# Seminar 7 – Passive Housing

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# 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

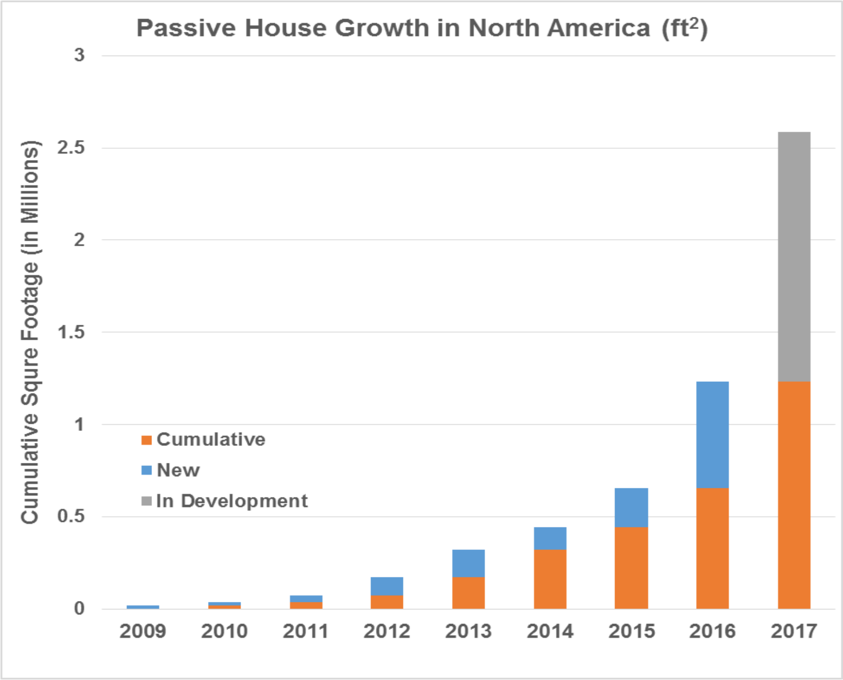

- Pat Fitzgerald, NYSERDA: Project Manager
- Jessica Grove-Smith, PHI: PHI modeler
- James Ortega, PHIUS: PHIUS modeler

# 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



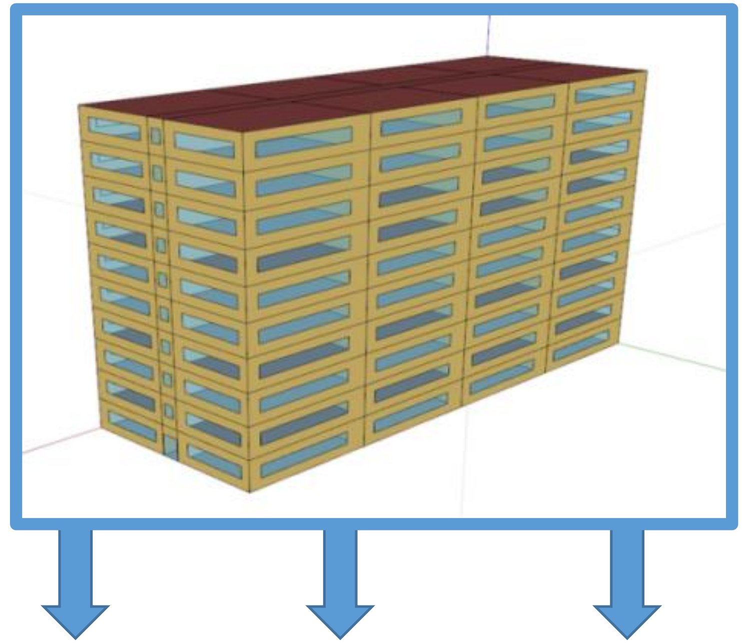

Frappé-Sénéclauze, Tom-Pierre et. al. *Accelerating Market Transformation for High-Performance Building;* Pembina Institute

# 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



ASHRAE

Standard 90.1 Appendix G Performance Rating Method (90.1 PRM)

