A Simplified Performance Rating Method for Small Commercial Buildings

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WBS # 3.2.6.51

Project Summary

Objective and outcome

- Develop a protocol for simplified modeling to guide development of simplified modeling tools and support energy efficiency programs which require whole building energy modeling
- Develop a report which identifies the variation in energy savings for the simplified performance rating method (S-PRM) versus the detailed PRM

Team and Partners

- PNNL
  - Michael Rosenberg, Supriya Goel, Andrea Mengual, Aowabin Rahman, Jeremy Lerond, Juan Gonzalez. Michael Tillou
- Partners
  - New York City Department of Buildings
    - Evaluating the S-PRM approach for code compliance
  - Willdan, Energy Trust of Oregon
    - Evaluating the S-PRM approach for beyond code programs
  - SOLARC, ZeroEnvy
    - Subcontractors, evaluating real projects for PRM vs S-PRM savings.

Stats

Performance Period: October 2019 – September 2023

DOE budget: $800K, Cost Share: $0K

Milestone 1: Technical report on existing simplified BEM tool capabilities. (2020)

Milestone 2: Development of the Draft Ruleset. (2020)

Milestone 3: Validation and Pilot Testing results. (2023)

Milestone 4: Updated S-PRM Ruleset (2023)

Introduction: Code Compliance Pathways

Prescriptive Path

Minimum requirement checklist

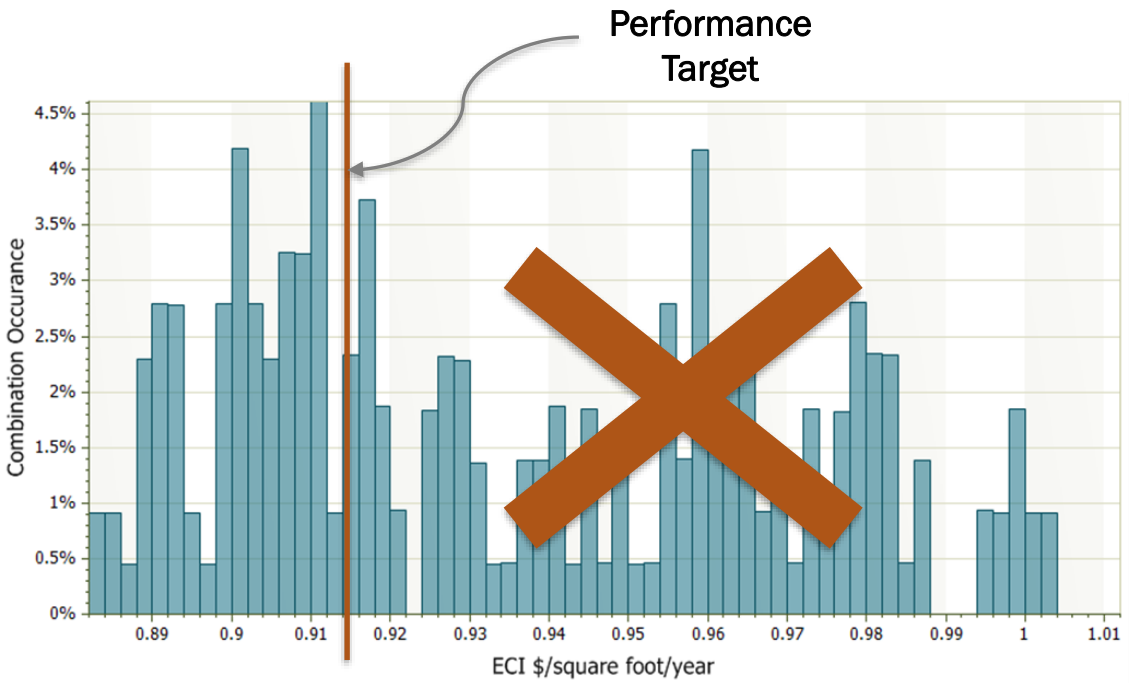
+ Simple, intuitive
− Inflexible
− Can result in a wide range of energy performance[1]

Performance Path

Use modeling to compare performance of proposed building to a variant that meets a prescriptive "baseline"

- Procedure for deriving baseline from proposed model is called a ruleset. Common examples are: ASHRAE 90.1 Performance Rating Method (PRM) aka "Appendix G", CA Title24 ACM, and RESNET ERI.

