximately 12 inches. The entire cavity is dense-packed with cellulose at 3.5 lbs/ft³. The exterior is sheathed in ZIP System (acting as water-resistive barrier and primary air barrier). The interior is finished with Intello Plus smart vapor membrane (acting as secondary air barrier and variable vapor retarder).

Why this assembly: The double-stud wall eliminates thermal bridging through framing (the studs do not span the full wall — they only span their respective halves). Dense-pack cellulose stops convective looping that fiberglass batts would allow at this depth. The vapor membrane on the interior allows winter drying outward and resists summer inward vapor drive. The dual air barrier (ZIP + Intello) provides redundancy at the airtightness target.

Roof — Raised-heel scissor truss, loose-fill cellulose, R-84

The roof framing uses raised-heel scissor trusses to maintain full insulation depth at the eaves (where conventional trusses are pinched and lose R-value). Loose-fill cellulose is blown to the specified depth — for R-84 in Cook County climate, this is approximately 23 inches of cellulose. The ceiling plane is the air barrier — the same Intello membrane continues from walls onto the ceiling, with all penetrations (light fixtures, attic access, mechanical) detailed for airtightness.

Why this assembly: Insulating at the ceiling plane (rather than the roof deck) is the standard Phius approach in this climate — it is the lowest-cost path to high R-value and isolates the air barrier from the most complex roof geometry. The raised heel ensures the insulation depth carries to the wall plate without compression.

Slab on grade / basement floor — R-20 sub-slab continuous

Below the slab is 4 inches of continuous rigid insulation (XPS or EPS, per spec), continuous from edge to edge. The Stego 10-mil vapor barrier sits directly under the slab and is taped continuously at all seams, terminating up the foundation wall with appropriate detail (typically Stego Crete Claw or equivalent at the slab edge).

Why this assembly: The sub-slab insulation breaks the conductive path from the slab into the ground (the ground is 55°F year-round in this climate, which would otherwise be a continuous heat loss). The Stego vapor barrier prevents ground moisture from migrating into the slab and into the indoor space.

3.3 Air Barrier Strategy — Dual System

R.271 uses a redundant dual air barrier: exterior (ZIP System sheathing) and interior (Intello Plus smart membrane). Both must be continuous around the entire envelope — six sides, every transition. Failure of one is partially backstopped by the other, but neither is allowed to be sloppy.

Exterior air barrier — ZIP System sheathing

The Huber ZIP System combines structural sheathing, water control, and primary air barrier in one product. Effectiveness depends on the seams being properly taped with ZIP System tape. Key requirements:

- Tape must be installed above 0°F per Huber spec. If construction extends into winter, framing must be heated or tape application paused.
- All seams taped — vertical, horizontal, transitions to roof, transitions to foundation.
- Tape rolled with a hand roller to ensure full adhesion. Untrained subs often skip this — the bond is significantly compromised without it.
- Fluid-applied sealant (Huber Liquid Flash or equivalent) at critical joints: window/door rough opening corners, transitions to non-ZIP materials, complex geometry.
- All penetrations (vents, conduit, etc.) sealed with appropriate gaskets and tapes.

Interior air barrier — Intello Plus smart membrane

Pro Clima Intello Plus (or specified alternate, Rothoblaas ClimaControl 80) is a smart vapor membrane that is also an air barrier. It is installed on the warm side of the insulation — typically on the interior face of the inner 2x4 stud wall, before drywall. Key requirements:

- Continuous around the entire interior envelope — walls and ceiling — with no breaks.
- All seams taped with Pro Clima Tescon Vana or equivalent.
- Penetrations (electrical, plumbing, mechanical) sealed with Roflex grommets and/or Tescon Profil tape.
- Transitions (wall to ceiling, wall to floor, wall to window) sealed with appropriate tapes and gaskets per detail.
- Maximum 3 months UV exposure — must be drywalled or covered within this window.
- No substitution without rater approval — fixed vapor barriers (poly) will cause moisture problems in this assembly.

