ASHRAE Standard 90.1 App G, PHI and PHIUS+

A NYSERDA Comparative Evaluation Study

June 16, 2017
Governor Cuomo’s strategy to build a clean, resilient and affordable energy system for all New Yorkers
New York State – Clean Energy Fund (CEF)

- 10-year, $5 billion funding commitment
- Reshapes New York’s energy efficiency, renewable energy and energy innovation programs
- Reduces cost of clean energy
- Accelerates adoption of energy efficiency to reduce load
- Increases renewable energy to meet demand
- Mobilizes private investment in clean energy

**Market Transformation:** Enables the creation of a new, integrated, and self-sustaining clean energy market
Multifamily New Construction Program (MF NCP)

- MF NCP to serve mid- and high-rise multifamily buildings
- Started development of CEF-funded MF NCP in Q4 2015
  - Promote construction of high performance buildings (“near-ZNE”)
  - Focus on market-based solutions
- Promote higher performance through tiered incentives

<table>
<thead>
<tr>
<th>Tier</th>
<th>Performance</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moderate efficiency</td>
<td>Technical Assistance</td>
</tr>
<tr>
<td>2</td>
<td>Very good efficiency</td>
<td>TA + $</td>
</tr>
<tr>
<td>3</td>
<td>Exceptional efficiency + Significant renewables/DG</td>
<td>TA + $$$</td>
</tr>
</tbody>
</table>
Passive House Market

- All passive house: Exponential growth in North America
- NY Multifamily passive house: ~12 projects pursuing PH in pre-CEF funded NYSERDA programs
- Release of PHIUS+ Multifamily Certification Standard & PHIUS+ Verifier certification
- Early development of VeriPHy

Frappé-Sénéclauze, Tom-Pierre et. al. *Accelerating Market Transformation for High-Performance Building; Pembina Institute*
How to incorporate PH into MF NCP?

• NYSERDA wanted to promote aspirational performance
• NYSERDA had previously incentivized projects following ENERGY STAR MFHR program, and wanted to continue to do so
• NYSERDA wanted to open the program to other market-based solutions, specifically passive house
• Where does passive house fall? How does it compare to MFHR? How does it compare to code? How do we claim savings?
How to incorporate PH into MF NCP?

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- NYSERDA had previously incentivized projects following ENERGY STAR MFHR program, and wanted to continue to do so
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- Where does passive house fall? How does it compare to MFHR?
- How does it compare to code? How do we claim savings?
Clarification on study

• No winners or losers
Study Methodology

ASHRAE 90.1 Appendix G

Passive House Institute US

Passive House Institute
Study Methodology

- Model the same building designs in each of the three protocols
- Compare resulting performance metrics
- Understand the sources of difference
- Develop an approximate mapping
Study Methodology

ASHRAE 90.1 Appendix G

\[ X \text{ [% Saving, $]} \]

\[ Y \text{ [kWh/person-yr]} \]

\[ Z \text{ [kBtu/ft}^2\text{-yr]} \]
ASHRAE 90.1 Appendix G (Appx G)

- Used by ENERGY STAR MFHR, LEED and is a NYS energy code compliance path
- Title: “Performance Rating Method”
- Scope: “…This appendix offers an alternative path for minimum standard compliance …. It is also provided for those who wish to use this appendix to quantify performance that exceeds the requirements of this standard”
**ASHRAE 90.1 Appendix G (Appx G)**

<table>
<thead>
<tr>
<th>Proposed Building Energy Cost</th>
<th>Baseline Building Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy model reflecting building design</td>
<td>Energy model of a virtual building configured as described in 90.1 Appendix G and meeting code prescriptively</td>
</tr>
</tbody>
</table>

- Same operating conditions
- Same utility rates and weather file
- Modeled in a simulation tool that meets requirements of 90.1 Appendix G
Evaluated Protocols and Tools

<table>
<thead>
<tr>
<th>Guiding Documents</th>
<th>Simulation Tool</th>
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</thead>
<tbody>
<tr>
<td>Appx G - ASHRAE Standard 90.1 2010 Appendix G;</td>
<td>eQUEST v3.65</td>
</tr>
<tr>
<td>ENERGY STAR MFHR Simulation Guidelines</td>
<td></td>
</tr>
<tr>
<td>PHIUS - PHIUS+ 2015 Certification Guide Book V1.01</td>
<td>WUFI V.3.0.3.0</td>
</tr>
<tr>
<td>PHI - PHPP v9.5 – PH Classic</td>
<td>PHPP v9.5</td>
</tr>
</tbody>
</table>

- Each configuration was modeled in each protocol by a team with expert knowledge of the corresponding protocol and modeling software.
- All models and analyses were shared between the teams to enable peer review.
The Team