+ Effectively sets a performance target, **achieves deeper savings** than prescriptive
+ Provides additional design flexibility
+ Supports both compliance and above code programs
− Requires a (detailed) model, which takes effort to develop



Unlocking deeper savings from energy codes requires that performance-based compliance becomes much more common

[1] Rosenberg M.I., R. Hart, J. Zhang, and R.A. Athalye. 2015. *Roadmap for the Future of Commercial Energy Codes.* PNNL-24009. Richland, WA: Pacific Northwest National Laboratory. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24009.pdf

Problem

- **Despite advantages and potential for deeper savings, performance-based compliance used in <5% of projects in >50% of jurisdictions surveyed[1]**
- **Challenge: time and cost associated with creating the proposed energy model[2]**
  - Large, complex buildings tend to use modeling, and can use it to take advantage of flexible design, LEED, and incentives, e.g., 179D
  - **88% of buildings are 25,000ft^2 or smaller**, however most projects involving buildings of that size have small budgets that cannot carry modeling costs
  - Without modeling, small projects lose access to design flexibility that leads to higher performance as well as to energy efficiency incentives
  - While simplified tools and approaches exist, **absence of a vetted and published ruleset** results in a lack of confidence and approval by code bodies and other program implementers.

[1]Rosenberg, M., R. Hart, J. Zhang, and R. Athalye. 2015. Roadmap for the Future of Commercial Energy Codes. Richland, WA. PNNL-24009

[2]Karpman M, M Rosenberg 2021. Performance-Based Code Compliance: A Roadmap to Establishing Quality Control and Quality Assurance Infrastructure https://www.energycodes.gov/sites/default/files/2021-07/Performance-Based_Code_Compliance_Roadmap_Final.pdf

Solution

Make the performance path more accessible to simple buildings

- **Simplifications, workflow automation, and improved reporting** are among the key initiatives identified to address some of the barriers to a greater use of the performance approach
- A **set of simplified modeling guidelines and requirements,** applicable to small/simple buildings, could reduce the barriers to performance-based compliance for these buildings
- Could **reduce the time, cost,** as well as errors associated with BEM in compliance (and LEED and incentive) modeling

Simplified Performance Rating Method (S-PRM)

Alignment and Impact

- **Feedback from stakeholders**
  - Whole building analysis is critical for developing **effective and strategic decarb/electrification** strategies for buildings[1]
  - Simplified energy modeling is critical to increase the use of modeling in **energy efficiency programs and code compliance**[2]
  - Standardized simplifications which have been analyzed and vetted would provide greater confidence in the modeling process.
- **Data reported from Willdan, developer of the simplified modeling tool Net Energy Optimizer (NEO), shows 10x+ increase in projects modeled for utility incentives when simplified modeling replaced detailed modeling** (Duke NCEEDA Program)
  - Not used for compliance, but demonstrates broad applicability and utility of simplified modeling

Simplified modeling is essential for extending the benefits of modeling, performance-path compliance and above-code programs to small and medium commercial buildings.

[1] Whole-building energy modeling for net-zero energy buildings: A review" by S. Saberi, et al. (2020)
[2] Goldwasser, B., & Selkowitz, S. E. (2013). Simplified building energy modeling for code compliance and energy efficiency program design. Building Simulation, 6(3), 241-252. doi: 10.1007/s12273-013-0137-9.

Alignment and Impact

- **Extend benefits of energy modeling and performance-path code-compliance (and above code programs) to small and medium commercial buildings (SMCBs).**

Increase Building Energy Efficiency

Both building energy modeling and performance-based code have shown to reduce energy use over prescriptive approaches[1,2]. Simplified PRM will make these tools more accessible to SMCBs, which account for 88% of commercial buildings (and over 50% over commercial building floor area).

Accelerate Building Electrification

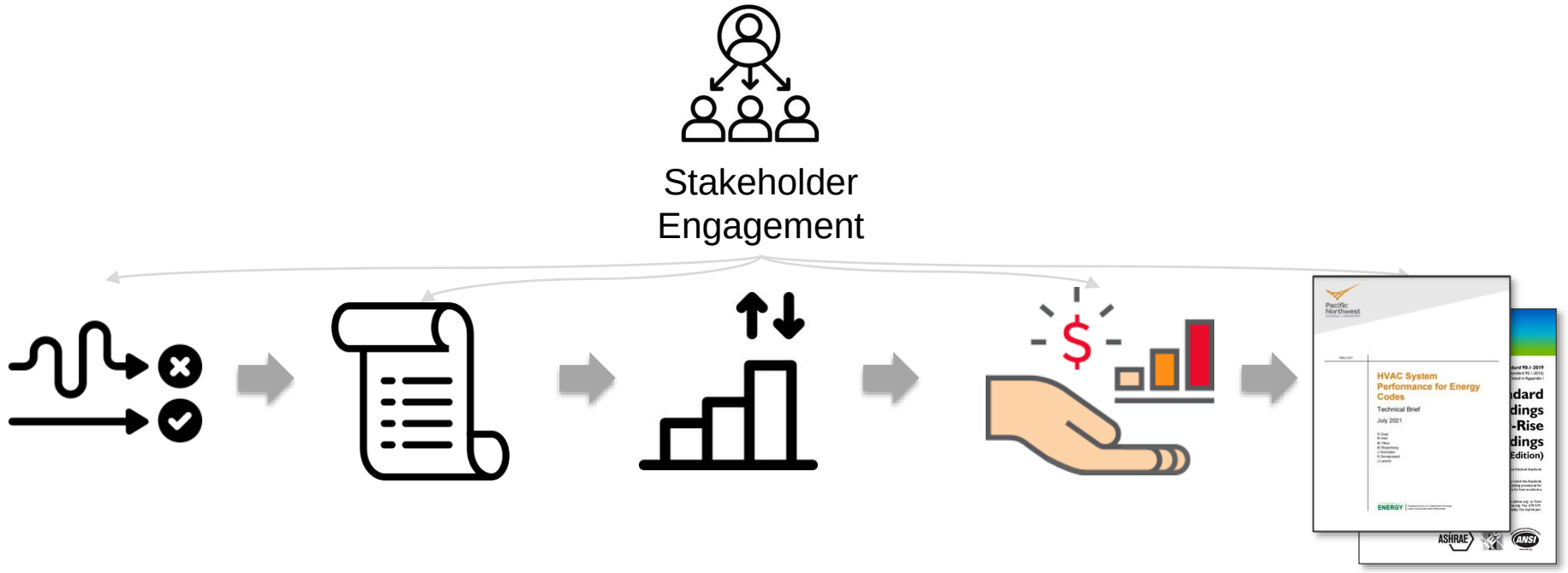
Performance-based codes can be tailored to meet different policy objectives, such as electrification. Simplified PRM will make it easier to apply performance-based codes to SMCBs.

