U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Standard for Evaluating Ruleset Implementations in Building Performance Modeling Software

Pacific Northwest National Laboratory
Supriya Goel, Senior Research Engineer
Supriya.goel@pnnl.gov

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Project Summary

Timeline:

Start date: October 2019

Planned end date: September 2022

Key Milestones

1. Approval of ASHRAE Standard; November 2019
2. Committee approval of the RMR Schema: December 2021
3. Public Review Draft of Standard 229P; July 2022

Budget:

Total Project $ to Date:

- DOE: $1.6M
- Cost Share: $0

Total Project $:

- DOE: $2.1M
- Cost Share: $0

Key Partners:

GARD Analytics
Karpman Consulting

Project Outcome:

- An automated project testing framework that can verify implementation of rulesets (such as 90.1 App G) in energy models
- An ASHRAE Standard which defines the protocols for project testing and provides a methodology that can be adopted and used for other rulesets (like T-24 ACM, RESNET)

Team

Supriya Goel

Michael Rosenberg

Michael Tillou

Project team includes experts in **performance-based ruleset development**

Team has **expertise in software development, schema development**

James McNeill

Juan Gonzalez

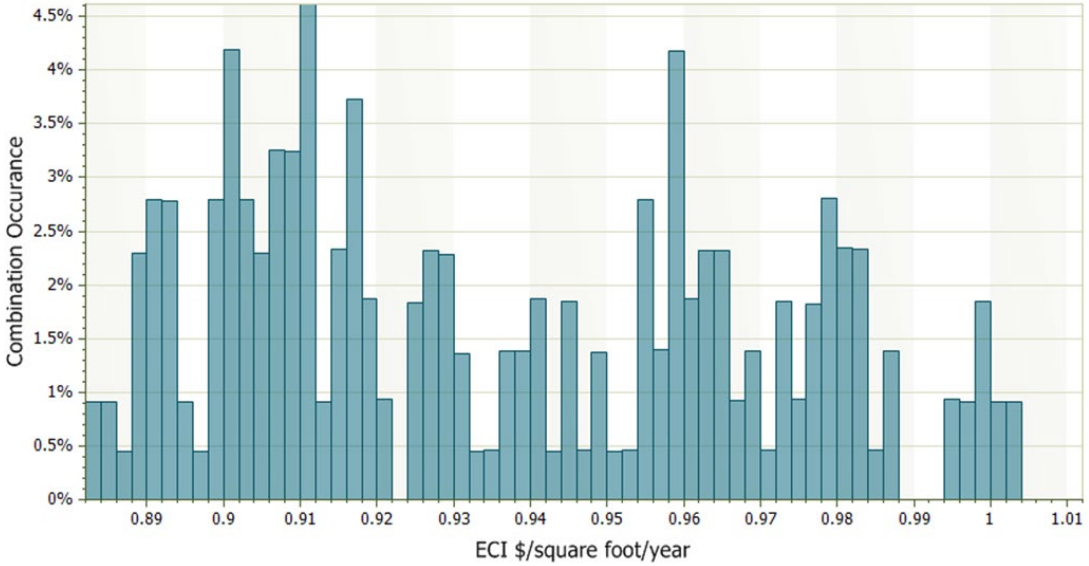
Charlie Holly

Jason Glazer, GARD Analytics
Subcontractor

Maria Karpman, Karpman Consulting
Subcontractor

Code Compliance Pathways – Prescriptive

- Buildings can comply with code using one of two "paths"
- **Prescriptive path:** minimum requirement checklist
  - \+ Simple, intuitive
  - – Inflexible
  - – Can result in a wide range of energy performance[1]

