BUILDINGENERGY BOSTON

How Will You Meet the Demand? Scaling Passive House Certification for the New Energy Code

Nicholas Hernandez (New Ecology Inc)
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Mark Norton (New Ecology Inc)

Curated by Danny Veerkamp and Alison Keay

Northeast Sustainable Energy Association (NESEA)
March 29, 2023

How will you meet the demand? Scaling Passive House Certification Process to Prepare for the New Energy Code

Introductions

New Ecology, Inc. A mission driven non-profit focused on making affordable housing healthy and sustainable with offices in Boston, Baltimore and Wilmington.

Buildings modeled in WUFI	100+
Feasibility Studies Completed	60+
Registered PH Projects	40+
Pre-Certified Projects	25+
Certified Projects	3

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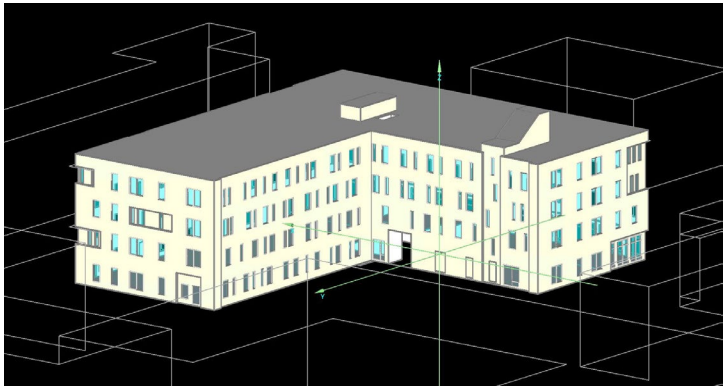
AGENDA

- The “why?” to scale PH Certification
- The “how?”: Affordable Housing – leading the way in high performance
- Typical Approach
- Project Manager Perspective
- Energy Modeler Perspective
- Verifier/Rater Perspective
- Takeaways and Lessons Learned.



PHIUS

August 5, 2020

Mr. Konieczny,

I'm pleased to inform you that project #1660: Old Colony Phase Three C is now a pre-certified *PHIUS+ 2015* project. Congratulations to you and your team.

In the next few days, please review the Project Details listed in the database and update them as necessary, as the project is now publicly visible. (We have set the iCFA, AHD, PE, and Heat Load to match the energy model.) Also, if you have any new photos for marketing or publicity purposes, please upload these to the Photos tab.

Thank you for choosing PHIUS+ 2015, and best wishes to your team on achieving final certification. Please contact us when commissioning is complete and you are ready for final certification review, or earlier if you have any other issues to discuss.

Regards,

James Ortega
Lisa White
Graham S. Wright
Isaac Elnicave
Andres Pinzon

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NEW ECOLOGY
Community-Based Sustainable Development

Why? Code, Code, Code

- Starting January 2023 and implemented through July 2024 Massachusetts will have three energy codes in effect
- High Level Takeaways (not a code presentation):
  - Residential – ERI (HERS42/45) or Passive House
  - Commercial – TEDI or Passive House with exceptions for high ventilation buildings
  - Limited Relative Pathway (ASHRAE) availability
- Other Considerations:
  - Municipal Opt-In Code – significant interest
  - Municipal Fossil Fuel Free Building Construction and Renovation Project – 10 communities in pilot program

Base Code (IECC 2021)

- New construction in towns & cities not a green community
- **52 communities**

Expected from BBRS: **July 2023**

Stretch Code (2023 update)

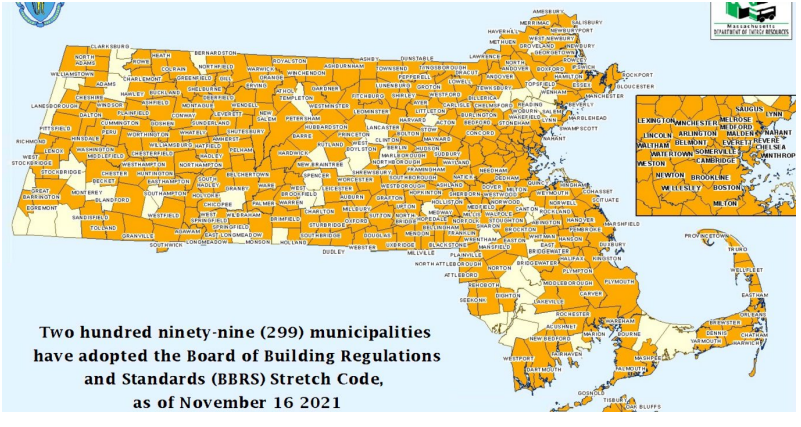
- New construction in towns & cities that are a green or stretch community
- **299 communities**

Residential : Jan 2023
Commercial: July 2023

Specialized Code ("Net-Zero")

- New Construction in towns & cities that vote to opt-in to this code
- **Effective date:** Typically 6-11 months after Town/City vote

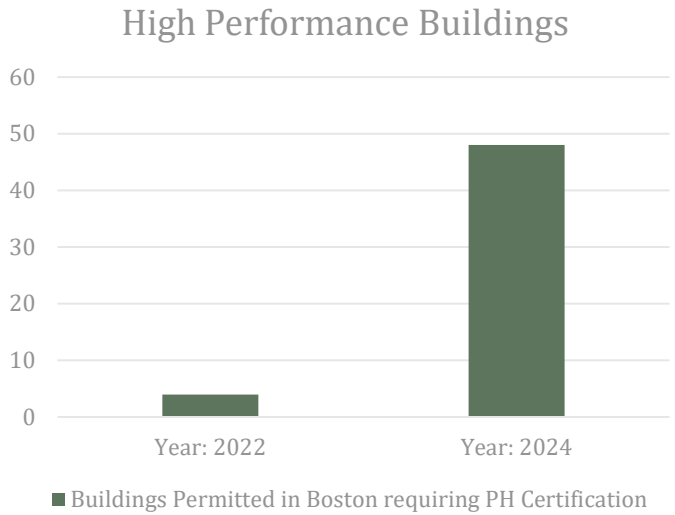
THREE ENERGY CODES IN MASSACHUSETTS



Increase in Demand

Fun Statistics - in 2022:

- Phius Design Certified 79 MF projects in the US – 25 were in MA and 11 non-res project in the US – 1 was in MA
- Boston issued 48 MF* Building Permits – 4 were PH Design Certified
- Cambridge issued 7 MF* Building Permit – 2 were PH design Certified
- 30% of Affordable Housing projects receiving LIHTC funding in 2022 were planned to achieve Passive House.
- Overall, 75% of Massachusetts's PHIUS design certified projects are Affordable



Early assessment of TEDI thresholds suggests PH may be an easier pathway to compliance = additional building typologies will join the PH bandwagon

*10 units+

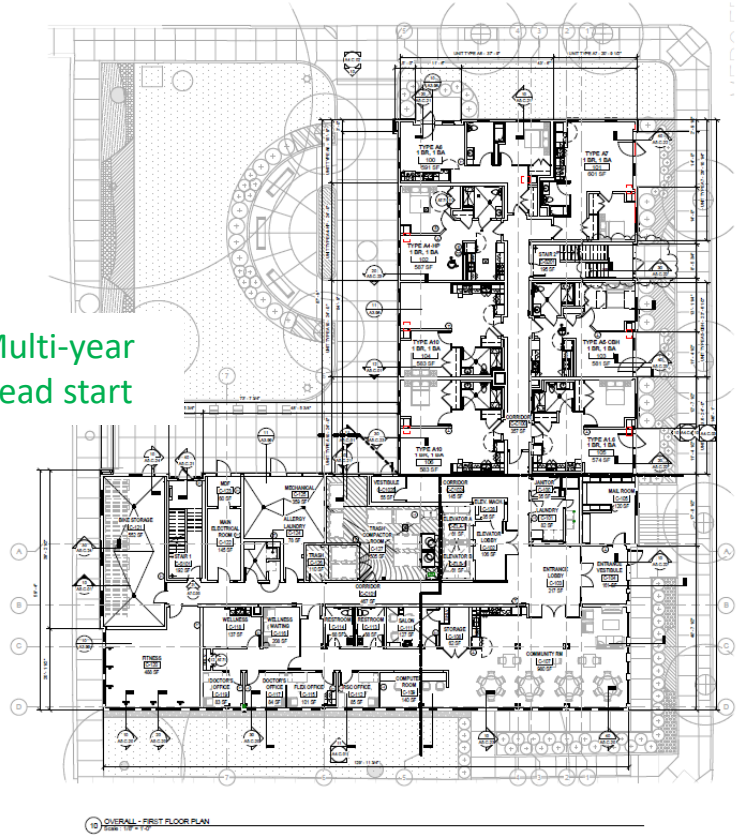
Affordable Housing: Getting an Early Start to High Performance

Starts and Stops = many projects in the pipeline

- Complex funding mechanisms
- Low Income Housing Tax Credits (LIHTC) – Provides incentives for entities to invest in affordable housing projects to offset taxable income with generated tax credits over a 10 year period
- Application and timing
  - Qualified Allocation Plan (QAP) rewards PH certification
  - Applications accepted 2x per year
  - Requires significant design progress before funding is awarded
  - Start and stop based on awards and projects in pipeline
  - When awarded, then rush to closing
- Immediate start of construction

=

Multi-year head start



~~Affordable~~ Housing (+ all construction): Accelerating to High Performance

- Steep Learning curve for project teams and NEI over the past 5 years with many challenges:
  - Understanding PH Certification metrics and updates – one class is just a start!
  - Educating Ownership - $, $, $
  - Educating design team – Architects/MEP/Structural
  - Educating construction team
  - Educating internal PM, modeling, and verification teams
- Expecting a **RUSH** of new high performance and PH projects in residential and non-residential sectors.