Prioritize Equity and Justice

Most commercial buildings in disadvantaged communities are SMCBs. Addressing the specific needs of those buildings will benefit those communities.

[1]Rosenberg M., S Goel, M Tillou. Paving the Way for Net Zero Energy Codes through Performance Based Approaches. In proceedings, 2020 ACEEE Summer Study on Energy Efficiency in Buildings. Asilomar, CA
[2]Roth, Amir, and Reyna, Janet. *Innovations in Building Energy Modeling: Research and Development Opportunities for Emerging Technologies*. United States: N. p., 2020. Web. doi:10.2172/1710155. https://www.nrel.gov/docs/fy21osti/77835.pdf

Approach



Simplify key aspects of PRM

Develop (draft) Ruleset

Validate Ruleset Simplification (Compared to Full PRM Modeling)

Pilot S-PRM Approach

Incorporate into ASHRAE 90.1 and/or other Standards

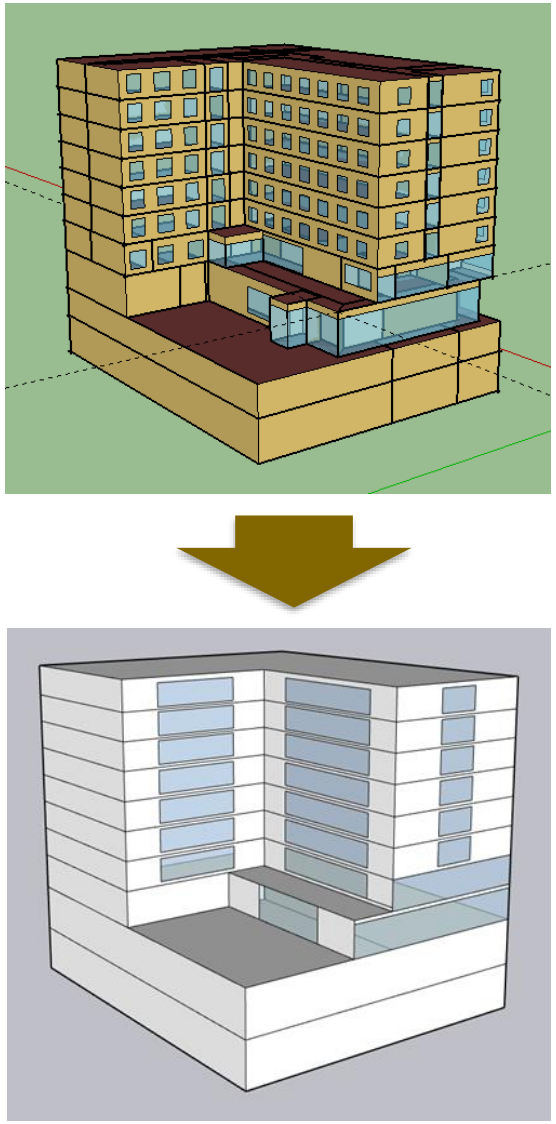
FY20

FY21

FY22-FY23

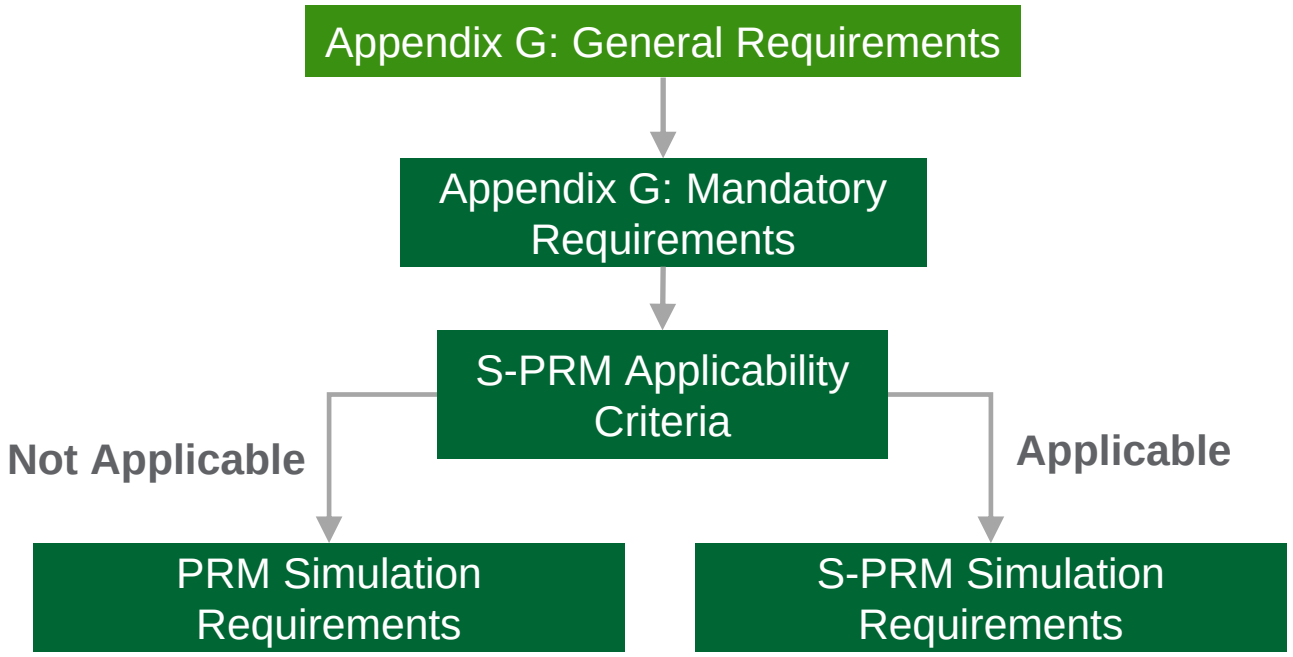
Approach: Simplify

- **A technical advisory group (TAG) was convened to identify key aspects of energy modeling that could benefit from simplification (verified by testing)**
- **Simplifications focused on parameters with a high ratio of modeling effort to results impact**
  - A simplified **building geometry**
  - **Defaults** for schedules and loads which can be overridden to align with building design and operation
  - Simplified modeling guidelines for complex measures such as **lighting and HVAC controls**
  - **Standard reporting requirements** for compliance with S-PRM
  - **Requirement for an automatically generated baseline**



Approach: S-PRM Ruleset

- S-PRM draft ruleset developed, reviewed by the TAG
- Includes applicability criteria to determine whether a project can comply via the PRM or S-PRM, i.e. discourage “path shopping” for code compliance
- Working with Standard 90.1 committee to incorporate this into the code