Why two air barriers

At 0.69 ACH50, a single missed detail can move the test result significantly. The dual-barrier approach provides redundancy: a missed tape on the ZIP layer is partially backstopped by the Intello, and vice versa. Field experience shows that single-barrier Phius projects pass blower door tests at first attempt at roughly 50% rate; dual-barrier projects pass at significantly higher rates. The cost of the second barrier is far less than the cost of rework on a failed test.

3.4 Critical Details from PH.1 (Air Sealing Details)

Plan sheet PH.1 contains the project-specific air sealing details. Every trade should be familiar with the details applicable to their scope. The following are the most commonly-missed details on Phius projects — confirm exact specifications against PH.1.

Sub-slab vapor barrier termination

Stego 10-mil vapor barrier under the slab terminates at the foundation wall. Detail typically uses Stego Crete Claw or equivalent — a profile that interlocks with the slab edge to maintain the seal at the most failure-prone joint. Vapor barrier extends approximately 6 inches up the foundation wall and is taped to the foundation. Critical that the concrete sub does not tear the vapor barrier during slab pour — pre-pour inspection by Ethos super is required.

Wall to foundation transition

ZIP System sheathing terminates at the foundation. The transition between sheathing and concrete is sealed with fluid-applied sealant per detail. The mudsill is gasketed with closed-cell sill seal. Any gap between sheathing and foundation is detailed to prevent both bulk water and air leakage.

Window/door rough opening detail

Windows are installed in 1/2-inch SHTH-4 plywood bucks set in the rough opening. The buck is taped to the ZIP sheathing on the exterior with ZIP tape rolled out fully. Fluid-applied sealant at the corners and any voids. The window flange is taped to the buck. On the interior, the buck-to-Intello transition is taped with Pro Clima Tescon Vana or equivalent. This detail is one of the highest air-leakage risk points in any Phius wall — train framers explicitly.

Wall to roof transition (top plate)

The top plate of the wall is sealed where the ceiling air barrier (Intello on the ceiling plane) terminates. The transition typically uses Tescon tape from Intello to the top plate, sealed continuously. Insulation in this area must not compress and must allow inspection.

Penetrations — electrical, plumbing, mechanical

Every wire, pipe, and duct that crosses the air barrier is a potential leak. The strategy on R.271 is:

- Service cavity — the interior 2x4 wall acts as a service cavity, allowing electrical and plumbing to run without crossing the Intello membrane. Most electrical can be run within the service cavity, leaving the membrane continuous.
- Where penetrations are unavoidable — use Roflex grommets for round penetrations (typically electrical conduit, pipes), Tescon Profil tape for irregular shapes.
- Mechanical ductwork penetrations — sealed with manufacturer-spec'd boots or fluid-applied sealant, depending on duct type.
- Photograph every penetration after sealing — required for QA documentation.

Chimney penetration (pellet stove)

The pellet stove chimney creates a penetration in both the ceiling air barrier and the roof. Detail per PH.1 requires sealed chimney passage and combustion air inlet. Direct-vent pellet stove (drawing combustion air from outside) is the preferred Phius approach. Confirm stove model with architect and verify Phius compatibility.

3.5 Mechanical Strategy

CERV2 ventilation (sole source — Build Equinox)

The CERV2 is a smart ERV (Energy Recovery Ventilator) that exchanges stale indoor air with fresh outdoor air, recovering both heat and humidity in the process. The CERV2 also monitors indoor air quality (CO2, VOC, humidity) and adjusts ventilation rate dynamically. It is the only ventilation source on the project — the building is too tight for any other strategy to work reliably.

- Static pressure budget: 0.00" w.c. external. Zero margin. Duct design must use low-pressure-drop fittings, smooth-wall ducts where possible, minimal flex duct. Manual D calculation required from mechanical sub.
- Located per M1 — confirm access for filter service and commissioning.
- Lead time: 8–12 weeks from Build Equinox. Order early.
- No equivalent substitution without rater approval and energy model update.