OLD COLONY 3C
FIRST AFFORDABLE SENIOR HOUSING CERTIFIED PASSIVE HOUSE IN MASSACHUSETTS

What Have We Learned From Affordable Housing?

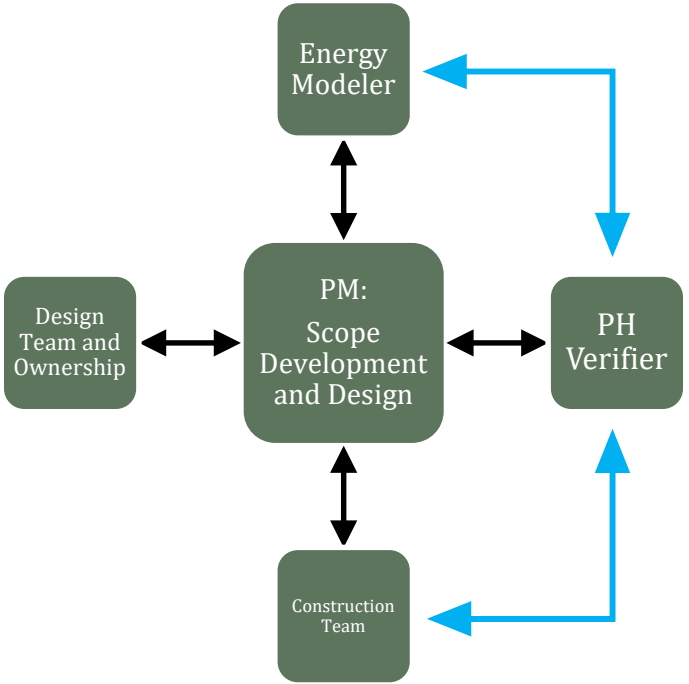
Projects follow a typical path to certification

Scope Development
- Feasibility Study
- Charette

Design
- Plan reviews
- CPHC services
- Communications internally with Energy modeler and Verifier
- Communications externally with design team and Phius
- Coordination

Energy Modeling
- Feasibility Study
- Modeling iterations
- Responses to Phius comments

Verification
- Design participation
- Lead person for construction questions and answers
- Phius documentation



Typical Approach vs NEI Approach

Typical

CPHC is the project manager and energy modeler. A Phius Verifier is brought on at start of construction

NEI

In-house resources for all stages and separated by role. All participate in the design stage.

Role	Benefit
Project Manager manages the design team, internal plan reviews and communicates Phius requirements. Coordinates energy modeling, verifier participation – tracks the BIG picture	Manages multiple projects, up to date on Phius requirements, experience with multiple construction typologies
Energy Modeler completes feasibility study and modeling for the project; provides input to performance of building components	Very fast and accurate early in the process; knows Phius protocols and shortcuts
Phius Verifier is included in design to be familiar with project design intent when construction begins	Provides input on constructability and hits the ground running once construction starts

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Typical Project – Define Objectives

Cut through the noise

Start Early – during scope development (pre-SD)

Set sustainability objectives early (Design Charrette)

- Passive House? LEED? EGC? NGBS? Other?
- Local Requirements?
- Focus on IAQ?
- Resiliency?
- Metering?
- Central systems?
- All electric?
- Renewables?

Typical Project – Define Objectives

CUT THROUGH THE NOISE

FOCUS THE TEAM

Resiliency

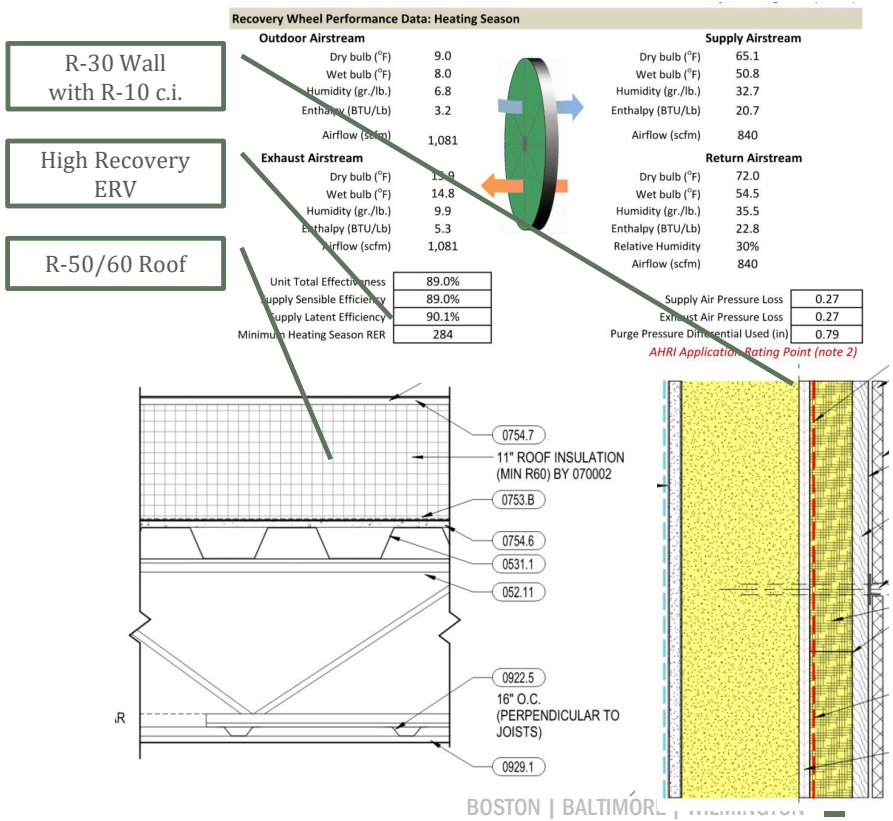
Typical Project – Define Performance

Set expectations high w/o fear!

Highlight critical PH requirements and define a 'starting point'

- Envelope Performance (CZ = 4/5)
  - **INFILTRATION – 0.06 CFM50/ft²**
  - R-50 - 60 Roof; R-30 wall with c.i.
  - R-10 – 15 slab/foundation; U-0.15 windows
- Ventilation Performance
  - ~80% recovery efficiency; 1 W/cfm electrical
- Heating/Cooling
  - Heating COP>3.7 @ 47F; Cooling COP>5 @ 95F DB

PM SETS EXPECTATIONS HIGH
MODELER SETS ASSUMPTIONS LOW



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Typical Project – Complete Feasibility

Make informed decisions with limited information

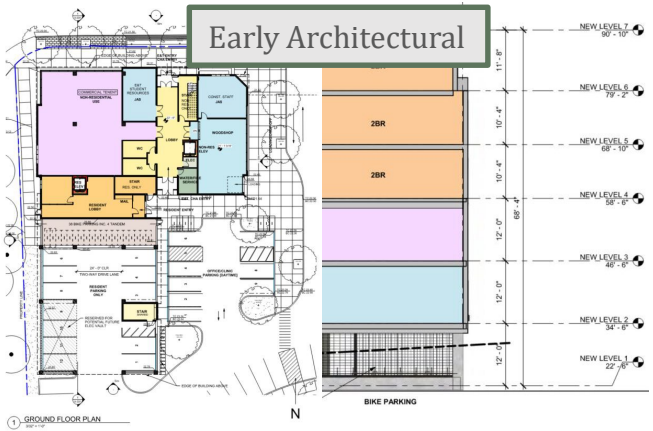
Request Minimum Information:

- HVAC, Plumbing, and electrical narratives
- Architectural concepts
- Floor plans and representative sections
- Make assumptions (more on this later from Nick)

Define Reference Building

- Based on previously completed building by same developer
- Based on minimum code

Early Architectural



Early Mechanical

Conceptual Mechanical System Options

Job Name: Rindge Commons, Cambridge, MA
Job #: 1937
Date: 10/22/2019 Rev.1

The following is an outline of preliminary HVAC system options for Rindge Commons based on the following owner and team feedback from the charrette on 9/20/19:

1. The project will likely pursue PHIUS+2018 or PHIUS+ Core certification as an alternate path to satisfy Cambridge's Article 22 requirement of "LEED Certifiability".
2. On site renewables (Photovoltaic) will be required at a significant scale to meet PHIUS+2018. PHIUS+Core is likely a more suitable program as it is intended for multi-family projects (PHIUS recognizes that the PHIUS+2018 source energy targets are virtually impossible to meet with high density occupancies and created PHIUS+Core to make certification attainable).
3. Individual tenant metering for heating and cooling would be preferred but is not required.
4. Individual air source heat pumps with individual outdoor units on the roof for each apartment would be the recommended system for 100% tenant metering of heating and cooling but this concept was ruled out to allow ample roof space for PV.
5. All electric HVAC and Domestic Hot water System approaches are not required but will be considered.

Typical Project – Report Feasibility Results

Look for a go/no go decision

Generate reference and proposed models and summarize findings

- Report must be concise and clear
- Propose options to meet PH threshold
  - Select ECMs based on cost
  - Select ECMs based on impact
    - Windows vs ground
- Schedule min 1-hour meeting to review findings
- Re-run model as needed

EXPERIENCED MODELER IS CRITICAL FOR THIS PHASE TO BE IMPACTFUL

Reference building

Proposed building

Missed threshold

Proposed ECM

NEW ECOLOGY Community-Based Sustainable Development	Project Name:		Rindge Commons Building B (Residential)	
	Climate		Boston Logan International Airport	
	Case		Reference Building (VRF Option)	PHIUS+ Core
Change from the Reference Building / Meets PHIUS Target / Misses PHIUS Target	Notes		Baseline envelope provided in drawings, VRF Heating & Cooling, Central Gas-Fired DHW	Upgraded envelope from reference building with added Solar PV to meet PHIUS+ Core requirements. VRF Heating & Cooling, Central Gas-Fired DHW
WUFI PASSIVE RESULTS	**Units**	**Target**		
Heating Demand	kBtu/ft2.yr	4.00	7.07	1.99
Cooling Demand	kBtu/ft2.yr	7.20	2.43	3.17
Heating Load	Btu/hr.ft2	3.80	6.82	2.46
Cooling Load	Btu/hr.ft2	2.50	2.67	2.41
SITE ENERGY RESULTS	**Units**	**Target**		
Source Energy	kWh/person.yr	5,500	5,378	4,905
Site Energy Use Index	kBtu/ft2.yr	-	21	20
Site Energy Consumption	kWh/yr	-	545,505	507,698
Geometry	**Units**			
Interior Conditioned Floor Area (iCFA)	ft2		87,754	87,754
Net Volume	ft3		799,891	799,891
Envelope Area	ft2		74,848	74,848
Average Window-to-Wall Ratio	%		19%	19%
Exterior Envelope	**Units**			
Roof	R		50	50
Exterior Wall (1F)	R (effective)		21	21
Exterior Wall (2-6F)	R (effective)		28	28
Slab	R		15.0	15.0
Window	U		0.27	0.18
	SHGC		0.3	0.3
Glazed Door	U		0.33	0.33
	SHGC		0.4	0.4
Opaque Door	R		4	4
Airtightness	**Units**			
Air changes per hour at 50 Pa	ACH50		3.00	0.34
Lighting Assumptions	**Units**			
Lighting	kWh/yr		85,426	85,426
Plug Loads	**Units**			
Miscellaneous Electric Loads	kWh/yr		84,695	84,695
Occupancy	**Units**			
Bedrooms	#		160	160
Average Occupancy	# Bedrooms + 1		237	237
Appliances	**Units**			
Refrigerator	kWh/year/unit		423	423
Dishwasher	kWh/year/unit		260	260
Clothes Washer	kWh/year/unit		116	116
Clothes Dryer	Energy Factor		3.4	3.4
Electric Cooktop	kWh/use		0.2	0.2
Ventilation	**Units**			
Dryer Exhaust	cfm		125	125
ERV Ventilation	cfm		5,500	5,500
ERV Power	W/cfm		1.0	0.8
ERV Recovery Efficiency	%		80%	80%
Mechanical Systems	**Units**			

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Typical Project – Design Process

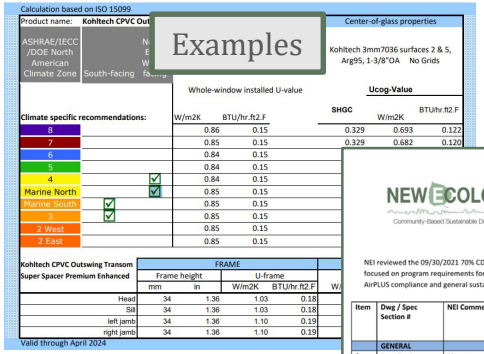
Minimize changes later

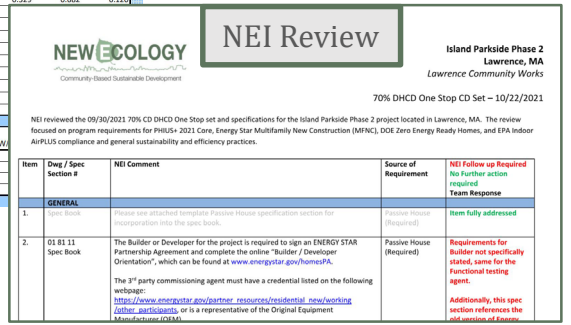
Early Design

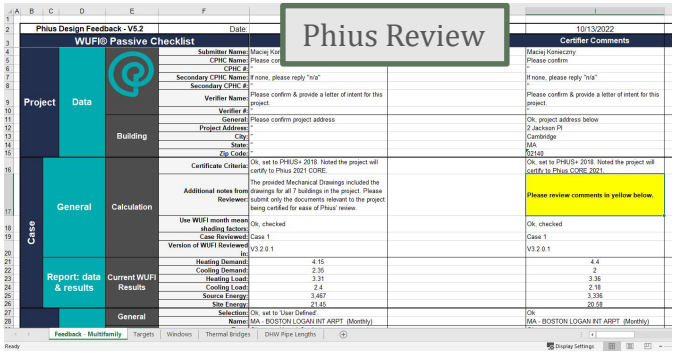
- Participate in regular meetings
- Provide examples and input
- Recommend materials/windows
- Register project with Phius

Mid Design

- Request a ~50% DD set; review and comment
- Submit project into queue and request changes from team
- Upload documentation for 1st round Phius review (earlier if complex)
- Review Phius comments – do **NOT** send feedback form to client







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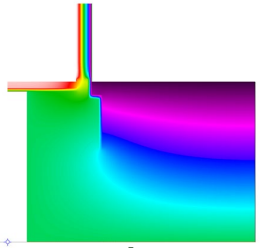
Typical Project – Design Process

Minor changes with quick turnaround

Construction Documents

- Use ~50% CD set for Round 2 review
- Time to focus on the minutia
- Use submittals from previous projects
- Model or mitigate TBs or CRs identified by Phius (hopefully only few)
- Submit for Pre-certification

REPEAT AS NEEDED → DESIGN PRE-CERTIFICATION → CONSTRUCTION



THERM Model

Calculated TB

Mitigated TB

2D model

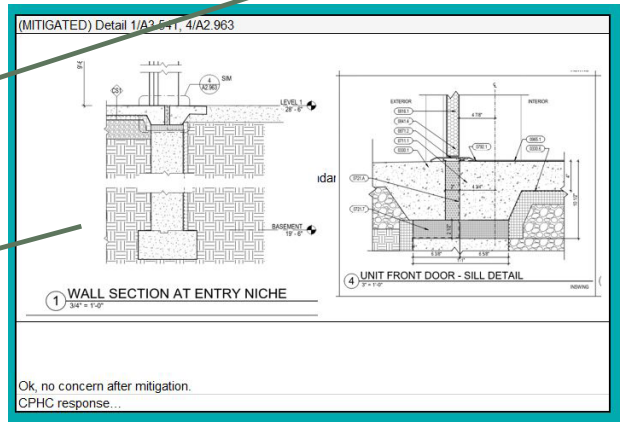
	U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Interior	0.0559	54.00	89.38	22.48	7.33%
Exterior	0.0103	54.00	486.625	22.56	7.33%

Component

		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Interior	0.0303	54.00	54.0	7.36	0.00%
Wall	Exterior	0.030	54.00	54.00	7.36	0.00%
Component B	Interior	0.0889	27.00	50.6	10.13	0.00%
Slab	Exterior	0.0889	27.00	50.63	10.13	0.00%

Psi

	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Interior	4.99	54.00	0.09	0.093
Exterior	5.07	54.00	0.09	



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Scalability in Energy Modeling

How is it different from the project management process?

