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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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Nicholas Hernandez  Energy Engineer hernandez@newecology.org 617-557-1700 x7047

Mark Norton  PHIUS+, LEED, HERS Project Manager | New Ecology, Inc. norton@newecology.org 617-522-6919
• 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.
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


THREE ENERGY CODES IN MASSACHUSETTS

- 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

Two hundred ninety-nine (299) municipalities have adopted the Board of Building Regulations and Standards (BBRS) Stretch Code, as of November 16, 2021.
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

- 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.
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.

<table>
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- Energy Modeler completes feasibility study and modeling for the project; provides input to performance of building components.
- Phius Verifier is included in design to be familiar with project design intent when construction begins.
Typical Project – Define Objectives

Start Early – during scope development (pre-SD)

Set sustainability objectives early (Design Charrette)

- Local Requirements?
- Focus on IAQ?
- Resiliency?
- Metering?
- Central systems?
- All electric?
- Renewables?
Typical Project – Define Objectives

CUT THROUGH THE NOISE

FOCUS THE TEAM
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
Typical Project – Complete Feasibility

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

Make informed decisions with limited information

Conceptual Mechanical System Options
Job Name: Ridge Commons, Cambridge, MA
Job #: 1837
Date: 10/22/2019 Rev. 1

The following is an outline of preliminary HVAC system options for Ridge Commons based on the following:

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 (Photovoltaics) 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.
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

**Typical Project – Report Feasibility Results**
Typical Project – Design Process

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
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

Minor changes with quick turnaround

Typical Project – Design Process

**THERM Model**

**Calculated TB**

**Mitigated TB**

**Component A**
- Wall
  - Interior: U = 0.05, dT = 54°F, L = 89.38 in, UdT = 22.48 btu/hr ft²°F
  - Exterior: U = 0.05, dT = 54°F, L = 89.38 in, UdT = 22.48 btu/hr ft²°F

**Component B**
- Slab
  - Interior: U = 0.01, dT = 54°F, L = 89.38 in, UdT = 22.48 btu/hr ft²°F
  - Exterior: U = 0.01, dT = 54°F, L = 89.38 in, UdT = 22.48 btu/hr ft²°F

**Psi for WUFI**
- Interior: Psi = 4.99, PsdT = 54°F, Psi = 0.00
- Exterior: Psi = 5.07, PsdT = 54°F, Psi = 0.00

 Psi

Psi for WUFI

0.093
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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

Geometry

Takeoffs

Calculations

Model

Phius Submission

Phius Response

Client Report

Construction

Submittal Review

Model
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.
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

Lighting and plug loads need to be updated for each project
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

Most optimal upgrade to lower heating
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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**Typical Approach vs NEI Approach**
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
Set Phius Expectations High and Early

### 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

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

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

<table>
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<tr>
<td>WB Air Tightness</td>
<td>0.06 cfm50/ft² of enclosure</td>
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<tr>
<td>Compartmentalization</td>
<td>0.30 cfm50/ft² of enclosure</td>
</tr>
<tr>
<td>Ventilation Flow Rate</td>
<td>Must be w/in 10% of design</td>
</tr>
<tr>
<td></td>
<td>Cannot fall below minimum</td>
</tr>
<tr>
<td>Heating/cooling Flow Rate</td>
<td>Must be w/in 10% of design</td>
</tr>
<tr>
<td>Duct Testing</td>
<td>4% at rough (4 cfm25/100ft²)</td>
</tr>
<tr>
<td>Return Balance</td>
<td>≤ 5 Pa</td>
</tr>
<tr>
<td>Hot Water Temp Rise Test</td>
<td>≥ 10 °F Temp Rise in ≤ 0.6 gal</td>
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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

Total Envelope Area = 53,158 SF

0.06 cfm50/ft² of enclosure

Effective Leakage Area = 177 Sq.in.
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

NOTICE TO ALL TRADE PARTNERS

1. All penetrations between the building zones and the exterior (ceiling, slab, walls, etc.) must be approved by Bowdoin Construction’s designated air sealing coordinator and project architect.

2. Trade Partners are responsible for sealing any penetrations created by the installation of their building system / components and must use sealing methods pre-approved by Bowdoin Construction’s air sealing coordinator and project architect.

3. Trade Partners will be held accountable for the cost of repairing any unapproved and / or improperly sealed penetration through the building’s air barrier system.
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
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
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
Thank You.

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Old Colony Phase Three C  
Boston, Massachusetts

- **BUILDING FUNCTION:** Multifamily  
- **PROJECT TYPE:** New Construction  
- **CONSTRUCTION COMPLETION:** 2021  
- **STATUS:** Final Certified  
- **AVERAGE CLIMATE ZONE:** 5A - Cool - Humid  
- **PROJECT COST:** $XX,XXX  
- **TOTAL BUILT SQUARE FOOTAGE:** 100,000 sq. ft.