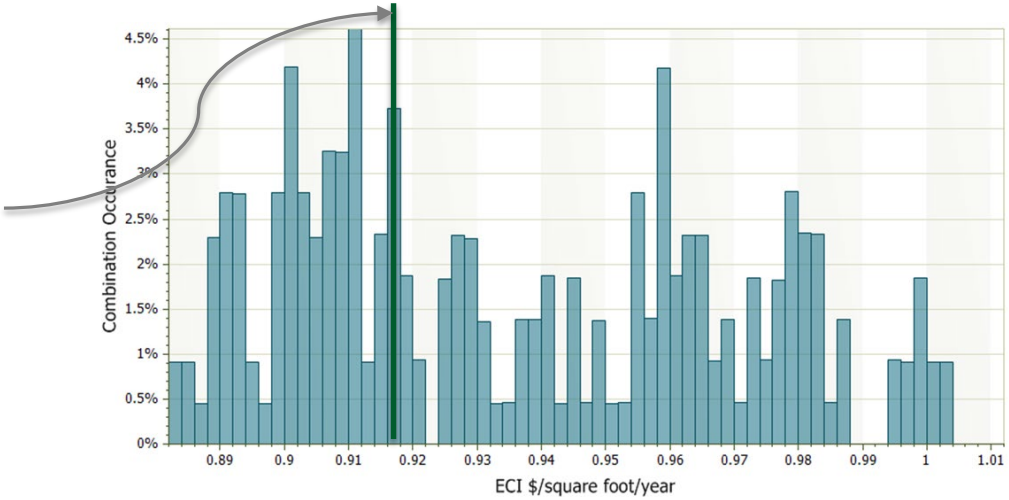


[1] Rosenberg M.I., R. Hart, J. Zhang, and R.A. Athalye. 2015.*Roadmap for the Future of Commercial Energy Codes*.PNNL-24009.Richland, WA: Pacific Northwest National Laboratory.https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24009.pdf

Code Compliance Pathways – Performance

- Performance path: use modeling to demonstrate performance meeting or exceeding that of a building built to minimum prescriptive requirements
  - + Effectively sets a performance target, **achieves deeper savings** than prescriptive
  - + Provides additional design flexibility
  - + Supports both compliance and above code programs (e.g., LEED)
  - – Requires a (detailed) model
  - – Requires a second "baseline" model ← source of (intentional) error

Performance Target



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

Performance Path Rulesets

- The mechanics of performance path compliance requires generating a code reference baseline version of proposed building that is then compared to proposed building via simulation (BEM)
- The procedure for transforming a proposed building model to a baseline building model is nominally deterministic and specified in a "ruleset"
- "Ruleset" may also specify requirements on proposed building model
- Examples of performance-path rulesets
  - **ASHRAE 90.1 Performance Rating Method, i.e, "Appendix G"**
    - Basis for LEED
  - ASHRAE 90.1 Energy Cost Budget
  - CEC Title 24 Alternative Calculation Method
  - RESNET Energy Rating Index
- BEM software is increasingly automating ruleset implementations for generating the baseline

Challenges: Performance Path Model Review

- Whole-building performance-based codes **play a vital role to achieve the net zero code goal.**
- However, despite advantages and potential for deeper savings, performance-based compliance used in **<5% of projects in >50% of jurisdictions surveyed**[1]
- Challenge I: **time and cost** associated with generating energy model
- Challenge II: **lack of resources & gaps in knowledge** required for model **review and compliance verifications**
  - **Ruleset implementations are inconsistent, and users can also manually "game" the baseline model**
  - **Manual review of (pairs of) models is tedious, challenging & inconsistent**
  - Code & program reviewers **want confidence** that models are compliant with the ruleset, no variances—honest or intentional
  - Recent survey: 28% of jurisdictions had confidence in model results[1].

[1] Source: 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

Approach: Proposed Solution

Streamline and Automate the Compliance Review Process

- **Develop Ruleset Checking Tool (RCT) that verifies ruleset implementation by comparing proposed & baseline models at project level**
  - Works for model pairs generated by any software, or even manually
- Reviewers run RCT to identify areas that need manual review
- Modelers run RCT before submission to identify and fix problem spots
- Leads to faster, more consistent, more predictable review
- Approach hasn't been implemented before, requires robust capabilities to ensure 100% ruleset coverage
- Many stakeholders with competing interests, including modelers, software developers, building officials