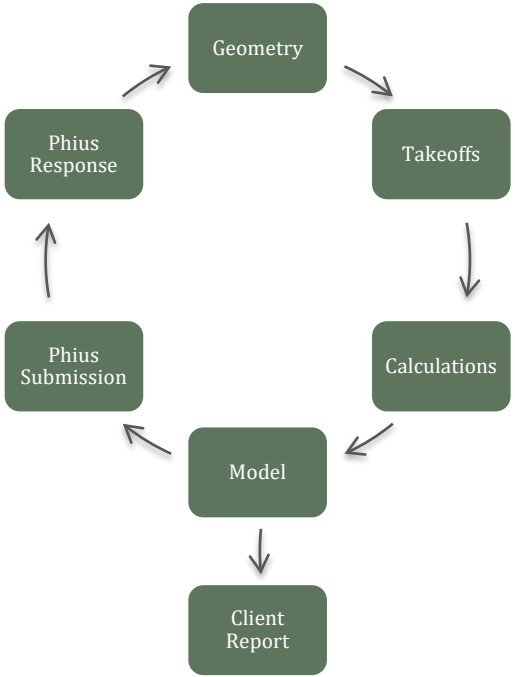
- Manage priorities instead of projects
- Maximize project output

How do we increase scalability?

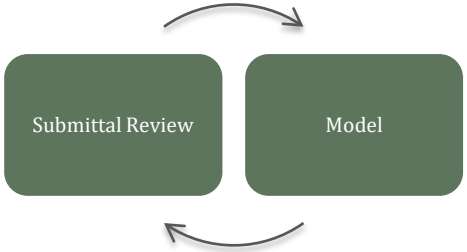
- Consistent/optimized workflow
- Quick and efficient processes

Energy Modeling Workflows

Design



Construction



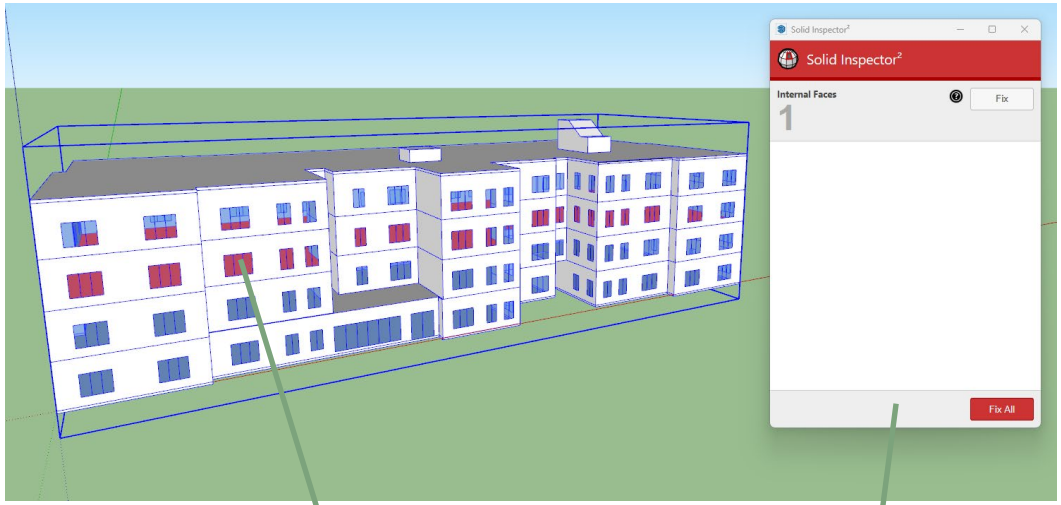
Building the Geometry

SketchUp

- Simple and user-friendly
- Many useful extensions
- Can import multiple file types
- Strongest compatibility with WUFI

Use hotkeys and extensions

- Assign keyboard strokes to most used tools
- Solid inspector, selection toys, etc.



Internal face causing discontinuous volume

Solid Inspector extension

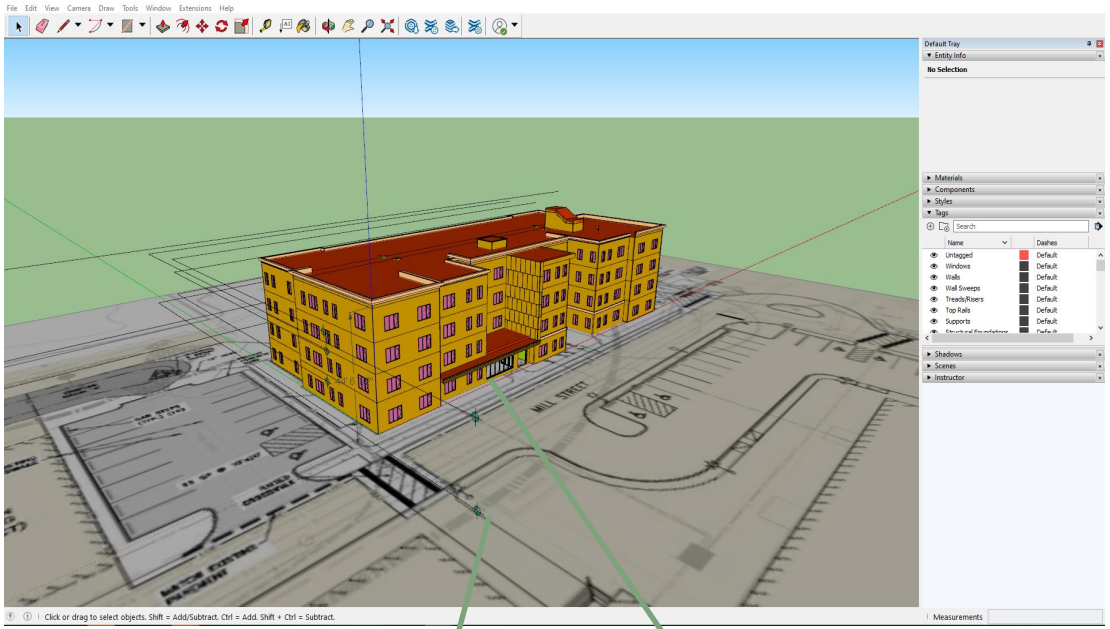
Building the Geometry

Make use of REVIT model

- Reference floor plans and elevations while tracing
- Draw doors/glazing according to schedule
- Draw/define only unique components, then copy paste

Shell, Glazing, Shading

- Import into WUFI at each stage to quality check geometry



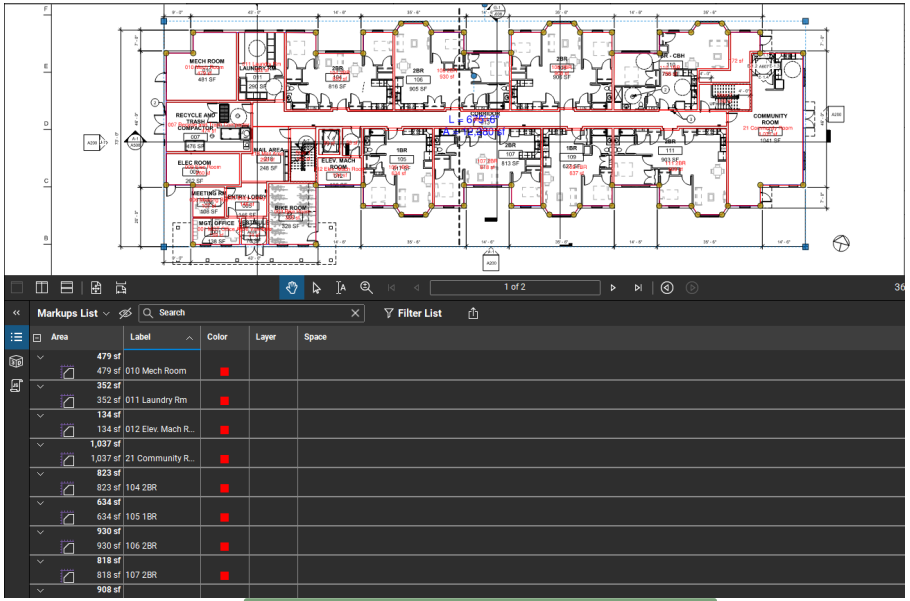
Performing Takeoffs

Many different tools can work

- Aim for familiarity, accuracy, and clarity

Save as individual files

- Measurements are there as soon as the file is opened
- Avoids cluttering the list of markups with irrelevant measurements