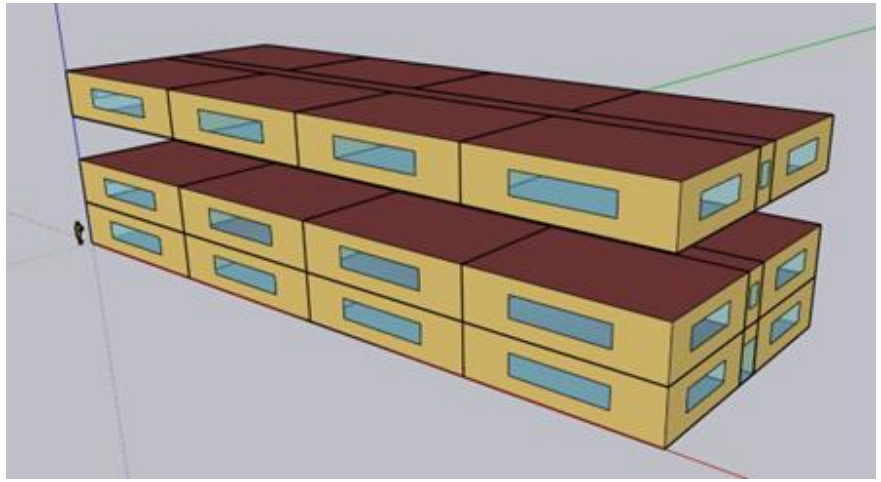


S-PRM Applicability Criteria

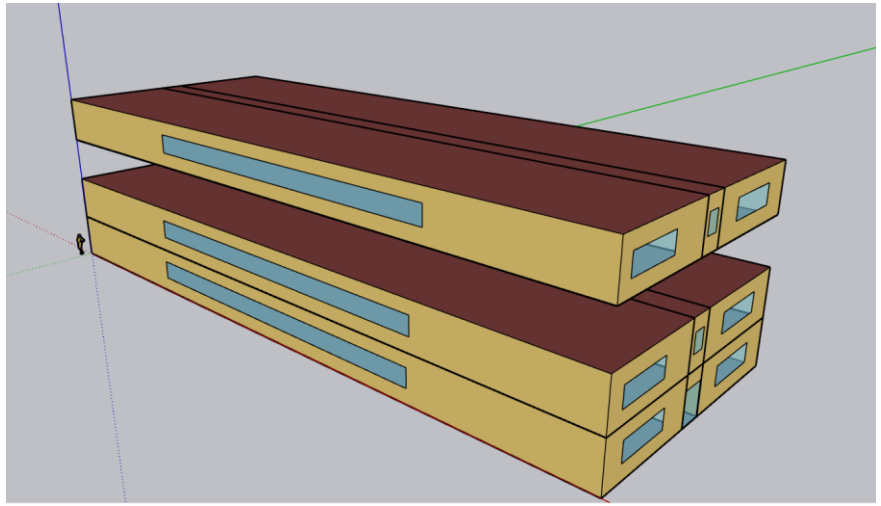
- Not restricted by floor area or number of floors
- Based on building characteristics
- Applicable types: office, retail, school, hotel and multifamily
  - Specific space types, such as computer rooms, commercial kitchens, etc.
- Ineligible system types
  - Multi-zone reheat systems
  - On-site chilled water plants
  - Systems including condenser heat recovery…. etc.

Approach: Simplification Testing

- **Key simplifications tested**
  - Default loads and schedules
  - Simplified fenestration modeling
  - Simplified lighting controls (occupancy + daylighting)
  - Simplified thermal zoning (perimeter and core)