Passive House Institute

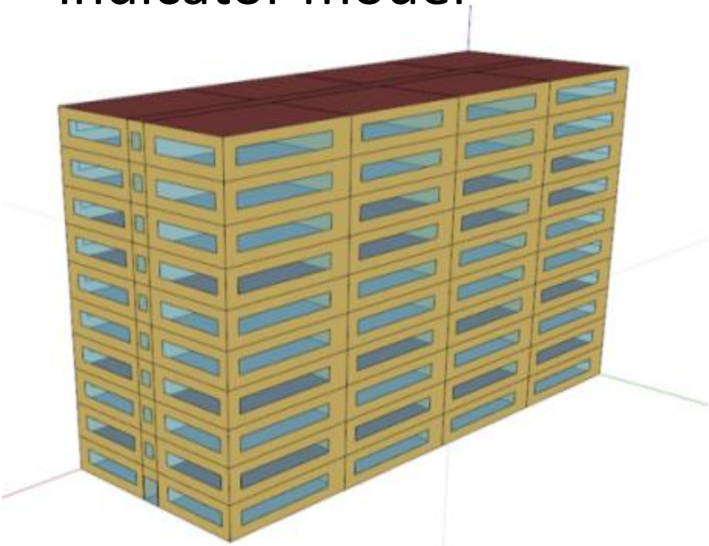
PHIUS Passive House Institute US

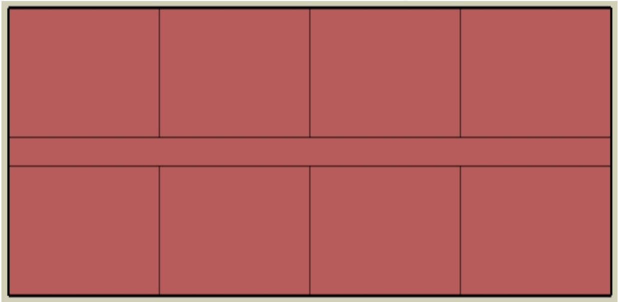
# Protocols and Tools

| | Guiding Documents | Simulation Tool |
|---|---|---|
| **90.1 PRM** | ASHRAE Standard 90.1 2010 Appendix G;  EPA's ENERGY STAR Multifamily High Rise Program Simulation Guidelines (MFHR SG) | eQUEST v3.65 |
| **PHIUS** | PHIUS+ 2015 Certification Guide Book V1.01 | WUFI V.3.0.3.0 |
| **PHI** | PHPP v9.5 – PH Classic | PHPP v9.5 |

# 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 sf$^2$ 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

| | Base Case | Package A | Package B | Package C | Package D | Package F |
|---|---|---|---|---|---|---|
| 90.1 PRM Team | x | x | x | x | x | x |
| PHIUS Team | x | x | x | x | x | |
| PHI Team | x | x | x | x | | x |

Each team had an advanced knowledge of the respective protocol

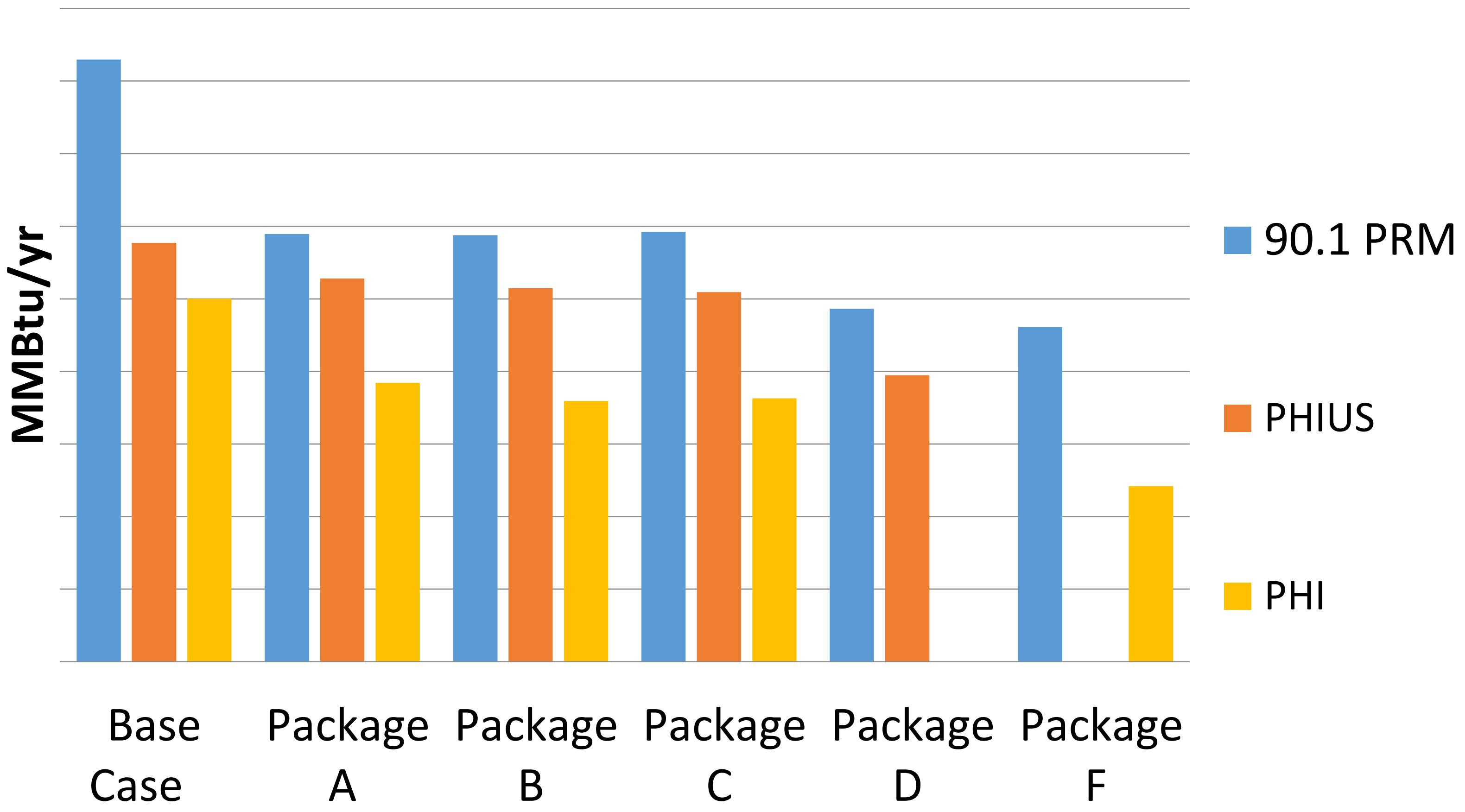
# Units of Performance: Source (Primary) Energy

