Seminar 7 – Passive Housing

ASHRAE Standard 90.1 Performance Rating Method, PHIUS+, and PHI Comparative Evaluation Study
Learning Objectives

• Understand similarities and differences in simulation requirements of ASHRAE Standard 90.1 Appendix G, PHIUS+ and PHI protocols
• Learn how to interpret energy use projections for projects modeled with ASHRAE Standard 90.1, PHIUS+ and PHI
• Compare modeled data for each of the two protocols with the actual measured performance for three multifamily case studies in varying climate zones
• Identify differences between the two most commonly used multifamily passive building modeling protocols and design targets
• Learn how the Passive House Planning Package (PHPP) can be used as a software tool to design and verify energy efficient buildings in North America and worldwide
• Learn about a new innovative approach for optimizing buildings for an efficient use of renewable energies
Acknowledgements

• Pat Fitzgerald, NYSERDA: Project Manager
• Jessica Grove-Smith, PHI: PHI modeler
• James Ortega, PHIUS: PHIUS modeler
Background

- ASHRAE Standard 90.1 Appendix G Performance Rating Method (90.1 PRM) is a compliance path within New York Energy Code, and the basis of many green building programs such as LEED NC and state incentive programs.

- Exponential growth of Passive House projects in North America over the last decade; most projects are single-family homes.

- NYSERDA multifamily program had previously incentivized projects following 90.1 PRM as adopted by ENERGY STAR Multifamily High-rise program, and wanted to continue to do so, but open the program to other market-based solutions.

Frappé-Sénéclauze, Tom-Pierre et. al. *Accelerating Market Transformation for High-Performance Building;* Pembina Institute
Study Goals

• Examine equivalency of 90.1 PRM, PHIUS+, and PHI performance metrics, to inform technical requirements of NYSERDA multifamily program

• Ensure that the given building design qualifies for the same incentive, independent on the followed protocol

• Work cooperatively with the vendors of the evaluated protocols, to inform further improvement of each

• No winners or losers
Methodology

- Model the same building designs in each of the three protocols
- Compare the resulting performance metrics
- Understand the sources of difference
- Develop an approximate mapping between the protocols
## Protocols and Tools

<table>
<thead>
<tr>
<th></th>
<th>Guiding Documents</th>
<th>Simulation Tool</th>
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<tbody>
<tr>
<td><strong>90.1 PRM</strong></td>
<td>ASHRAE Standard 90.1 2010 Appendix G; EPA’s ENERGY STAR Multifamily High Rise Program Simulation Guidelines (MFHR SG)</td>
<td>eQUEST v3.65</td>
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<tr>
<td><strong>PHIUS</strong></td>
<td>PHIUS+ 2015 Certification Guide Book V1.01</td>
<td>WUFI V.3.0.3.0</td>
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<tr>
<td><strong>PHI</strong></td>
<td>PHPP v9.5 – PH Classic</td>
<td>PHPP v9.5</td>
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Building shape and floor plan based on the Pacific Northwest National Lab (PNNL) high-rise apartment multifamily progress indicator model

- 84,360 sf² 10-story
- 79 apartments
- Windows account for 30% of gross exterior wall on each exposure
- Slab-on-grade foundation
- Located in NYC
Evaluated Configurations

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

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

**Packages D & F:** High performance configurations with features found in the best projects expected to qualify for the top incentive tier; exceed passive house standards

Each configuration was documented in the level of detail typically found in the project’s construction documents.
Modeled Configurations by Team

<table>
<thead>
<tr>
<th>Team</th>
<th>Base Case</th>
<th>Package A</th>
<th>Package B</th>
<th>Package C</th>
<th>Package D</th>
<th>Package F</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.1 PRM Team</td>
<td>X</td>
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<td>PHIUS Team</td>
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Each team had an advanced knowledge of the respective protocol
Units of Performance: Source (Primary) Energy

• Site-to-Source Energy conversions:

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<tr>
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<th>[Source BTU] / [Site BTU]</th>
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<tbody>
<tr>
<td></td>
<td>EPA Portfolio Manager</td>
</tr>
<tr>
<td>Gas</td>
<td>1.05</td>
</tr>
<tr>
<td>Electricity</td>
<td>3.14</td>
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• Conversions are periodically updated – for example PHI introduced Renewable Primary Energy Demand (PER), with conversions dependent on the climate zone and end use.
EPA Portfolio Manager site-to-source energy conversions used for all protocols.
Investigated reasons for the difference in the total annual energy use by looking at the individual end uses.
Base Case Source Energy: Plug Loads

Key reason for the difference:
Modeling assumptions are more optimistic in PHI than PHIUS, which is more optimistic than in MFHR SG.
Plug Loads EUI in a Sample Multifamily Building

There is a significant disagreement between reputable sources about the appropriate modeling assumptions.
### Base Case Source Energy: Lighting

<table>
<thead>
<tr>
<th>Category</th>
<th>90.1 PRM</th>
<th>PHIUS</th>
<th>PHI</th>
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<tr>
<td>DHW</td>
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<td>Fans</td>
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<td>Plug Loads</td>
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<td>Lighting</td>
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**Key reason for the difference:** Modeling assumptions for systems and operating conditions not inherent in design, such as in-unit lighting.
Key reason for difference:

- **Modeling assumptions:** MFHR SG assumes higher DHW demand than PHIUS or PHI. (25 vs. 6.6 gal/person/day)

- **Modeling rules:** EPA MFHR does not capture DHW distribution losses, but PHIUS and PHI do.
Other Sample Differences in the Modeling Rules

• PHIUS and PHI include savings from manual controls, while HRMF SG allows credit only for the automatic controls inherent in design.

• 90.1 PRM does not require hygrothermal assessment or explicit modeling of envelope thermal bridging
Base Case Source Energy: Fans

Key reason for the difference

- **Modeling rules**
  90.1 PRM requires extracting supply fan energy from equipment efficiency ratings (e.g. EER, COP) and modeling fans explicitly.

- **Simulation tool capabilities**
  WUFI and PHPP cannot explicitly model continuous running fans associated with heating & cooling systems.
• WUFI and PHPP were designed to model high performing buildings with relatively simple mechanical systems, and do not meet many of the simulation capabilities required by ASHRAE Standard 90.1.

• Sample limitations that affected the case study:
  - could not explicitly model different mechanical systems serving common corridors (e.g. gas-fired RTU) versus apartments (e.g. VRF heat pumps)
  - Energy use of continuously running PTAC fans has to be estimated outside of the simulation tool, and entered as an auxiliary electricity use.
Predominant End Uses

National Average Source EUI kBtu/SF-Yr

Based on PNNL Progress Indicator Models compliant with Standard 90.1 2013
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
- the precision of the calculation tool

These factors affect ALL protocols!
Rated versus Actual Performance

www.fueleconomy.gov
the official U.S. government source for fuel economy information

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 Mileage Will Vary

U.S. Government
Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE
Electrical Home Products, Inc.
Model: EED9WP10PS
Capacity: 40 Gallons

Estimated Yearly Operating Cost
1870 kWh
Your cost will depend on your utility rates and use

Cost Range of Similar Models
$220
$264
The actual achieved performance depends on building design, quality of construction, and efficient operation and maintenance.

90.1 PRM inherits testing and commissioning requirements of ASHRAE Standard 90.1, which is the minimum required by code.

Additional measurement and verification requirements (if any), enforcement practices, and simulation rules differ between adopters of 90.1 PRM, affecting the outcomes.

Similar factors affect the actual performance of PHI and PHIUS+ certified projects.
Conclusions

- 90.1 PRM, PHIUS, and PHI showed significantly different consumption for the same building design.

- The key drivers of the difference include:
  - prescribed operating conditions and modeling rules
  - prescribed usage of building systems not inherent in design
  - simulation tool capabilities
  - site-to-source conversion factors

- Limitations of the simulation tools not compliant with Standard 90.1 will complicate analysis of buildings with complex and/or diverse HVAC systems.

- Consumers and design professionals should be educated about the nature of performance metrics produced by the rating protocols.
Maria Karpman¹, Shelley Beaulieu², Jessica Grove-Smith³, James Ortega⁴. 2017.

ASHRAE Standard 90.1 Performance Rating Method, PHIUS+, and PHI Comparative Evaluation Study.

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QUESTIONS?

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