  - HVAC system aggregation
- **Each simplification has been analyzed individually to identify its impact on savings**
  - And to ensure that it does not create a “loophole” or “inversion” with respect to PRM



Midrise Apartment: Original Prototype



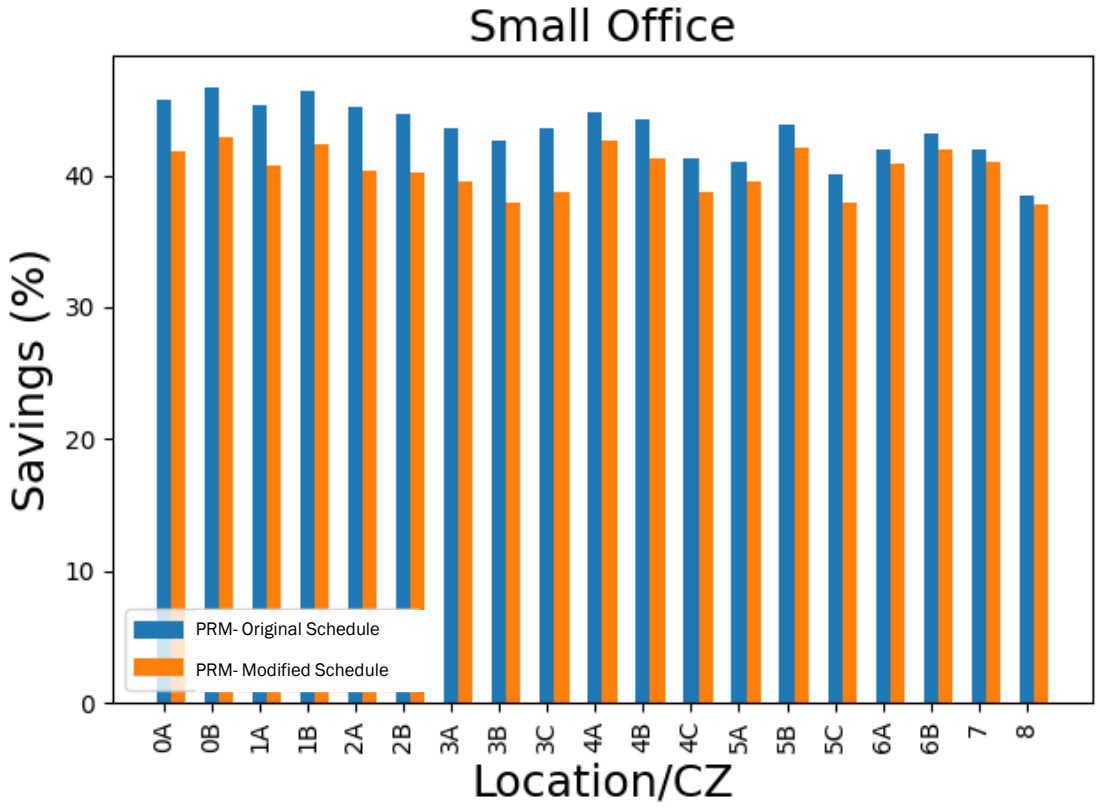
Midrise Apartment: S-PRM Model with the Simplified Thermal Zoning

Approach: Simplification Testing Example

Default schedules

- Original approach involved prescribing schedules (based on ASHRAE Standard 90.1 Appendix C).
- Validation testing identified that schedules can have a significant impact on savings.
- Hence the revised approach for S-PRM is to provide default schedules instead of prescribing them.