- NYSERDA Manager – Pat Fitzgerald, NYSERDA
- Project Manager – Shelley Beaulieu, TRC Energy Services
- Technical Lead – Maria Karpman, Karpman Consulting
- PHIUS Modeler – James Ortega, PHIUS
- PHI Team 1 Modeler – Lois Arena, Steven Winter Associates
- PHI Team 2 Modeler – Jessica Grove-Smith, PHI (Germany)
Case Study Description

Building shape and floor plan based on the Pacific Northwest National Lab (PNNL) high-rise apartment multifamily progress indicator model

- 84,360 ft², 10-story
- 79 two-bedroom apartments
- Windows account for 30% of gross exterior wall on each exposure
- Slab-on-grade foundation
- Climate zone 4A (NYC)
Evaluated Configurations

Base Case: All systems minimally compliant with ASHRAE 90.1 2010; mechanical design based on ASHRAE 90.1 2010 Appendix G baseline
Evaluated Configurations

Packages A, B, & C: Base Case with the features commonly seen in projects that exceed code, but below passive house standards

• Good, above-code envelope
• Infiltration per ASHRAE 90.1
• DHW: condensing boiler with low-flow fixtures
• High-efficiency lighting, ENERGY STAR refrigerators
• Trickle vents and continuous kitchen and bathroom exhaust
• Apartment HVAC
  – Packages A and B: condensing boilers with hydronic baseboards + Window AC
  – Package C: VRF
• Corridor HVAC
  – Package A: Roof top unit
  – Packages B and C: Roof top unit with ERV
Evaluated Configurations

Packages D & F: High performance configurations with features found in the best projects, ~Tier 3; exceed passive house standards

- Very good, above-code envelope
- Infiltration values per passive standard requirements
- DHW: condensing boiler with low-flow fixtures
- High-efficiency lighting + occupancy sensors, ENERGY STAR refrigerators + more efficient elevator
- Balanced ERV in Apartments & Corridor spaces
- Same HVAC in Apartments & Corridor spaces
  - Package D: condensing boilers with hydronic baseboards
  - Package F: VRF
Modeling Results: Annual Source* Energy

* Site-to-source energy conversions based on the EPA Portfolio Manager
**Base Case Source* Energy: DHW**

<table>
<thead>
<tr>
<th>DHW</th>
<th>Appx G</th>
<th>PHIUS</th>
<th>PHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fans</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Plug Loads</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lighting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Heating</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cooling</td>
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</tbody>
</table>

Key reason for difference:
- **Modeling assumptions**
  Appx G has a higher assumption For DHW demand than PHIUS or PHI. (25 vs. 6.6 gal/person/day)

- **Modeling rules**
  Appx G does not capture DHW distribution losses, but PHIUS and PHI do.

* Site-to-source energy conversions based on the EPA Portfolio Manager
Base Case Source* Energy: Fans

Key reason for difference:
- Modeling rules
  Appx G requires fan use related to heating and cooling to be separately modeled.
- Simulation tool capabilities
  WUFI and PHPP do not capture continuous running fans associated with heating/cooling

* Site-to-source energy conversions based on the EPA Portfolio Manager
Base Case Source* Energy: Plug Loads & Lighting

Key reason for difference: Modeling assumptions

Assumptions are more optimistic in PHI than PHIUS, which is more optimistic than Appx G.

Impacts thermal loads

* Site-to-source energy conversions based on the EPA Portfolio Manager
Source Energy of Selected Packages

Package A

- DHW
- Fans
- Plug Loads
- Lighting
- Pumps
- Heating
- Cooling

Package D

- DHW
- Fans
- Plug Loads
- Lighting
- Pumps
- Heating
- Cooling

Package F

- DHW
- Fans
- Plug Loads
- Lighting
- Pumps
- Heating
- Cooling

Legend:
- Appx G
- PHIUS
- PHI
Key Reasons for the Differences: Modeling Rules

- PHIUS and PHI protocols capture savings from manual controls
- Appx G allows credit only for automatic controls inherent to design
Key Reasons for the Differences: Modeling Rules

Appx G protocol does not require* explicit modeling of certain envelope details, which are integral to PHI and PHIUS:

• Hygrothermal assessment
• Detailed thermal bridging

* Note that some tools that comply with Appx G protocol do include functionality above and beyond the requirements.
Key Reasons for the Differences: Capabilities of the Simulation Tools

WUFI and PHPP are designed for buildings with relatively simple mechanical systems.