Geothermal heat pump

The building is heated and cooled by a geothermal heat pump connected to ground-loop wells. All-electric design — no natural gas service. Geothermal performance depends on well design (count, depth, geology) — verify well design package from mechanical engineer or geothermal sub before drilling.

Heat pump water heater (HPWH)

Domestic hot water is produced by a heat pump water heater. HPWHs draw heat from the surrounding air, slightly cooling and dehumidifying the space they are installed in. Location matters — typically installed in the mechanical room or basement where waste cooling is not problematic.

All-electric design — implications

R.271 has no natural gas, propane, or oil service. All cooking (induction range), water heating (HPWH), space heating/cooling (geothermal heat pump), and clothes drying (electric or heat pump dryer) is electric. This eliminates combustion safety risk (no carbon monoxide), simplifies the envelope (no flue penetrations except pellet stove), and pairs naturally with future PV. Owner-supplied appliances must conform to this — verify induction range model and HPWH model.

3.6 PV-Ready Provisions

Even though PV is not part of the current scope, the building is designed PV-ready. This means an electrical conduit (typically 1" EMT) is installed from the main panel area to the attic, with capped terminations at both ends. This conduit allows future PV string wiring without re-opening finished walls or ceilings.

PV-ready conduit is an easy detail to miss — it is one $200 item on a $1.5M project. Add to the electrical sub scope explicitly, inspect at electrical rough, and confirm capped and labeled at both ends.

Phase 4: Role-Specific Modules

Each section in this phase is designed to be excerpted as a standalone training document for the relevant role. Sections 4.1 and 4.2 are for Ethos internal staff; sections 4.3 through 4.7 are for external trade partners and should be distributed to subs at preconstruction.

All roles should have first read Phases 1, 2, and 3 before turning to their role-specific module — the role-specific content assumes the foundational concepts are understood.

4.1 Superintendent / Project Manager (Ethos)

Your responsibilities on a Phius project

- Schedule and run the pre-construction meeting with rater, architect, and key subs. This is where the assembly logic and critical details are reviewed with the field team.
- Maintain the photo log throughout construction. Phius QA documentation cannot be reconstructed — it must be captured in the moment. Establish a Google Drive or BT folder structure for photos at project start.
- Schedule the mid-construction blower door test with the rater. Coordinate with framing, MEP, and insulation subs so that the envelope is closed in but not yet covered when the test happens.
- Manage RFIs related to Phius details. Any field condition that does not match the plans must be resolved through the architect and, where it affects performance, the rater.
- Enforce the no-substitution policy on Phius-critical products. Substitutions require written rater approval before sub orders.
- Coordinate with the rater for inspections at key stages: post-air-sealing pre-insulation, post-insulation pre-drywall, post-drywall final.
- Track owner decisions (appliance selections, finish selections, PV scope) that affect Phius compliance.

Key decisions you will make daily

- Approve/reject sub field details that deviate from plans. If unclear, RFI.
- Authorize substitutions — never for Phius-critical items without rater approval.
- Schedule trade transitions to support photo documentation (e.g., do not allow insulation to start until air sealing is photographed and approved).

Photo documentation — what to capture

- Sub-slab vapor barrier installation — before slab pour, every seam, every penetration.
- ZIP System sheathing — after taping, every seam, every transition, every penetration.

- Window install — at each major step (buck install, window set, exterior tape, interior tape).
- Interior air barrier (Intello) — before insulation, every seam, every penetration.
- Insulation — at install (cellulose blow, foam install) and at final cover-up.
- Penetration seals — every electrical box, every pipe, every duct.

4.2 Lead Carpenter / On-Site QC (Ethos)

Your role

You are the daily eyes-on-the-work for Phius compliance. You support the superintendent on QA, but you are also expected to identify problems before they become buried. You walk the project with knowledge of the assembly logic and you flag deviations.

Daily walk priorities

- Air barrier continuity — both exterior (ZIP) and interior (Intello). Visual inspection: any gap, any untaped seam, any tear is a problem.
- Tape adhesion — ZIP tape and Pro Clima tape must be rolled out. Probe with fingernail — if it lifts, it failed.
- Penetration seals — every wire, every pipe, every conduit through the air barrier. Is it sealed with the right product? Is the seal complete?
- Substitutions on the job site — any product on the truck that is not on the spec, escalate to the super.