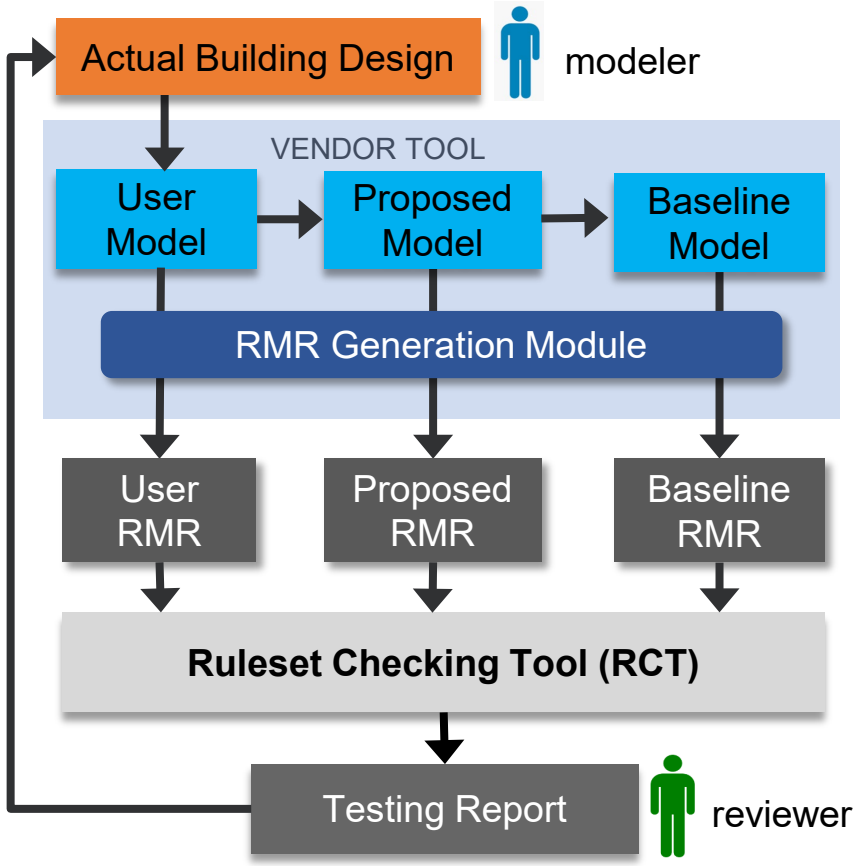
ASHRAE Standard 229P: Protocols for Evaluating Ruleset Implementation in Building Performance Modeling Software

Approach: ASHRAE 229P

- The project testing approach is being implemented within a **consensus-based ANSI/ASHRAE Standard, 229P**
  - **Title:** Protocols for Evaluating Ruleset Implementation in Building Performance Modeling (BPM) Software
  - **Purpose: establishes tests and acceptance criteria** for implementation of rulesets & related reporting in BPM software.
  - **Scope:**
    - Applies to **BPM software** that implements rulesets.
    - Applies to rulesets associated with new or existing buildings & their systems, system controls, their sites, & other aspects of buildings described by the ruleset implementation being evaluated
- Standard committee includes a **diverse group of stakeholders,** key to success of the standard being implemented & adopted
- Phase I implements Standard 90.1 Appendix G, could be developed further to apply to T-24 NACM and RESNET in the future.

Approach: Project Testing Framework

- Two new software components
- **Ruleset Modeling Reporting (RMR) schema**
  - Ruleset level of detail
  - Not a detailed BEM-to-BEM schema
  - Not ruleset specific
  - Exported by BPM vendors
- **Ruleset Checking Tool** (RCT)
  - Checks implementation of ruleset logic on RMR submittals
  - Produces standard output report
  - Open-source



Approach: Compliance with Standard 229P

Standard 229 does not impose project or performance requirements beyond those of the ruleset being tested, e.g., ASHRAE 90.1 Appendix G

ASHRAE 229P compliance applies to software tools

- Software tools need to implement an **RMR export capability**
- 229P will define **RMR tests** defined to test and verify this capability
- Note: Software tools do not need to implementation ruleset automation