- Site-to-Source Energy conversions :

| | [Source BTU] / [Site BTU] | | |
|---|---|---|---|
| | EPA Portfolio Manager | PHIUS | PHI |
| Gas | 1.05 | 1.1 | 1.1 |
| Electricity | 3.14 | 3.16 | 2.6 |

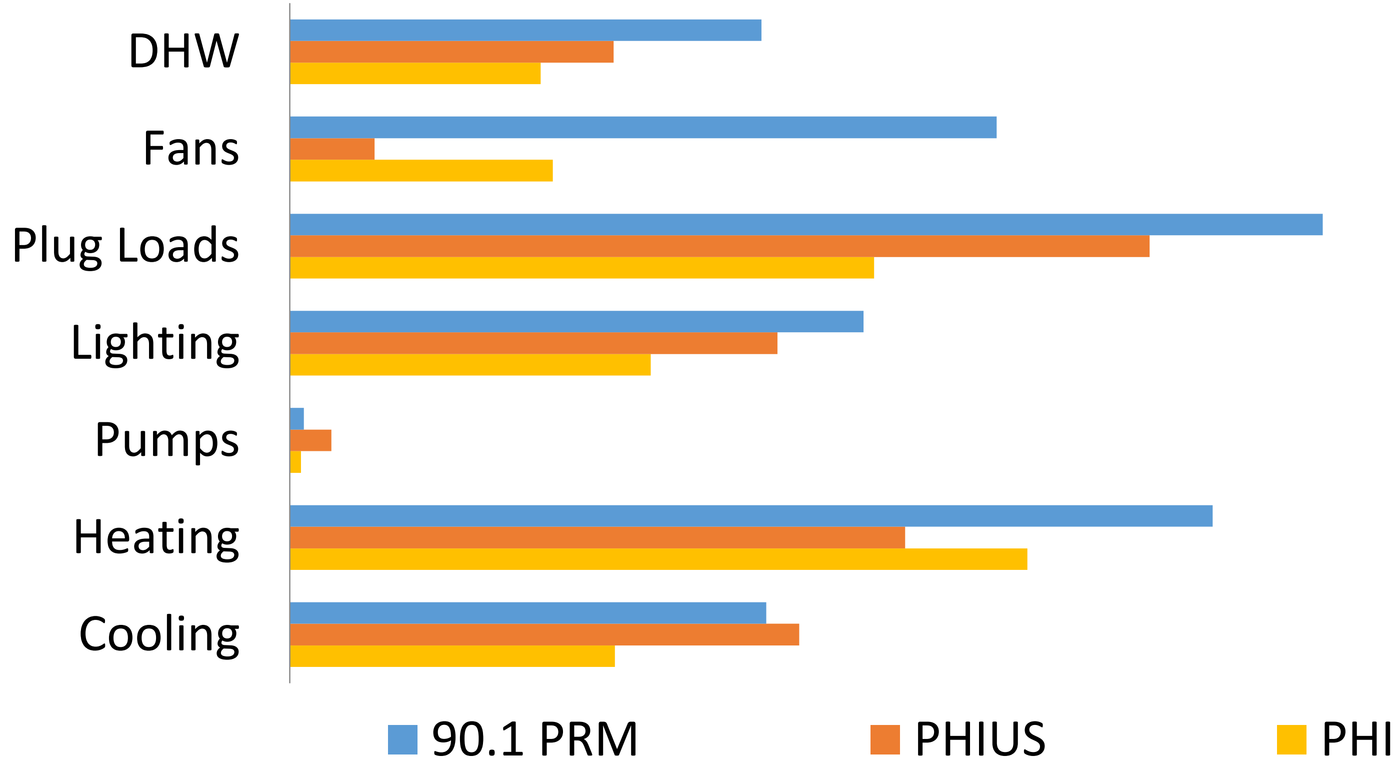
- Conversions are periodically updated – for example PHI introduced Renewable Primary Energy Demand (PER), with conversions dependent on the climate zone and end use.