Can use markups to clearly label each measurement in Bluebeam

Performing Takeoffs

Measure only unique components

- Floor, units, pipe runs, etc.
- Can then copy/paste to identical components

Measure worst case scenarios

- DHW individual pipe run, in-unit ERV duct length, etc.
- Not recommended if extreme outlier
  - Use average

Running the Calculations

Use a template file

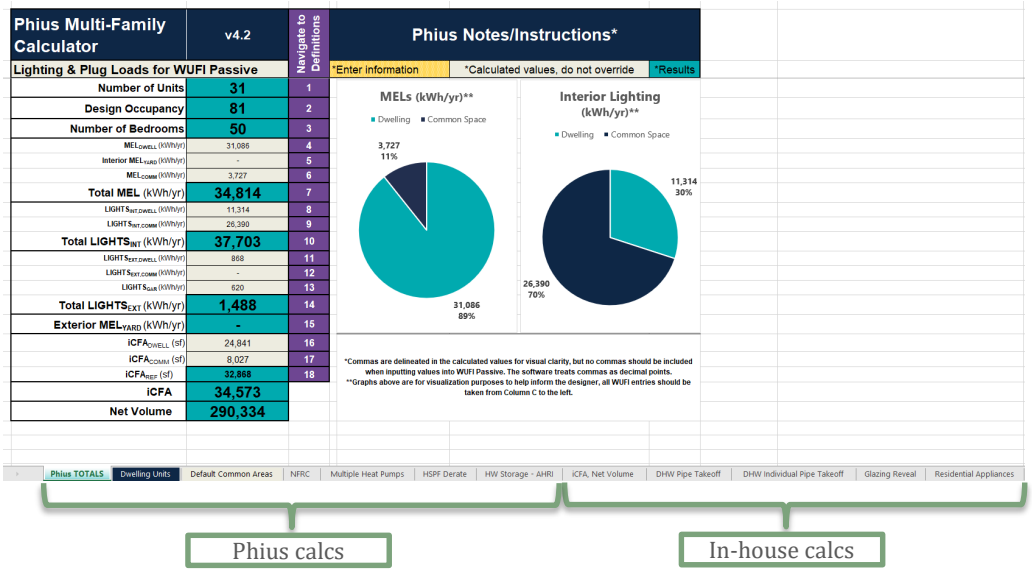
- Easily adjust inputs from project to project

Keep Phius and in-house spreadsheets in one file

- Many inputs are cross-referenced
- Streamlines data entry into WUFI
- Autofill report

Stay Organized

- Note down the takeoff file names used to complete calculations
- Save submittals and certifications as you use them
  - Note down these as well



WUFI Modeling

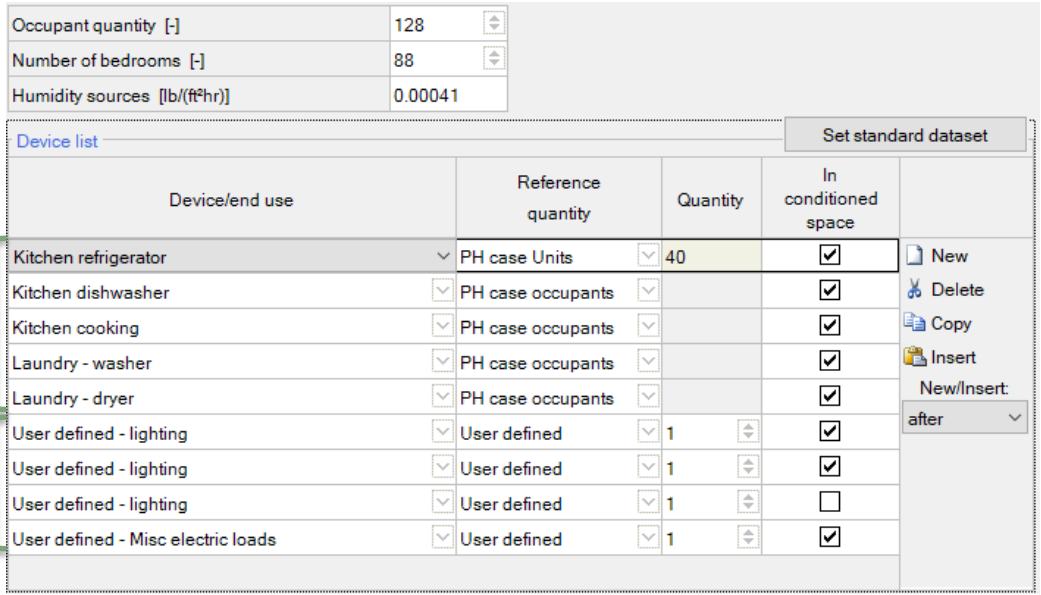
Have a completed model as a template

- Can import new geometry to replace old
- Ensure default inputs are correct
- Note which inputs need to be changed

Don't overcomplicate the model

- One component per each unique envelope type
- Input ventilation per device not room
- Typically only one mechanical system needed

Appliances can be left as defaults



Occupant quantity [-]	128
Number of bedrooms [-]	88
Humidity sources [lb/(ft²hr)]	0.00041

Device list — Set standard dataset

Device/end use	Reference quantity	Quantity	In conditioned space
Kitchen refrigerator	PH case Units	40	☑
Kitchen dishwasher	PH case occupants		☑
Kitchen cooking	PH case occupants		☑
Laundry - washer	PH case occupants		☑
Laundry - dryer	PH case occupants		☑
User defined - lighting	User defined	1	☑
User defined - lighting	User defined	1	☑
User defined - lighting	User defined	1	☐
User defined - Misc electric loads	User defined	1	☑

New
Delete
Copy
Insert
New/Insert:
after

Lighting and plug loads need to be updated for each project

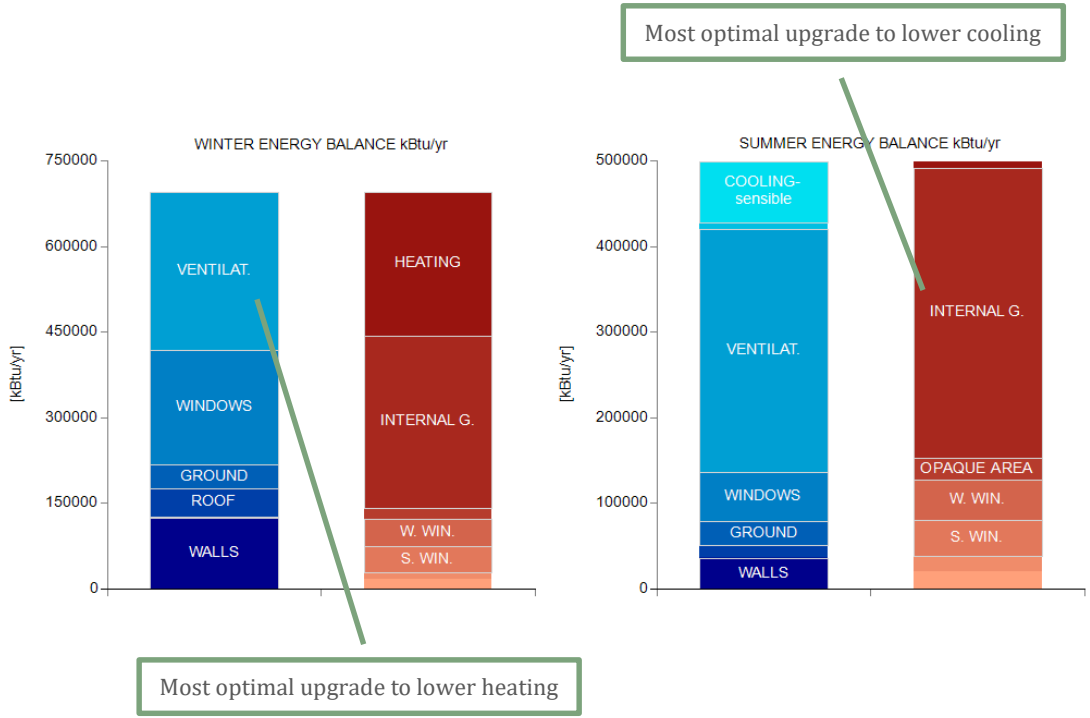
WUFI Modeling

Create a product database

- Heat pump/ERV AHRI certifications, Window/Storefront product data, etc.
- Can pick from this database to use as a placeholder while the actual product is still pending

What if the model fails?