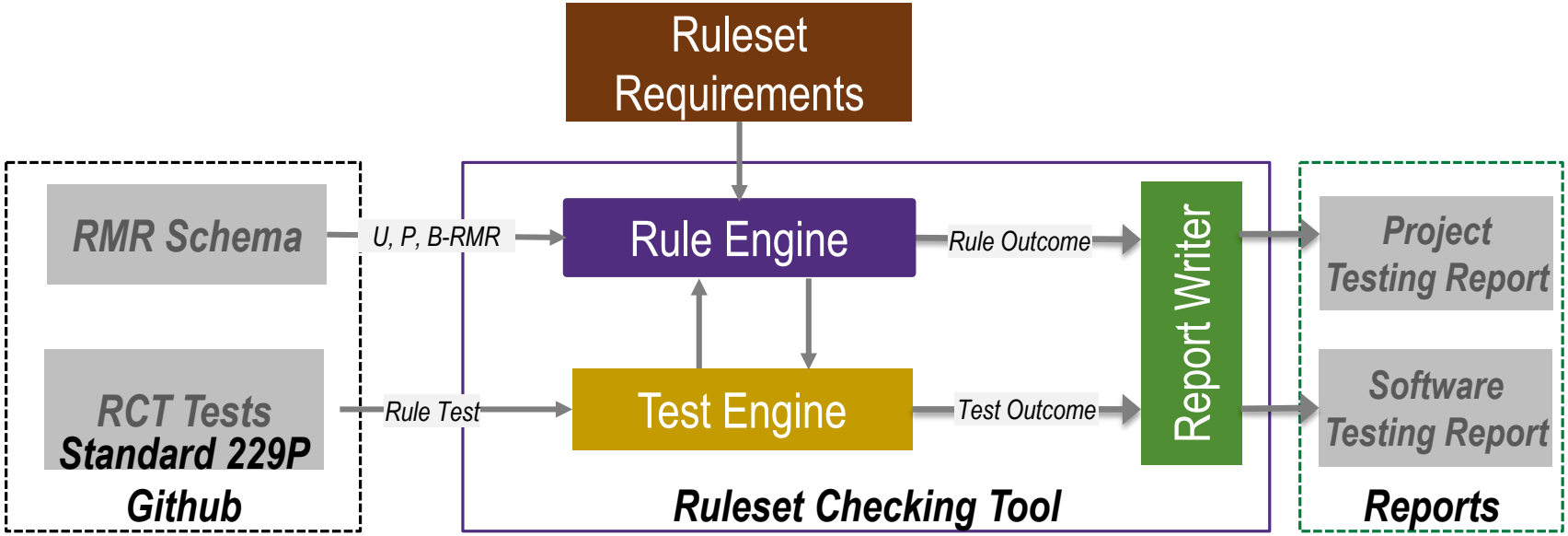
Authority Having Jurisdiction (AHJ)

- AHJs may continue to approve BPM tools as usual
- Initially, may want to approve only BPM tools that comply with 229P in order to enable use of RCT for project review
- Later, may want to approve only BM tools that comply with 229P and that project experience shows produce error-free baselines

Approach: RCT Development and Testing

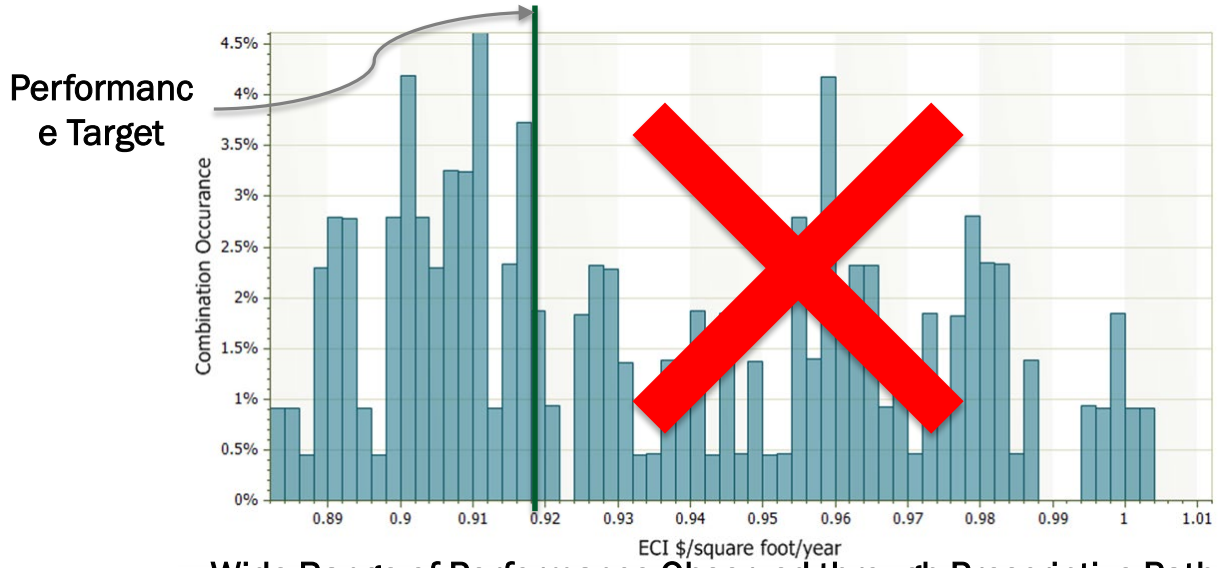
Project team is developing an open-source RCT for ASHREA 90.1 Appendix G

- **Complies with 229P** requirements
- RCT has 4 broad components (i) Ruleset Requirements (ii) Rule Engine (iii) Test Engine, (iv) Report Generator
- '**Ruleset Requirements**' (how rules are to be interpreted and tested) are being defined with significant input from Standard 90.1 ECB subcommittee, will provide additional guidance to modelers and software developers working with Appendix G