# Results: Annual Source Energy



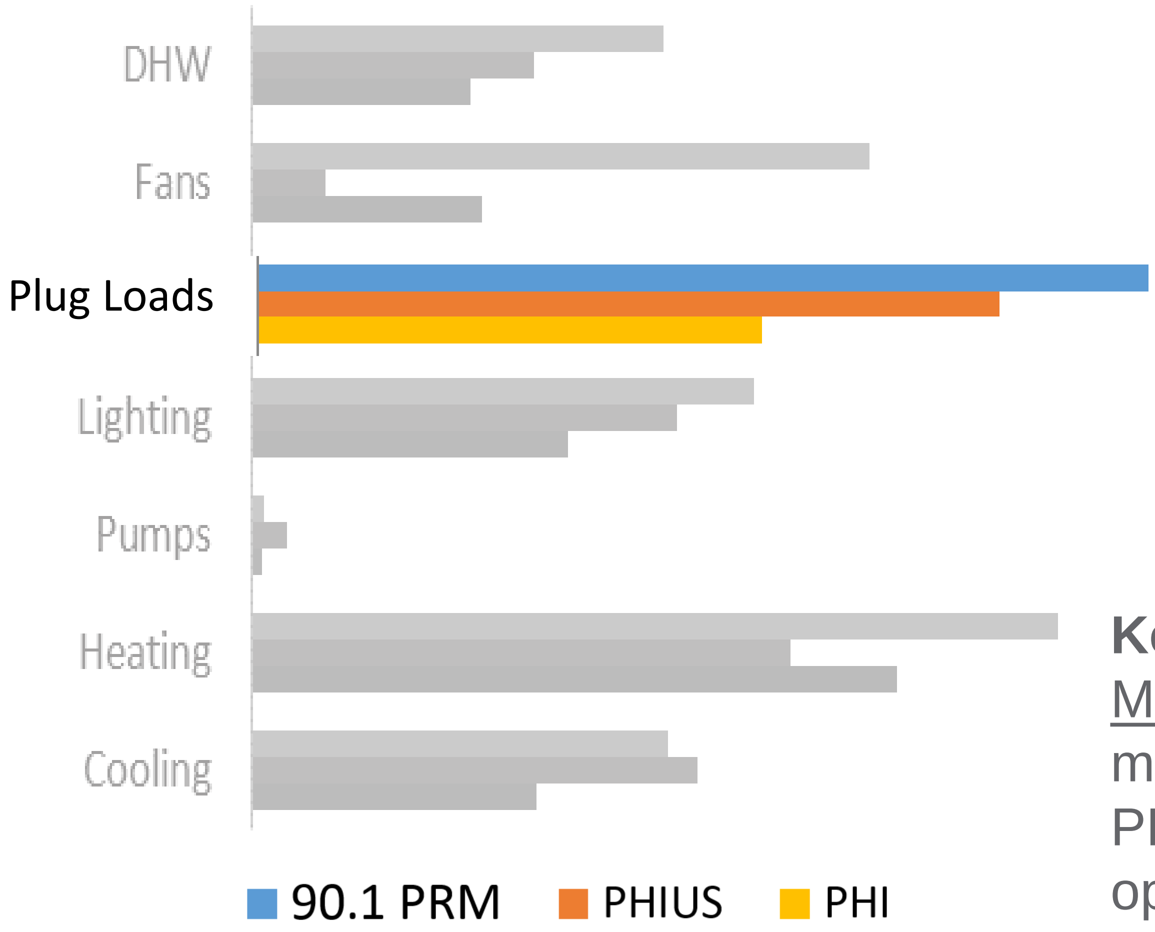

EPA Portfolio Manager site-to-source energy conversions used for all protocols

# Base Case Source Energy By End Use




Investigated reasons for the difference in the total annual energy use by looking at the individual end uses.