Lighting EFLH	
PRM:	3654
90.1 App C	2948.5

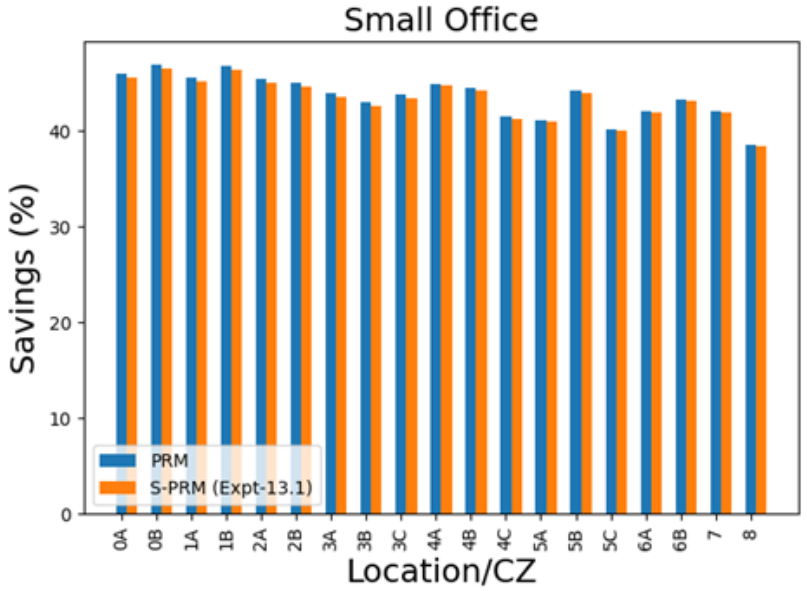


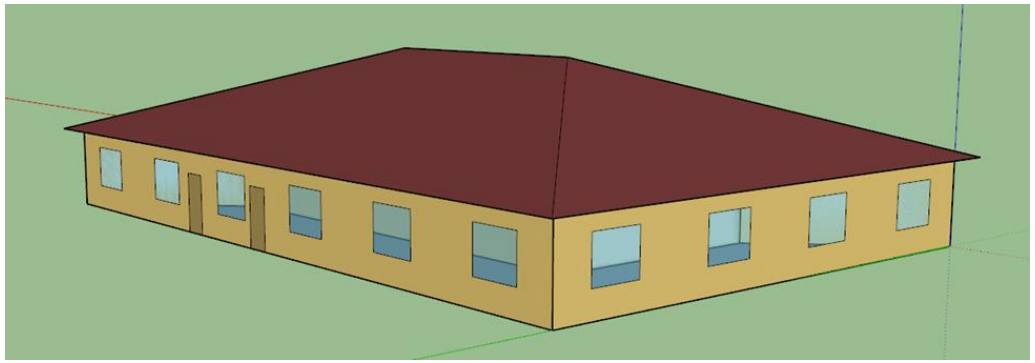
Impact of modifying the lighting schedule to have the same equivalent full load hours as the 90.1 Appendix C schedule for offices

Approach: Another Simplification Testing Example

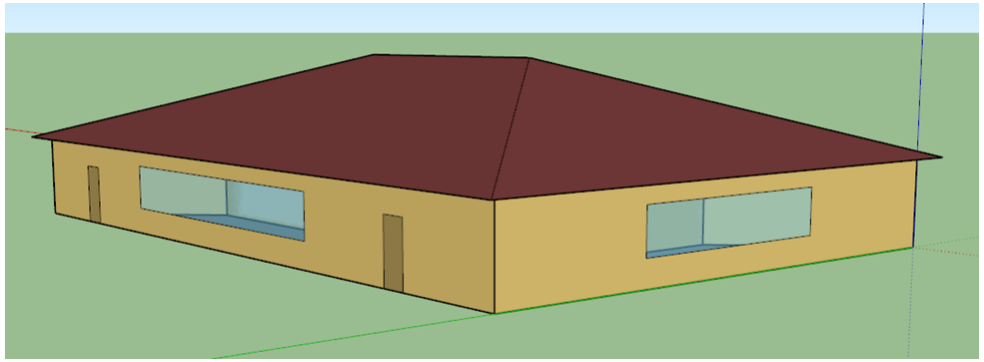
Simplified Window Layout + Daylighting

- S-PRM requires all windows to be combined into a single window, centered on the façade. This results in lower savings via daylighting (<0.6%)
- This simplification has been included in the ruleset due to the low impact on savings