- Look at WUFI's energy balance graphs
- Start with window SHGC
- Experiment with upgrades in areas of high impact



Team Communication

Project Manager

- Agree upon start dates and deadlines
- Settle project priorities
- Highlight key documents and files needed
- Coordinate the review of PHIUS comments
- Point out which submittals need review during construction phase

Rater/Verifier

- Emphasize critical details that play a role in passing the model
- Provide shell area and building volume
- Confirm mechanical and envelope changes

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In-house resources for all stages and separated by role. All participate in the design stage.

Role	Benefit
Project Manager manages the design team, internal plan reviews and communicates Phius requirements. Coordinates energy modeling, verifier participation – tracks the BIG picture	Manages multiple projects, up to date on Phius requirements, experience with multiple construction typologies
Energy Modeler completes feasibility study and modeling for the project; provides input to performance of building components	Very fast and accurate early in the process; knows Phius protocols and shortcuts
Phius Verifier is included in design to be familiar with project design intent when construction begins	Provides input on constructability and hits the ground running once construction starts

Scaling Phius Project Verification

- Verifier helps steer the final phase of project with the PM/CPHC
- Interaction with Consultant starts Pre-Construction & goes through construction completion and final Certification
- Dedicated Verifier for each project
- Reports to Consultant and team during construction
- Communicate high expectations and standards early
- GC and subcontractor training and buy in
- Mid-point Whole Building Test
- Finalizing Final Certification

PHIUS + VERIFIER

Set Phius Expectations High and Early

- Verifier as Co-manager
- Review Pre Certification
- Project Team PHIUS Kickoff meeting
- Clarify Verification Process and Roles

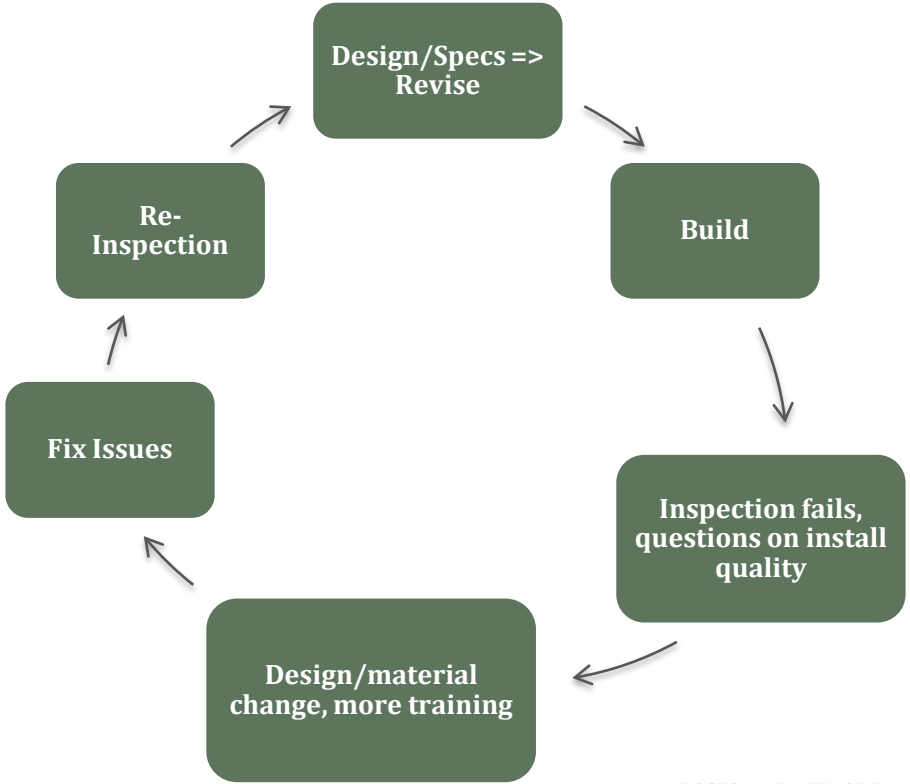
NEW ECOLOGY

Agenda

- Welcome, Introduction and Meeting Goals
- Review of Program Requirements
  - Passive House 2021
  - Energy Star, Indoor AirPLUS, WaterSense, ZERH
- Testing and Verification
- Review Checklists
- Review of Details

Verification Information and Workflow

- Design Team
- GC and Subcontractors
- Verifier
- PM/CPHC/Modeler
- Manufacturers



Phius Verification Process and Inspections/Training

- Review List and Timing of Phius Inspections & Testing
- Phius, Energy Star, ZERH, IAP
- Trainings for GC and subcontractors
- Mockups

Phase	Description	Timing
Early Construction	Foundation, Slab, Slab Edge Insulation	As Installed
	Vapor barrier below slab, haunches, grade beams, and over top of foundation	As Installed, before concrete
Mid Construction	Insulation inspection: • Exterior wall cavity (confirm density) • Exterior Continuous • Rim joists • Roof (incl. parapets, curbs, etc.)	As Installed
	Thermal bridges	As Installed
	Duct leakage testing at rough • Heating/cooling (if any) • Ventilation (Witness Test)	Before boarding
	Mid-point BD testing • Compartmentalization (unit ready) • Whole Building (building tight to weather)	When ready

Verification Testing and Inspections Schedule

- 20- 40 Site Visits
- Critical Inspections/Tests:
  - Slab Insulation and VB
  - Mid-Point Whole Building Infiltration Test
  - Duct Testing at Rough
  - Final Whole Building Infiltration Test

Phase	Description	Timing
Construction Completion and Final Inspections	Final Whole Building Test	At Construction completion
	Central ventilation air balancing witness test	As completed
	In unit heating/cooling air flow Confirm room pressure balance	At Construction completion
	Document fixture and appliance equipment list	At Construction completion
	Confirm heating, cooling, ventilation, DHW, PV equipment installation	At Construction completion
	Confirm ERV power draw	At Construction completion, Post Cx, post TAB
	DHW temperature rise test	At Construction completion
	IR scan of building interior and exterior	At Construction completion

NEW ECOLOGY
Community-Based Sustainable Development

Contractor Trainings

Invite the following:

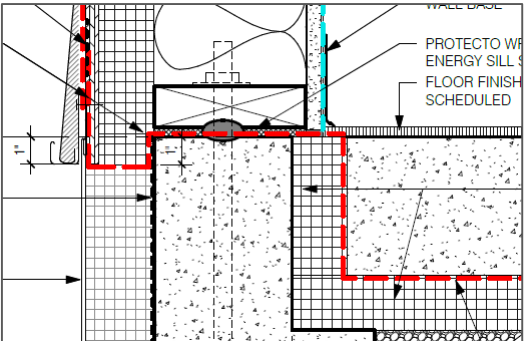
- Architect, Mechanical Engineer
- GC
  - Critical that site super and PM be present
- Subs
  - Critical that foreman working on the project is present
  - Air Sealing and Insulation, HVAC, plumbing, concrete

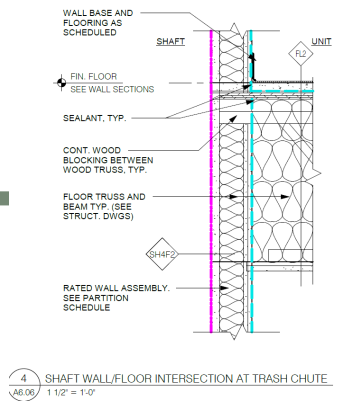
Review Thresholds and how they relate to each trade – do not over simplify

Criteria	Threshold
WB Air Tightness	0.06 cfm50/ft^2 of enclosure
Compartmentalization	0.30 cfm50/ft^2 of enclosure
Ventilation Flow Rate	Must be w/in 10% of design Cannot fall below minimum
Heating/cooling Flow Rate	Must be w/in 10% of design
Duct Testing	4% at rough (4 cfm25/100ft^2)
Return Balance	≤ 5 Pa
Hot Water Temp Rise Test	≥ 10 ˚ F Temp Rise in ≤ 0.6 gal

Contractor Trainings

- Hammer home air sealing
- Discuss whole building air barrier and compartmentalization boundary
- Provide field examples and relate to project details
- Provide examples of fails and successes





$0.06\ cfm50/ft^2$ of enclosure

Effective Leakage Area = 177 Sq.in.