Sample limitations:

- Continuously running fans in heating & cooling system were not captured
- Could not explicitly model different mechanical systems serving common corridors and apartments
### Metric Results for each Package

<table>
<thead>
<tr>
<th>Standard</th>
<th>Package A</th>
<th>Package B</th>
<th>Package C</th>
<th>Package D</th>
<th>Package F</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appx G</td>
<td>30%</td>
<td>29%</td>
<td>23%</td>
<td>39%</td>
<td>40%</td>
<td>-</td>
</tr>
<tr>
<td>PHIUS</td>
<td>6661</td>
<td>6486</td>
<td>6373</td>
<td>4964</td>
<td>-</td>
<td>6200</td>
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<tr>
<td>PHI</td>
<td>46</td>
<td>46</td>
<td>41</td>
<td>-</td>
<td>28</td>
<td>38</td>
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<table>
<thead>
<tr>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appx G</td>
</tr>
<tr>
<td>PHIUS</td>
</tr>
<tr>
<td>PHI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard</th>
<th>Version</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appx G</td>
<td>ASHRAE 90.1-2010</td>
<td>Performance Rating, % savings ($)</td>
</tr>
<tr>
<td>PHIUS</td>
<td>PHIUS+ 2015</td>
<td>Primary Energy, kWh/Person - Yr</td>
</tr>
<tr>
<td>PHI</td>
<td>PH Classic</td>
<td>Primary Energy, kBtu/ft²-Yr</td>
</tr>
</tbody>
</table>
Difference between Rated and Actual Performance

From ASHRAE Standard 90.1: Neither the *proposed building performance* nor the *baseline building performance* are predictions of actual *energy* consumption or costs for the *proposed design* after *construction*. Actual experience will differ from these calculations due to:

- variations such as occupancy
- building operation and maintenance
- weather
- *energy* use not covered by this procedure
- changes in *energy* rates between design of the *building* and occupancy
- the precision of the calculation tool

**These factors affect ALL protocols**
Difference between Rated and Actual Performance

Your Mileage Will Vary

EPA fuel economy estimates are based on standardized tests designed to reflect "typical" driving conditions and driver behavior, but several factors can affect MPG significantly:

- How & where you drive
- Vehicle condition & maintenance
- Fuel variations
- Vehicle variations
- Engine break-in

Your cost will depend on your utility rates and use.
Takeaways

• Appx G, PHIUS, and PHI showed significantly different consumption for the same building design.

• The key drivers of the difference include:
  - Rules governing what should be modeled (e.g., manual vs automated shading)
  - Estimated usage of building systems not shown on drawings
  - Simulation tool capabilities
Takeaways

• Limitations of WUFI and PHPP will complicate analysis of the building designs that involve complex and/or diverse HVAC systems

• Lack of requirements within Appx G protocol could result in potential issues with thermal bridging and hygrothermal performance

• Consumers should be educated about the nature of performance metrics produced by the protocols
Multifamily New Construction Program

- NYSERDA’s MF NCP was published in 2016 as PON 3319

- **Eligible Projects:**
  - Multifamily building(s) with four (4) or more stories
  - Electricity customer of Con Edison, Orange and Rockland Utilities, National Grid, New York State Electric and Gas, Central Hudson Gas and Electric, Rochester Gas and Electric

- MF NCP documents are available at [www.nyserda.ny.gov/Multifamily-NC](http://www.nyserda.ny.gov/Multifamily-NC)
MF NCP: Performance Tiers

• Tier 3:

  Savings through building performance, renewables, distributed generation, or a combination

  Savings through building performance *only*
# MF NCP Tier 3 Performance Thresholds

<table>
<thead>
<tr>
<th>Performance Path with ENERGY STAR</th>
<th>PHIUS+</th>
<th>PHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings through building performance only</td>
<td>35%*</td>
<td>5200 kWh/person/yr</td>
</tr>
<tr>
<td>Plus impact from renewables &amp; distributed generation</td>
<td>42%*</td>
<td>4200 kWh/person/yr</td>
</tr>
</tbody>
</table>

*ASHRAE version is dependent on what version of NYS Energy Code the project is permitted under
Next Steps

• Finalize and publish study
• Add ASHRAE 90.1-2013 Appx G standard (current code)
• Update study as each protocol evolves
• Incorporate cost-effectiveness into study
• Compare passive house project models to Appx G models for select projects in our pipeline
• Analyze actual performance of buildings that followed the 3 standards
Passive House Market

Multifamily 4+ Story Projects in North America

<table>
<thead>
<tr>
<th></th>
<th>Passive MF, 4+ Stories</th>
<th>NYSERDA Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Certified</td>
<td>8</td>
<td>Legacy</td>
</tr>
<tr>
<td>Certified</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>MF NCP</td>
<td>15</td>
<td>Inquiries</td>
</tr>
<tr>
<td>Inquiries</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Thank you!

Questions about this study?
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