Small Office: PRM Model



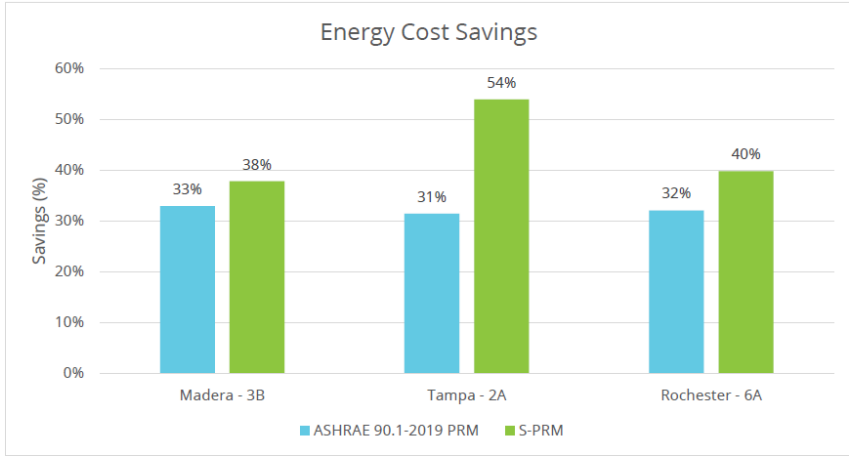
Small Office: S-PRM Model

Approach: Testing Simplifications on Real-World Projects

PRM versus S-PRM for actual projects

- Impact of S-PRM simplifications was analyzed on **actual projects** which had been modeled using Standard 90.1 2019 PRM.
- S-PRM resulted in higher savings for the office buildings. This was traced to the baseline HVAC system map for S-PRM.
- S-PRM ruleset originally required all baseline systems to be single zone CAV systems irrespective of number of floors.
- This results in higher energy use in the S-PRM baseline compared to the PRM baseline when the PRM baseline has VAV fans.
- **The baseline HVAC system map for S-PRM was revised in FY23 to address this inconsistency.**

Office Building Analyzed in 3 Climate Zones



Building Type	Size	Baseline Building System Type	
		Cool Climates (3b, 3c, and 4-8)	Warm Climates (0 to 3A)
Residential	Any size	Packaged Terminal Air Conditioner	Packaged Terminal Heat Pump
Heated-only Storage		Heating and Ventilation (Fossil Fuel Furnace)	Heating and Ventilation (Electric Resistance)
All Other	< 4 Floors	Packaged Single Zone (CAV) Air Conditioner with Gas Furnace	Packaged Single Zone (CAV) Heat Pump
	>= 4 Floors	Packaged Single Zone (VAV) Air Conditioner with Gas Furnace	Packaged Single Zone (VAV) Air Conditioner with Electric Resistance heating

Previously, 'all other' buildings types had PSZ CAV systems, irrespective of number of floors.

Progress and Future Work

FY20	FY21	FY22	FY23
Evaluated several simplified modeling tools, rulesets, and energy efficiency programs, and **published a report which outlines key requirements of a simplified PRM.** Project team (PNNL + IBPSA-USA) identified key stakeholders and **established a technical advisory group.**	**S-PRM ruleset was developed** with input from the TAG and shared with the 90.1 ECB subcommittee.	Worked with subcontractors to evaluate **PRM/S-PRM differences in savings for real projects.** Updated S-PRM ruleset based on feedback from the subcontractors. Piloted S-PRM with Energy Trust of Oregon.	Will complete the **validation testing using the prototypes** to identify the impact on savings of the modified ruleset.
Report on simplified energy modeling and modeling tools	Draft S-PRM Ruleset	PRM versus S-PRM comparison on real projects, prototypes	Pilot with energy efficiency programs/utilities

FY23 Progress

- **Validation Analysis:** Completed the validation analysis of each S-PRM simplification analyzed individually using the prototype building. The validation analysis report with the updated S-PRM ruleset will be published in FY23.
- **90.1 Engagement:** Started discussions with ASHRAE 90.1 ECB subcommittee to incorporate the S-PRM approach into Standard 90.1-2025.
- **Pilot Partner:** Working with NYC Department of Buildings, Energy Trust of Oregon, and Willdan on potential opportunities to pilot the S-PRM approach.