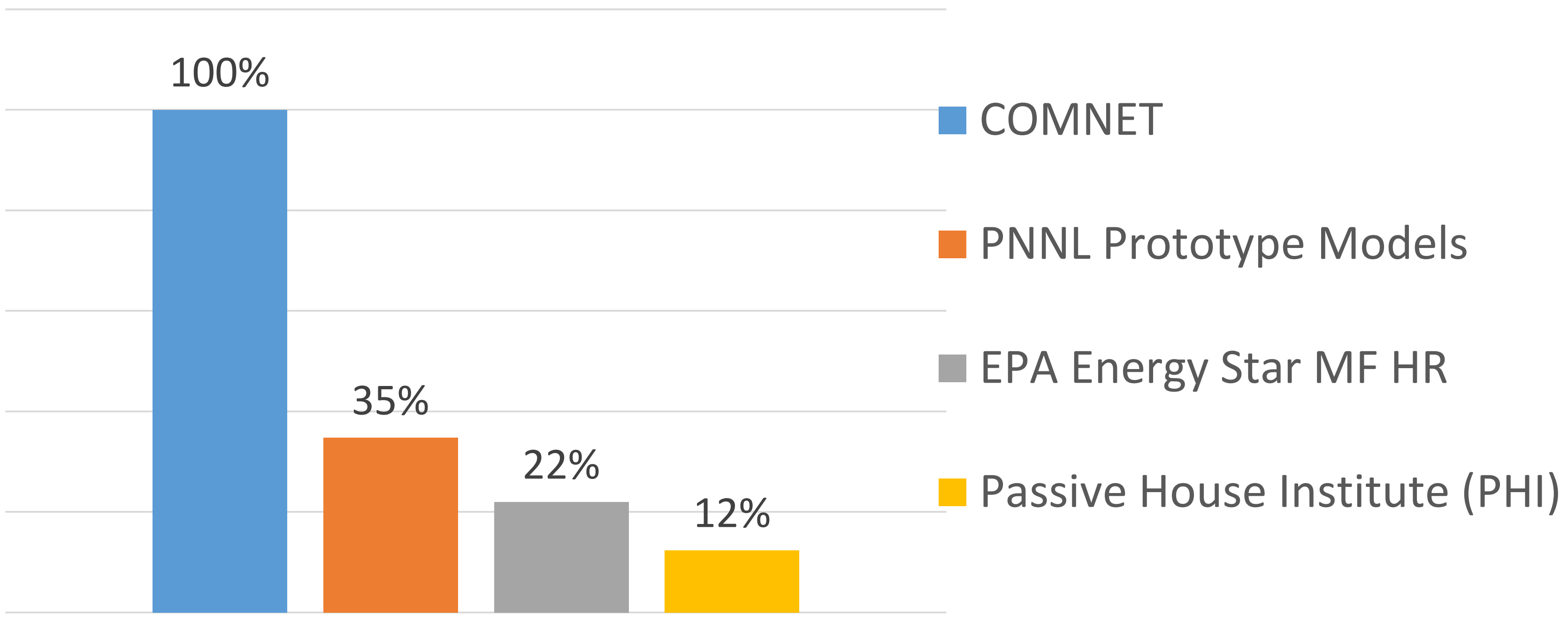
# Base Case Source Energy: Plug Loads




**Key reason for the difference**

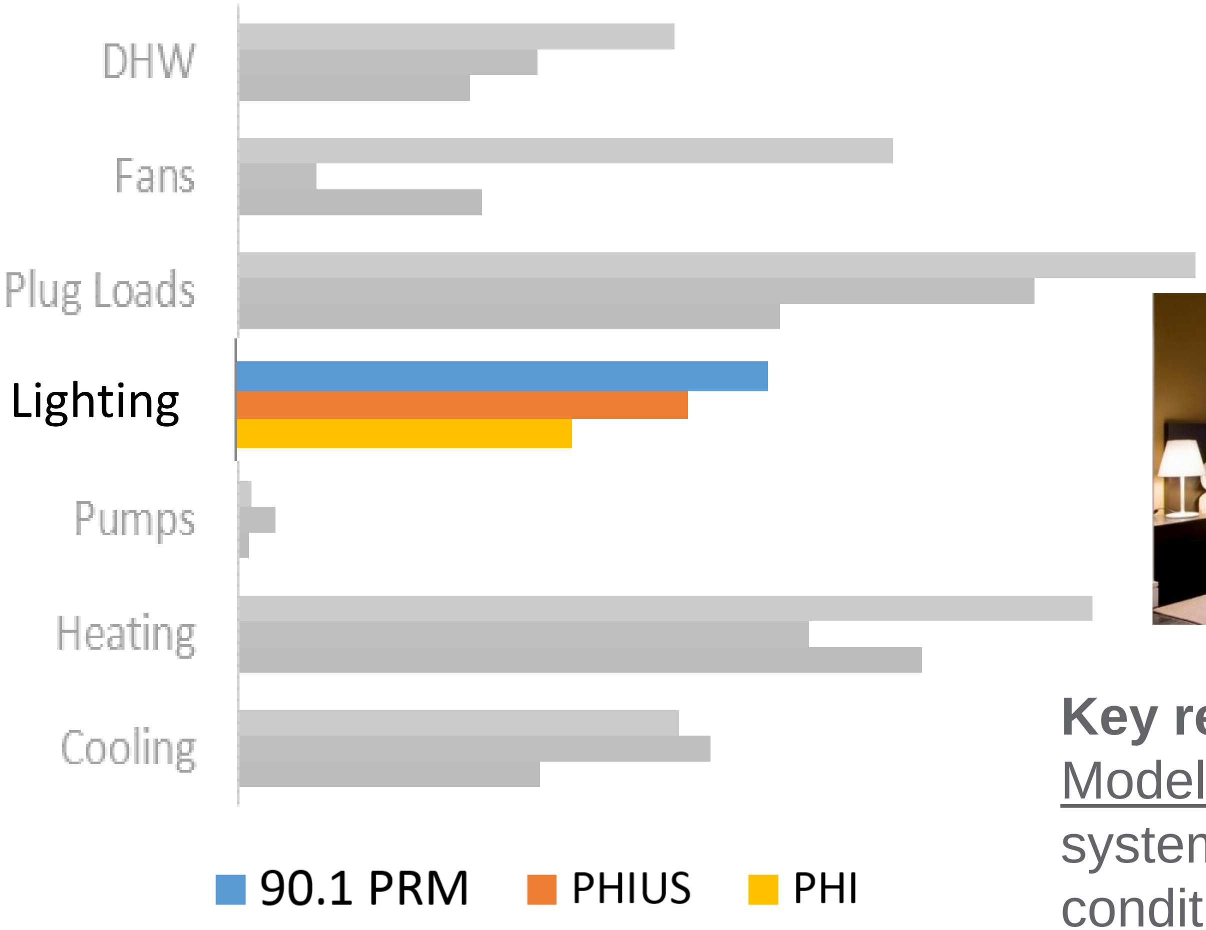
<u>Modeling assumptions</u> are more optimistic in PHI than PHIUS, which is more optimistic than in MFHR SG