Mock-up methodology

For every Phius-critical detail (window install, penetration seal, air barrier transition), the first one installed is a mock-up — built with the sub, inspected before production, photographed, and used as the reference standard for the project. This is the most effective way to align sub work with Phius detail expectations.

Common failures to watch for

- ZIP tape not rolled — looks installed but will fail at blower door test.
- Window installed direct to rough opening (no buck) — requires removal and reinstall.
- Electrical boxes installed through Intello without grommet — requires backing out and re-sealing.
- Stego vapor barrier punctured during slab pour — requires patch with Stego tape before concrete.
- HFC-blown spray foam delivered instead of HFO — reject at delivery.
- Plumber drilled through top plate without sealing — requires fluid-applied at penetration.

4.3 Framing Sub

Why this project is different from your typical work

On a code-minimum job, framing is structural — your job is to build a wall that stands up and meets shear/uplift requirements. On a Phius project, your work also defines the air barrier and the water control layer. The same sheathing nail that meets code can leak air at Phius targets if not properly placed. Read Phases 1 and 3 of the curriculum before starting framing — the building science explains why details matter.

Your Phius-critical scope

- Install ZIP System sheathing per Huber specifications. All seams taped with ZIP System tape. Tape rolled fully. Above 0°F.
- Apply Huber Liquid Flash or equivalent fluid-applied sealant at all critical joints (window/door RO corners, transitions to non-ZIP materials, complex geometry).
- Install 1/2" SHTH-4 plywood window/door bucks in the rough openings before windows arrive. Tape buck-to-sheathing on exterior.
- Install raised-heel scissor trusses per truss schedule. Coordinate with structural engineer for any field conditions affecting drag trusses.
- Install sealing materials at the mudsill (closed-cell sill seal) and at the wall-to-foundation transition.
- Communicate with insulation sub on the air sealing handoff — exterior is your scope, interior is theirs, transitions need both.

Common pitfalls in framing for Phius

- Sheathing nails over-driven through ZIP face — every over-driven nail is a leak. Adjust nail gun pressure and inspect first row of every wall.
- Tape on dirty or wet ZIP face — clean and dry surface required. Wipe with rag if needed.
- Window bucks installed plumb to interior but not parallel to sheathing — verify alignment at both faces.
- Drag truss hold-downs missed or substituted — coordinate with Ethos super on truss install hardware.

Photo support

Ethos will photograph your work at key stages. Expect inspection holds at: post-sheathing pre-tape, post-tape, post-window-buck, post-drag-truss-install. Plan schedule around these holds — they do not delay if photos are coordinated.

4.4 Insulation Sub

Why this project is different

On a typical project, you blow cellulose and install fiberglass batts. On R.271, you are also installing the interior air barrier (Intello Plus), executing the most-detailed Phius scope. The interior air barrier work is closer to the standard of finish carpentry than to standard insulation — patient, deliberate, dimensionally accurate. The dense-pack cellulose work itself is more technical than open-blow attic insulation. Plan for slower production rates than typical.

Your Phius-critical scope

- Install Intello Plus smart vapor membrane on the interior face of the interior 2x4 wall, continuous around walls and ceiling. Maximum 3 months UV exposure — drywall must follow within this window.
- Tape all Intello seams with Pro Clima Tescon Vana or equivalent.
- Seal all penetrations through Intello — Roflex grommets for round penetrations, Tescon Profil tape for irregular shapes.
- Coordinate transitions: Intello to top plate, Intello to floor plate, Intello to window/door bucks. Each detail per plan PH.1.
- Dense-pack cellulose in wall cavity at 3.5 lbs/ft³ — verify density by net opening method on first wall of each type.
- Loose-fill cellulose in attic to specified depth (R-84 — approximately 23" loose-fill cellulose). Provide attic baffles at eaves to maintain ventilation gap above insulation.
- Install closed-cell HFO spray foam where specified (typically rim joist, slab edge thermal break). Verify HFO blowing agent — reject HFC-blown product on site.