Pilots indicate S-PRM reduces modeling effort from 80+ hrs to <20 hrs

Future Work

- **Continue to explore and test simplification strategies and applicability restriction relaxations to expand applicability of S-PRM (without cannibalizing PRM)**
- **Continue to work with simplified BEM software vendors**
- **Continue working with ASHRAE Standard 90.1 on incorporating S-PRM**
- **Continue to look for opportunities to pilot the S-PRM approach**
  - Tax credits, incentive programs, a state or city code

- **Measure of success**
  - Number of programs that require whole building assessment using S-PRM
  - Number of simplified energy modeling tools that adopt and implement the ruleset
  - Increase in the use of whole building energy modeling for small/simple buildings due to adoption of S-PRM

Thank You

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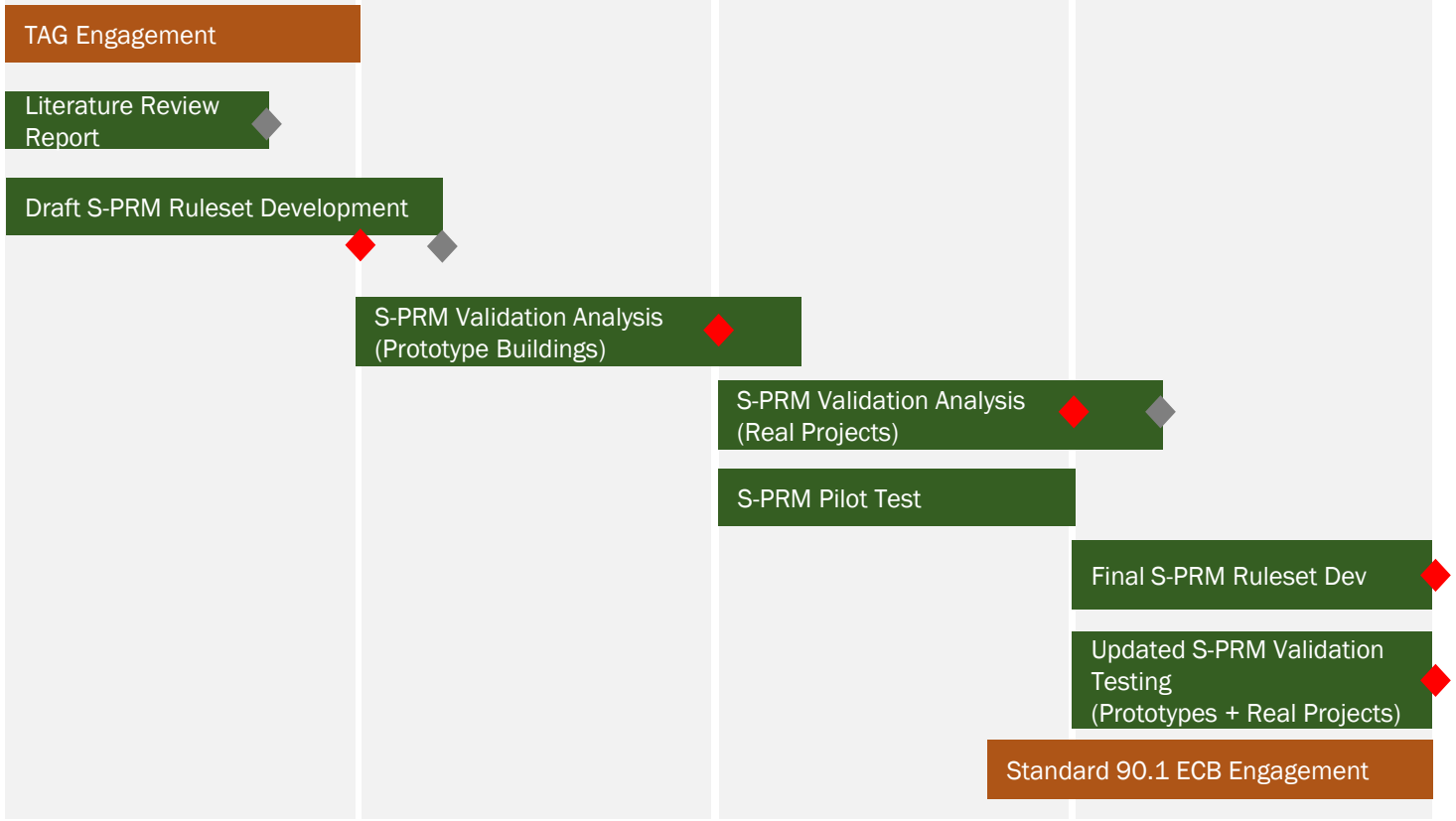
REFERENCE SLIDES

Project Execution

	FY 20	FY 21	FY 22	FY 23
Planned	$ 290,000	$ 277,785	$ 395,335	$ 255,934
Spent	$ 122,215	$ 82,451	$ 339,400	$ 82,072



Project Start Date: 10.01.2019
Project End Date : 09.30.2023

- Schedule/Milestone originally planned
- Schedule/Milestone actual
- Go/No Go Decision point

Team

Supriya Goel
Mechanical Engineer

Michael Rosenberg
Chief Scientist

Michael Tillou
Advisor

Andrea Mengual
Energy Research Engineer

Expertise in codes and standards and Performance based rulesets

Supporting the development of the S-PRM ruleset and pilots.

Aowabin Rahman
Data Scientist

Juan Gonzalez
Building Research Engineer

Jeremy Lerond
Building Research Engineer

Expertise in python scripting, building energy modeling

Supporting the S-PRM simplifications validation testing