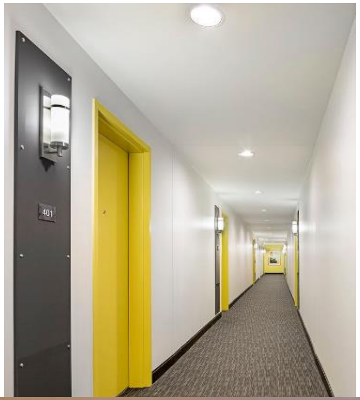
# Plug Loads EUI in a Sample Multifamily Building




There is a significant disagreement between reputable sources about the appropriate modeling assumptions

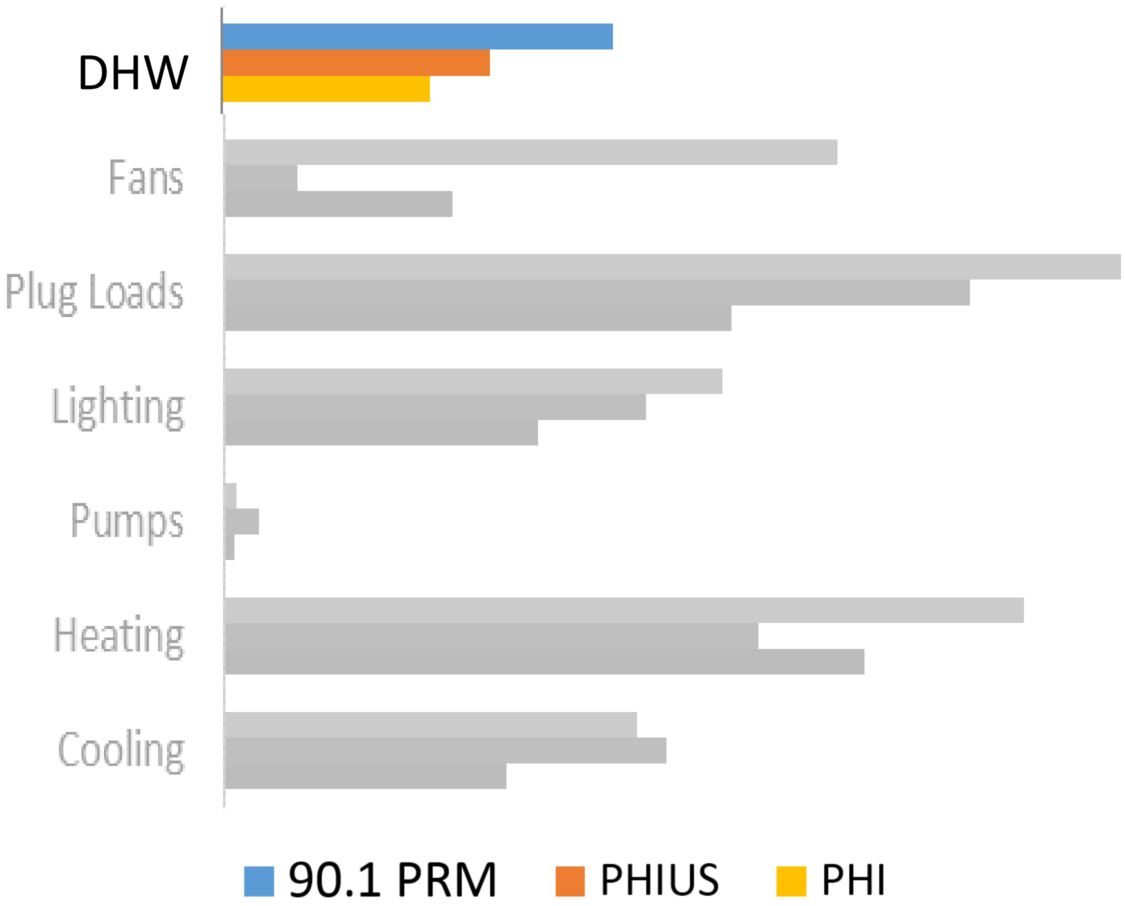
# Base Case Source Energy: Lighting



**Key reason for the difference:**
Modeling assumptions for systems and operating conditions not inherent in design, such as in-unit lighting