Total Envelope Area = 53,158 SF

Contractor Trainings – Air Sealing Coordinator

- Projects should designate an air sealing coordinator
- Example of a sign that works
  - All penetrations must be approved
  - GC putting subs on notice of critical importance of sealing penetrations

Mockups

- Mockups including:
  - Foundation and slab VB and insulation installations and penetrations
  - Wall assemblies including WRB, widow flashing, window installation, and transitions to foundation and roof
  - MEP Penetrations
- Make part of trainings
- Assess Constructability
- Assess Subcontractors

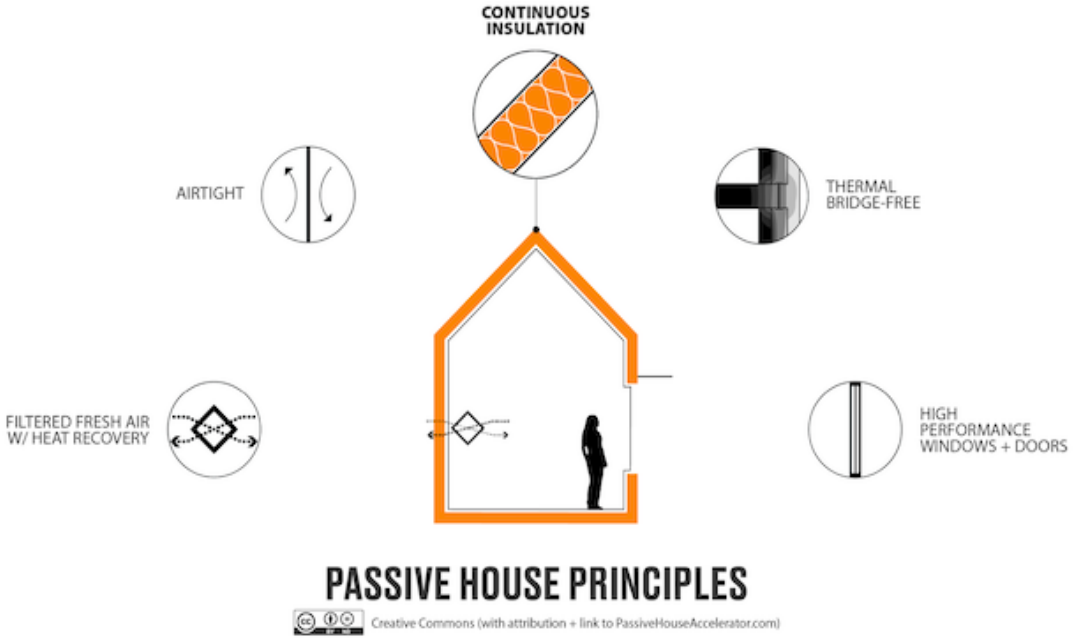
Inspections/Testing and Information flow

- First inspections reinforce expectations
- Emphasize execution is critical to performance and Pass/Fail of Phius certification
- On-site instruction to bolster contractor trainings
- Phius photo documentation
- Inspection Reports to PM and project team

OSHA?
More importantly (?) damage to insulation

What Are We Looking For?

- Air Sealing, Air Sealing, Air Sealing
- Assemblies and insulation quality and Confirming R-Values
- Thermal bridging
- Confirmation of performance
- Infiltration – Building and Units
- Duct leakage
- Ventilation
- Mechanicals, PV, Appliances, Lighting

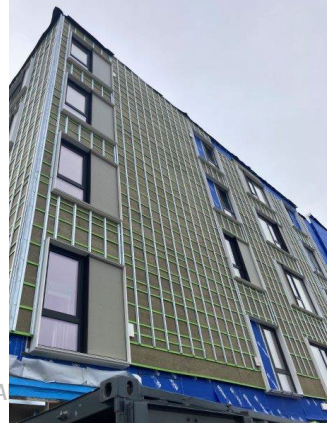


Air Sealing – Compartmentalization and Envelope

- Unit and Building envelope
- Framing, pre-rock, panel joints, MEP penetrations, etc.
- Mid point Unit Blower door test

Insulation

- Slab, foundation, walls cavity, roof
- Continuous Exterior
- Confirming install quality, Design, R-Values
- Cellulose Density Reports

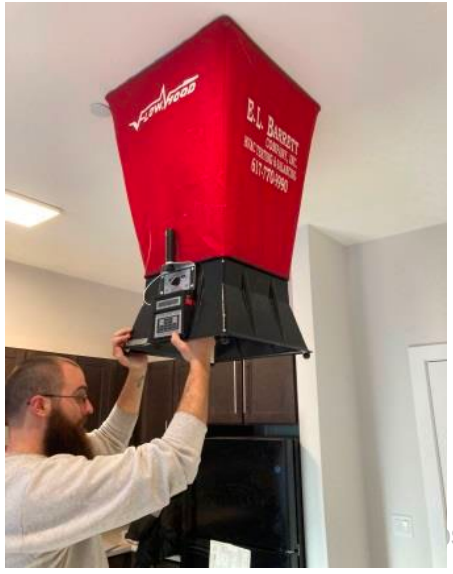


Thermal Breaks

- Confirming thermal break installs
- Infrared photos at Final

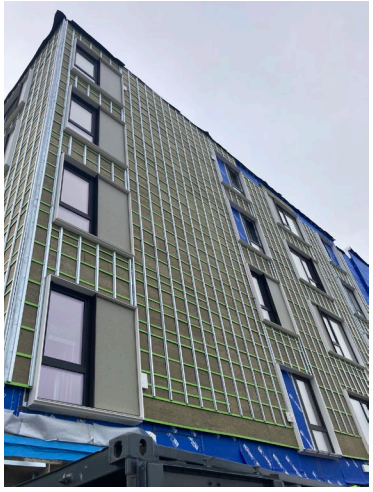
Duct Testing

- Heating/Cooling
- Central Ventilation
- Testing & Balancing
- Confirming Min. Flows



Mid Point Whole Building Infiltration Test

- Optional, but really shouldn't be
- Critical test of how envelop is performing
- MEP Penetrations
- Roof Penetrations/transitions
- Windows and Doors

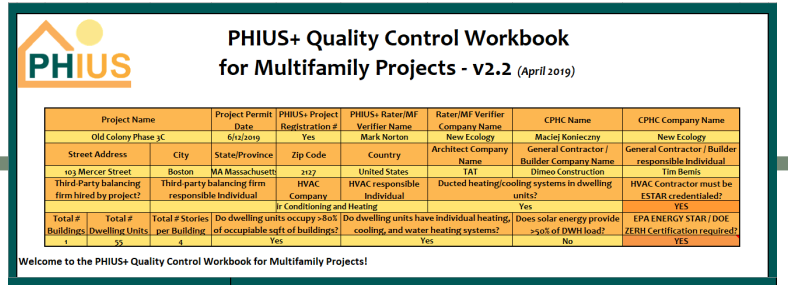


Final Testing and Verification

- Ventilation Testing and Balancing
- Final Whole Building Blower Door Test

- Data Collection for PHIUS QA Workbook
- Complete Energy Star, IAP and ZERH Checklists

- PHIUS submission of QA Workbook, photos and documentation,
- PHIUS QA response
- PHIUS Re-submission

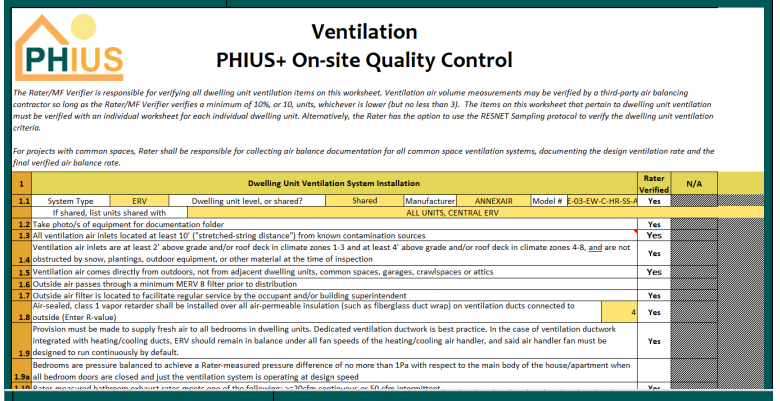


PHIUS

PHIUS+ Quality Control Workbook for Multifamily Projects - v2.2 *(April 2019)*

Project Name		Project Permit Date	PHIUS+ Project Registration #	PHIUS+ Rater/MF Verifier Name	Rater/MF Verifier Company Name	CPHC Name	CPHC Company Name
Old Colony Phase 3C		6/12/2019	Yes	Mark Norton	New Ecology	Maciej Konieczny	New Ecology
Street Address	City	State/Province	Zip Code	Country	Architect Company Name	General Contractor / Builder Company Name	General Contractor / Builder responsible Individual
103 Mercer Street	Boston	MA Massachusetts	2127	United States	TAT	Dimeo Construction	Tim Bemis
Third-Party balancing firm hired by project?	Third-party balancing firm responsible Individual	HVAC Company	HVAC responsible Individual	Ducted heating/cooling systems in dwelling units?			HVAC Contractor must be ESTAR credentialed?
	Air Conditioning and Heating			Yes			YES
Total # Buildings	Total # Dwelling Units	Total # Stories per Building	Do dwelling units occupy >80% of occupiable sqft of buildings?	Do dwelling units have individual heating, cooling, and water heating systems?		Does solar energy provide >50% of DWH load?	EPA ENERGY STAR / DOE ZERH Certification required?
1	55	4	Yes	Yes		No	YES

Welcome to the PHIUS+ Quality Control Workbook for Multifamily Projects!