Common pitfalls

- Stretching or over-tensioning Intello — causes wrinkles and incomplete coverage.
- Skipping tape rolling — same as ZIP tape, must be rolled out fully.
- Penetration sealing with mastic only (no grommet/profile tape) — fails over time and at blower door.
- Cellulose density below 3.5 lbs/ft³ — leads to settling, voids, and convective looping.
- HFC spray foam substitution — disqualifies the project from Phius certification.

Pre-blower-door responsibilities

Before the mid-construction blower door test, walk the envelope with the Ethos super and confirm: all Intello seams taped, all penetrations sealed, all transitions detailed. The blower door is the test — your air sealing scope must be substantially complete and ready for inspection.

4.5 Mechanical, Plumbing, HVAC Rough Subs

Why this project is different

On a code-minimum project, a wire crossing an exterior wall is just a wire. On R.271, that same penetration is a hole in the air barrier — and air leaks correlate directly with energy loss and certification failure. Every wire, every pipe, every duct that crosses the air barrier requires deliberate sealing.

Service cavity strategy — your friend

The interior 2x4 wall on R.271 is designed as a service cavity — meaning electrical and most plumbing should be routed within this wall, on the interior side of the Intello membrane. If you can run everything in the service cavity, the membrane stays continuous and your work does not become an air-sealing project.

When penetrations are unavoidable

- Round penetrations through Intello — Roflex grommets (sized to the pipe/conduit OD). Install with adhesive flange against the membrane.
- Irregular penetrations — Tescon Profil tape, applied with the appropriate dimension flap (4" or 6" depending on penetration size).
- Ductwork through air barrier — coordinate with Ethos super. Boots and seals per manufacturer.
- Top plate penetrations — sealed with fluid-applied sealant at both top and bottom of penetration.

HVAC duct design — CERV2 constraint

If you are the mechanical sub, the duct design for the CERV2 ERV must clear 0.00" w.c. external static pressure. This is a zero-margin design. Submit Manual D calculation to architect/rater before duct fabrication. Use long-radius fittings, smooth-wall ducts, minimal flex. Verify against CERV2 ECM motor curve.

Coordination with envelope subs

Your work happens after framing and before insulation. Air sealing of your penetrations is your scope on the exterior side (ZIP) and on the interior side (Intello). Coordinate with Ethos super for inspection of every penetration before insulation closes them in.

4.6 Electrical Sub

Scope overlaps with 4.5

Most of section 4.5 applies. The notes below are electrical-specific.

Critical scope items

- Service cavity-first routing — keep wiring on the interior side of Intello wherever possible.
- Penetrations through Intello — Roflex grommets at conduit, Tescon Profil tape at irregular boxes.
- Exterior wall electrical boxes — special airtight boxes (e.g., Lessco) where penetration is unavoidable. Confirm box type with Ethos super.
- PV-ready conduit — 1" EMT (or per spec) from the main panel area to the attic. Capped at both ends, labeled. This is easily missed — add to your scope checklist explicitly.
- Panel sizing — confirm with mechanical sub and Ethos PM regarding geothermal heat pump load, HPWH load, induction range load. All-electric house pulls more amperage than mixed-fuel.
- Future battery storage prep — if scope includes future battery (Tesla Powerwall or equivalent), confirm panel and wall space coordination.

Inspections

Penetration seals will be inspected by Ethos super before insulation. Plan to be available for walk-throughs and photo documentation.

4.7 Concrete Sub

Why this project is different

On a typical project, the slab pours and you walk away. On R.271, the slab is the indoor face of an insulated, vapor-controlled assembly. The sub-slab vapor barrier (Stego 10-mil) must be intact, taped, and properly terminated before the pour. Damage during pour is not a small issue — it is a Phius performance issue.