# Base Case Source Energy: DHW




**Key reason for difference:**

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

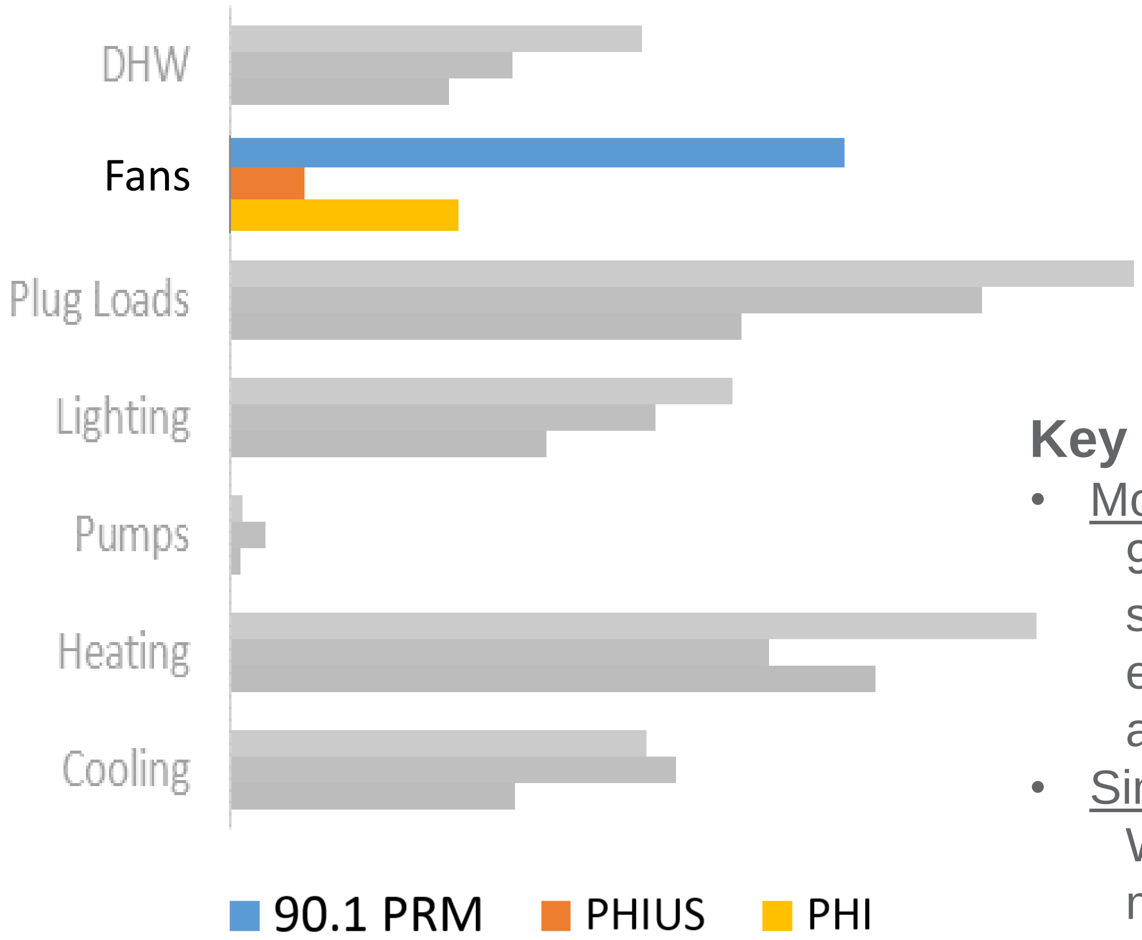
- Modeling rules
  EPA MFHR does not capture DHW distribution losses, but PHIUS and PHI do.