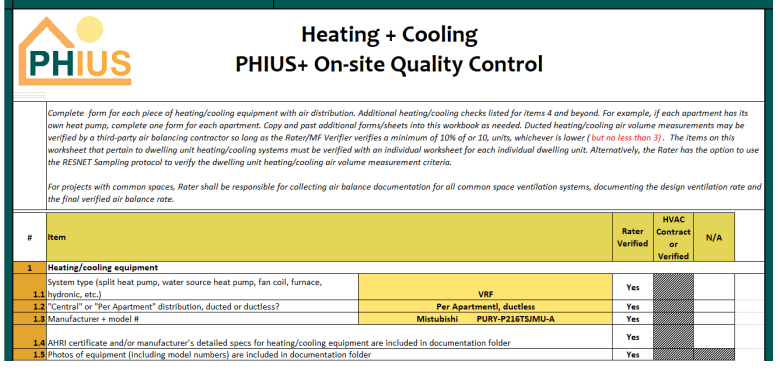
PHIUS

Ventilation
PHIUS+ On-site Quality Control

The Rater/MF Verifier is responsible for verifying all dwelling unit ventilation items on this worksheet. Ventilation air volume measurements may be verified by a third-party air balancing contractor so long as the Rater/MF Verifier verifies a minimum of 10%, or 10, units, whichever is lower (but no less than 3). The items on this worksheet that pertain to dwelling unit ventilation must be verified with an individual worksheet for each individual dwelling unit. Alternatively, the Rater has the option to use the RESNET Sampling protocol to verify the dwelling unit ventilation criteria.

For projects with common spaces, Rater shall be responsible for collecting air balance documentation for all common space ventilation systems, documenting the design ventilation rate and the final verified air balance rate.

	Dwelling Unit Ventilation System Installation								Rater Verified	N/A
1.1	System Type	ERV	Dwelling unit level, or shared?	Shared	Manufacturer	ANNEXAIR	Model #	E-03-EW-C-HR-SS-A	Yes	
	If shared, list units shared with			ALL UNITS, CENTRAL ERV						
1.2	Take photo/s of equipment for documentation folder								Yes	
1.3	All ventilation air inlets located at least 10' ("stretched-string distance") from known contamination sources								Yes	
1.4	Ventilation air inlets are at least 2' above grade and/or roof deck in climate zones 1-3 and at least 4' above grade and/or roof deck in climate zones 4-8, and are not obstructed by snow, plantings, outdoor equipment, or other material at the time of inspection								Yes	
1.5	Ventilation air comes directly from outdoors, not from adjacent dwelling units, common spaces, garages, crawlspaces or attics								Yes	
1.6	Outside air passes through a minimum MERV 8 filter prior to distribution									
1.7	Outside air filter is located to facilitate regular service by the occupant and/or building superintendent								Yes	
1.8	Air-sealed, class 1 vapor retarder shall be installed over all air-permeable insulation (such as fiberglass duct wrap) on ventilation ducts connected to outside (Enter R-value)							4	Yes	
1.9	Provision must be made to supply fresh air to all bedrooms in dwelling units. Dedicated ventilation ductwork is best practice. In the case of ventilation ductwork integrated with heating/cooling ducts, ERV should remain in balance under all fan speeds of the heating/cooling air handler, and said air handler fan must be designed to run continuously by default.								Yes	
1.9a	Bedrooms are pressure balanced to achieve a Rater-measured pressure difference of no more than 1Pa with respect to the main body of the house/apartment when all bedroom doors are closed and just the ventilation system is operating at design speed									
1.10	Rater-measured bathroom exhaust rates meets one of the following: >=20cfm continuous or 50 cfm intermittent								Yes	



PHIUS

Heating + Cooling
PHIUS+ On-site Quality Control

Complete form for each piece of heating/cooling equipment with air distribution. Additional heating/cooling checks listed for items 4 and beyond. For example, if each apartment has its own heat pump, complete one form for each apartment. Copy and past additional forms/sheets into this workbook as needed. Ducted heating/cooling air volume measurements may be verified by a third-party air balancing contractor so long as the Rater/MF Verifier verifies a minimum of 10% of or 10, units, whichever is lower (but no less than 3) . The items on this worksheet that pertain to dwelling unit heating/cooling systems must be verified with an individual worksheet for each individual dwelling unit. Alternatively, the Rater has the option to use the RESNET Sampling protocol to verify the dwelling unit heating/cooling air volume measurement criteria.

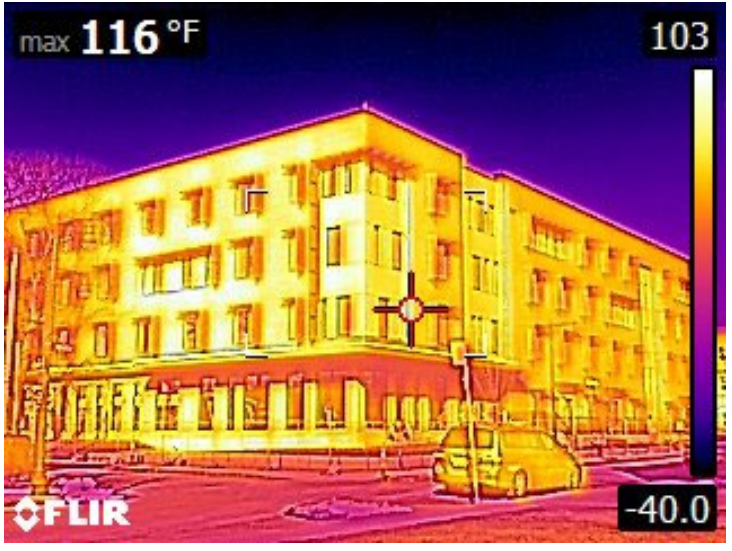
For projects with common spaces, Rater shall be responsible for collecting air balance documentation for all common space ventilation systems, documenting the design ventilation rate and the final verified air balance rate.

#	Item		Rater Verified	HVAC Contractor Verified	N/A
1	**Heating/cooling equipment**				
1.1	System type (split heat pump, water source heat pump, fan coil, furnace, hydronic, etc.)	VRF	Yes		
1.2	"Central" or "Per Apartment" distribution, ducted or ductless?	Per Apartmentl, ductless	Yes		
1.3	Manufacturer + model #	Mitsubishi PURY-P216TSJMU-A	Yes		
1.4	AHRI certificate and/or manufacturer's detailed specs for heating/cooling equipment are included in documentation folder		Yes		
1.5	Photos of equipment (including model numbers) are included in documentation folder		Yes		

NEW ECOLOGY
Community-Based Sustainable Development

In Summary

- Aggressive code in Massachusetts
- Steep learning curve
- Feasibility is Critical
- Phius Guidebook IS critical
- Using templates streamlines modeling
- Keep It Simple
- Define a continuous workflow for entire team
- Set expectations high, early, and often
- Mid point whole building test should be mandatory



NEW ECOLOGY
Community-Based Sustainable Development

Thank You.

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PROJECT 1660

Old Colony Phase Three C

Boston, Massachusetts

BUILDING FUNCTION
Multifamily

PROJECT TYPE
New Construction

ASHRAE CLIMATE ZONE
5A - Cool - Humid

CONSTRUCTION COMPLETION
2021

STATUS
Final Certified

INT. CONDITIONED FLOOR AREA
49339 sq. ft.