Your Phius-critical scope

- Verify the sub-slab vapor barrier (Stego 10-mil) is installed by the appropriate trade before scheduling the pour. All seams taped, all penetrations sealed.
- Walk the vapor barrier with Ethos super before pour to identify any tears or damage from your crew or others.
- Patch any tears with Stego Wrap Tape — never leave a tear exposed.
- Stego Crete Claw or equivalent at the slab edge — maintains the vapor seal at the most-failure-prone joint.
- If specified, use CarbonCure mix from Ozinga — verify with dispatch and confirm in delivery tickets. Premium is approximately $2–5/CY.
- Foundation walls — pour per structural design, with insulation per assembly schedule. Damp-proofing and dimple membrane per plan.

Sequence

- Excavation and footings.
- Foundation walls.
- Sub-slab insulation install (typically by insulation sub or general carpenter).
- Sub-slab vapor barrier install (typically by insulation sub or general carpenter).
- Ethos pre-pour inspection.
- Slab pour — concrete sub.
- Photo documentation.

Phase 5: Tools, Resources, and Continued Learning

Phius work is a discipline that rewards deep learning. The resources below are the curated set Ethos recommends for building staff and trade partners who want to develop beyond this single project.

5.1 Formal Training

Phius Builder's Track (recommended for Ethos lead staff)

Phius offers a multi-day Builder's Track training that covers Phius standards, assembly logic, QA, and certification. The training is held in-person regionally and online. Cost is in the $1,500–$2,500 range. Strongly recommended for the Ethos lead carpenter and at least one project manager. Information at phius.org/training.

475 High Performance Building Supply

475.supply is a national distributor of Phius-aligned products (Pro Clima Intello, Tescon tapes, Roflex grommets, Contega seals, etc.) and also publishes a substantial library of free training videos, product literature, and assembly details. Their YouTube channel and blog are the most accessible introduction to European building-science thinking in the US market. Recommended for all trades.

5.2 Required Reading

Building Science Corporation papers (Lstiburek)

- BSI-001: The Perfect Wall — foundational paper on the four control layers.
- BSI-008: Hockey Pucks — on smart vapor management.
- BSI-066: Walls That Work — wall assembly logic for various climates.

Available free at buildingscience.com. Lstiburek is the dean of North American residential building science — his papers are practical, opinionated, and rigorously sourced.

Green Building Advisor (GBA)

GBA (greenbuildingadvisor.com) is the most active online community for residential high-performance construction. Article library covers nearly every Phius-relevant detail. Q&A forum is staffed by working builders and building scientists. Subscription is in the $90/year range and is worth it for any lead Ethos staff.

Pretty Good House (book — Bensonwood, Pfeiffer, Riversong)

Practical book on high-performance residential construction, written by builders for builders. Pre-dates Phius Core 2021 but the building-science content remains current. Recommended for any Ethos staff doing their first high-performance project.

5.3 Product Documentation (have on the job site)

- Pro Clima Intello Plus installation manual — pdf at proclima.com or 475.supply.
- Huber ZIP System manual — pdf at huberwood.com.
- Stego sub-slab vapor barrier installation guide — pdf at stegoindustries.com.
- Build Equinox CERV2 manual — pdf at buildequinox.com.
- Huntsman Heatlok HFO product data and SDS — pdf at huntsman.com (verify HFO version, not HFC).

5.4 QA Checklists

Use Phius's published QA checklists as a baseline for project documentation. These are available at phius.org/builder-resources. Adapt for R.271 specifically — include project address, certification target, and rater contact at the top of every checklist used.

5.5 When You Need Help

Building science questions during construction — sequence:

1. Ask the Ethos superintendent first. Most field questions have an answer in the plans or in this curriculum.
2. If unresolved, RFI to the architect. Document the question and the answer for the project record.
3. If the question affects performance (energy, airtightness, durability), the architect will involve the Phius rater. The rater has authority over substitutions and performance-affecting changes.
4. Trade-specific questions about a product — contact the manufacturer's technical support line. Most Phius-aligned manufacturers (Pro Clima, Build Equinox, Huber, Huntsman) have responsive tech support.