# 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



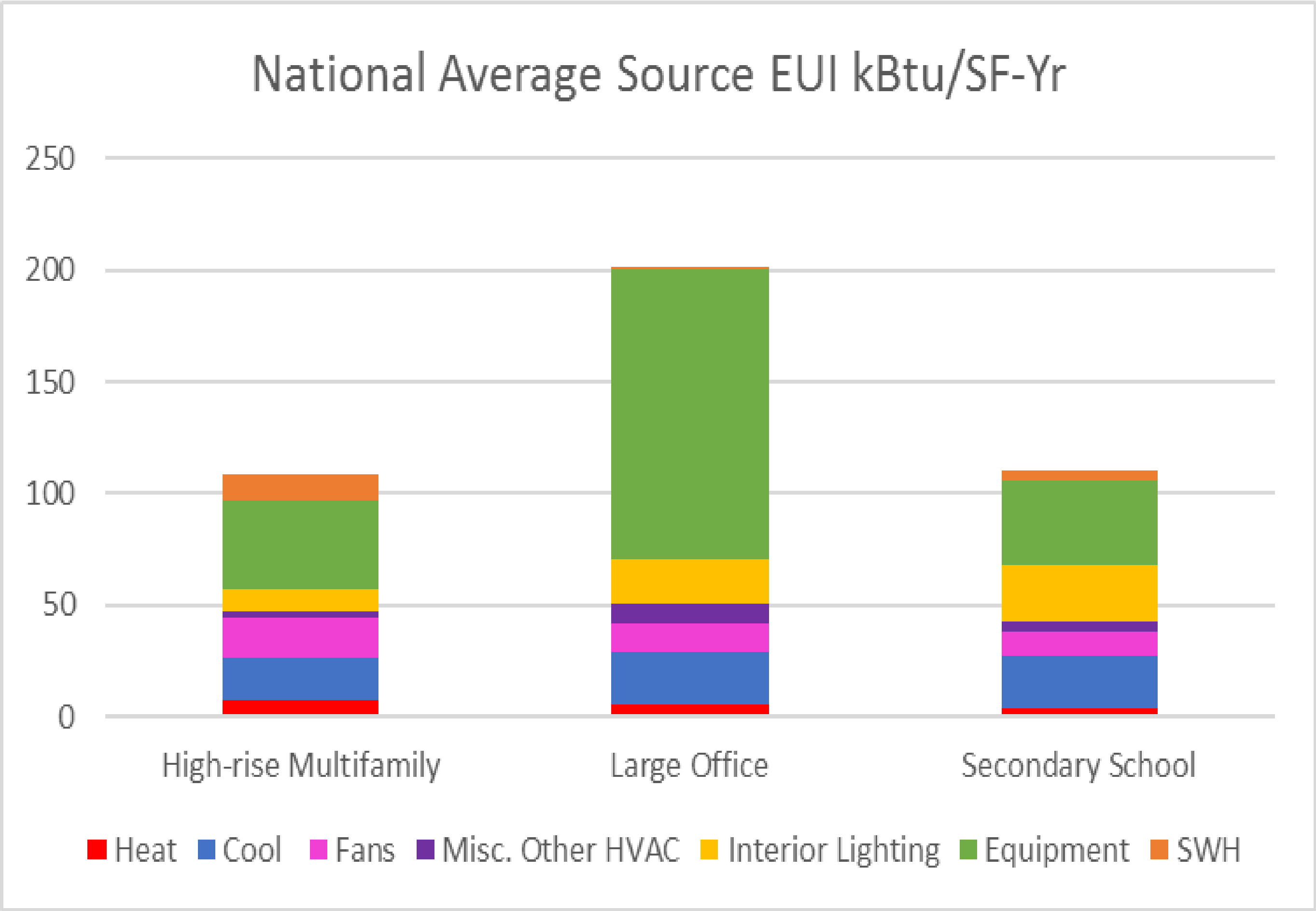

**Key reason for the difference**

- 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

# Differences in Simulation Tool Capabilities

- 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




Based on PNNL Progress Indicator Models compliant with Standard 90.1 2013

# So Which Protocol Got it Right?

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

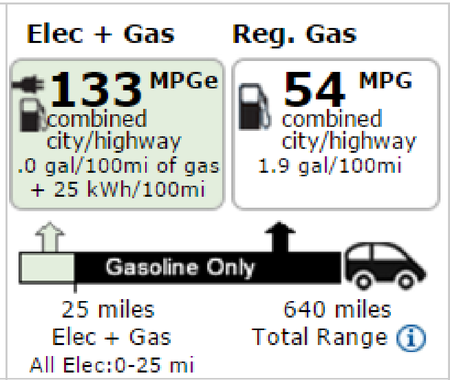
These factors affect ALL protocols!

# Rated versus Actual Performance

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**www.fueleconomy.gov**

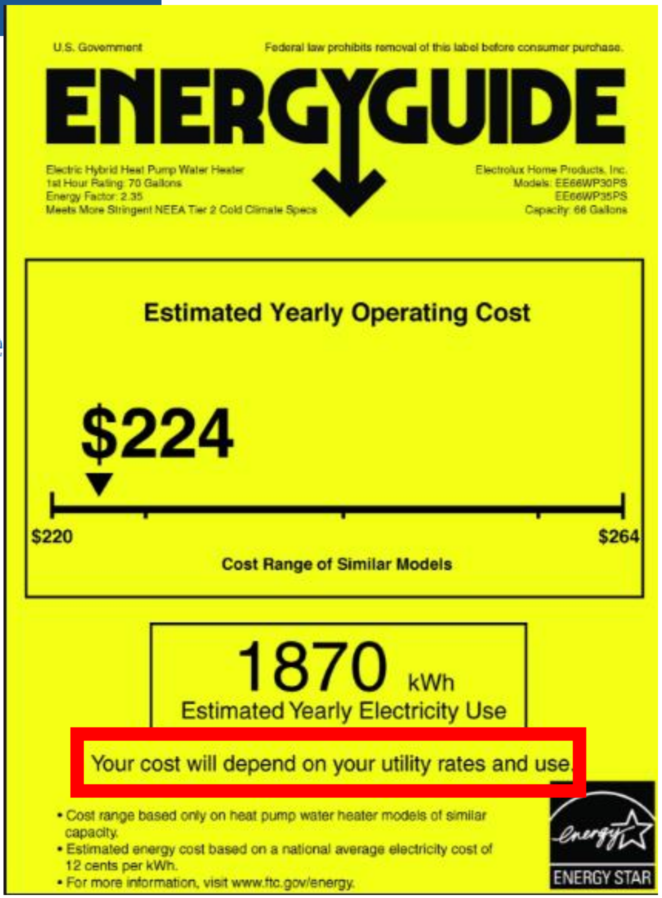
the official U.S. government source for fuel economy information




## Your Mileage Will Vary

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

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



# Design is Only One Piece of the Puzzle

- 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.

NYS BUILDING STANDARDS AND CODES ≠ LEED NC ≠ ENERGY STAR Multifamily High-rise

- 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

# Bibliography

Maria Karpman[1], Shelley Beaulieu[2], Jessica Grove-Smith[3], James Ortega [4]. 2017.

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

Presented at the 2017 Building Performance Analysis Conference, Atlanta, Georgia, September 27-29.

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# QUESTIONS?

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