> **Final Note:** Phius work is harder than code-minimum work. It is also more interesting — the building works as a system, the details connect to physics, and the result is measurably better than conventional construction. Every project Ethos completes builds capability that compounds. R.271 is the start.

Appendix: Key Terminology

Selected terms that appear throughout this curriculum and Phius documentation. Not exhaustive — a working reference.

Term	Meaning
ACH50	Air Changes per Hour at 50 Pascals of pressure differential. The standard blower-door metric. Phius Core 2021 target: 0.69 ACH50 or 0.05 CFM50/ft² of envelope area, whichever is stricter.
Air Barrier	A continuous layer in the envelope that resists bulk air movement. On R.271, the ZIP sheathing (exterior) and Intello membrane (interior) both serve as air barriers.
BOD	Basis of Design — the specific products and assemblies the design assumes. Substituting a BOD product without rater approval is not allowed on Phius work.
Blower Door Test	Pressurization test that measures total air leakage through the envelope. Performed mid-construction (diagnostic) and at completion (certification).
CERV2	Build Equinox's smart ERV (energy recovery ventilator) with onboard air quality sensing. Sole-sourced ventilation on R.271.
CFM50/ft²	Cubic feet per minute of air leakage at 50 Pa, per square foot of envelope area. The Phius Core 2021 primary airtightness metric.
Continuous Insulation	Insulation that is continuous across the envelope without thermal bridges (no studs interrupting it). Sub-slab insulation on R.271 is continuous.
Dense-pack	Cellulose installed at 3.5 lbs/ft³ — the density required to prevent settling and convective looping. Lower densities will fail over time.
Drag Truss	A truss designed to transfer lateral loads (typically wind shear) across a roof plane. R.271 has 4 custom drag trusses per structural drawings.
ERV	Energy Recovery Ventilator — exchanges stale indoor air with fresh outdoor air, recovering both heat and humidity in the process. CERV2 is the ERV on R.271.
HFO vs. HFC	Spray foam blowing agents. HFO has global warming potential ~1; HFC has GWP ~1,400. Phius requires HFO-blown closed-cell spray foam. Reject HFC product on site.
HPWH	Heat Pump Water Heater — produces domestic hot water using ambient heat. All-electric water heating on R.271.
Intello Plus	Pro Clima smart vapor membrane — variable permeability based on ambient humidity. Tight in winter, open in summer. Interior air barrier on R.271.

Phius Core 2021	Current Phius certification standard (effective September 2021). Replaces PHIUS+ 2018.
Phius Rater	Independent third party who verifies Phius performance — pre-construction, mid-construction, final. Has authority over substitutions.
PV-Ready	Designed and pre-wired to accept future photovoltaic installation. Typically includes conduit from panel area to attic.
Raised-heel Truss	Truss with energy-heel detail at the eave allowing full insulation depth above the wall plate. Required for Phius roof R-value targets.
Roflex	Pro Clima penetration grommet — adhesive flange seals to the air barrier, stretchy collar seals to the pipe/conduit. Standard for round penetrations through Intello.
Service Cavity	An interior wall cavity used to run electrical and plumbing, allowing the air barrier to remain continuous behind the cavity. The interior 2x4 wall on R.271 is the service cavity.
Smart Vapor Membrane	A membrane whose vapor permeance changes with ambient humidity. Tight at low RH (winter), open at high RH (summer). Intello Plus is the canonical example.
Static Pressure (ductwork)	The resistance ducts impose on airflow. CERV2 budget on R.271 is 0.00" w.c. external — zero margin. Duct design must be tight.
Stego Crete Claw	Mechanical termination profile for the sub-slab vapor barrier at the slab edge — maintains the seal at the most failure-prone joint.
WUFI	Wärme-Und-Feuchte-Instationär — industry-standard hygrothermal simulation software. Predicts heat and moisture behavior in assemblies over time.
ZIP System	Huber's structural sheathing with integrated water control and air barrier. Primary exterior air barrier on R.271.