Impact

- **Increased use of performance-path for compliance, leading to more savings**
  - Performance path defines minimum performance targets, hence helps rule out designs which meet prescriptive code but are not as efficient as the target
  - This approach will likely reduce the barrier for compliance reviews for jurisdictions and modelers
  - A more streamlined review process will encourage jurisdictions to **adopt performance-based compliance paths,** hence increasing the number of projects that comply with code using the performance path versus the prescriptive path



Wide Range of Performance Observed through Prescriptive Path

Impact

- **Performance based codes are critical to meet ambitious energy and carbon reduction goals[1].**
- Though compliance reviews are not the only barrier to a wider adoption of performance-based codes, it is a significant one
- Standard 229P will help address this barrier, **improve modeling workflow and automation**, and facilitate greater adoption of energy modeling for code compliance[2]

[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

Progress: Standards Committee

- Title, Purpose, and Scope for Standard approved November 2019,
- Committee membership approved January 2020.
  - 16 voting members, 24 non-voting members: software vendors, modelers and practitioners
- Committee meetings: 12 meetings, over 20 working group meetings
- Standard 229P project committee meets every 2 months
- Committee is discussing and **approving RMR data groups**
- PNNL team is working on **draft standard language** and will bring it to the committee for review and approval in the next few months

Progress: Technical Progress

- Project in **mid-stage of development**
- **Rules and Test Case Descriptions:** Project team has developed test case descriptions (TCD) for ~70% of Standard 90.1 rules
- **Schema:** RMR schema has been defined for all TCDs
- **RMR Tests:** These are being identified and the framework for the same is being defined
- **RCT Tests:** RCT tests have been developed for ~20% of Standard 90.1 rules (Transformer, envelope and lighting)
- **RCT Development**: RCT framework has been developed and rule definitions are being added

Progress: Technical Progress

Standard 90.1 Rule: Interior lighting power in the *baseline building design* shall be determined using the values in Table G3.7.

Rule Test: Baseline LPD for "Office-Enclosed" should be equal to 1.1 W/ft2

```
"id": 0,
"name": "zone_name",
"spaces": [
    {
        "id": 1,
        "name": "Space 1",
        "lighting_space_type": "OFFICE_ENCLOSED",
        "floor_area": 1000,
        "status_type": "NEW",
        "interior_lighting": [
            {
                "id": 1,
                "name": "Office Lighting",
                "power_per_area": 1.1
            }
```

RMR Snippet

```
def get_calc_vals(self, context, data=None)
    space_lighting_power_per_area = sum(
        find_all("interior_lighting[*].power_per_area", context.baseline)
    )
    lighting_space_type = context.user["lighting_space_type"]
    interior_lighting_power_allowance = table_G3_7(space_type=lighting_space_type)
    return {
        "space_lighting_power_per_area": space_lighting_power_per_area,
        "interior_lighting_power_allowance": interior_lighting_power_allowance,
    }
def rule_check(self, context, calc_vals, data=None):
            return (
        calc_vals["space_lighting_power_per_area"]
        == calc_vals["interior_lighting_power_allowance"]
    )
```

Rule Engine (RCT) Implementation

Stakeholder Engagement

ASHRAE 229P committee includes representation from

- Software tools (Carrier, Trane, DesignBuilder, TRNSYS, EDSL, OpenStudio, NEO, eQuest)
- Jurisdictions and Building Officials (NYC, Canada, CEC, FL)
- Program reviewers (GBCI)
- Practitioners (AEI, Kolderup Consulting)
- Researchers (PNNL, NREL)

In addition to the committee members, a large number of software vendors are regularly engaged to review the RMR.

Success of the Standard is dependent on

- Standard making it through **ASHRAE consensus process** & being published
- **BPM vendors** implementing **RMR export in their tools**
- **Jurisdictions adopting Standard 229P** and requiring compliance with the same for all buildings complying with Standard 90.1 2019

Remaining Project Work

FY 21 Ongoing work

- **TCD, RMR:** This FY the project team will complete the development of all 90.1 TCDs and the RMR schema for the same
- Rule tests, rule definitions and ruleset requirements will be identified for ~50% of Appendix G rules.

FY 22- Planned Work

- Complete development of RMR tests
- Complete development of RCT tests
- Standards committee approval of all RMR data groups
- Development of the first public review draft of Standard 229P

FY 23- Future work

- Address public review comments
- Publish Standard 229

Overall project development is on schedule, within budget

Thank You

Pacific Northwest National Laboratory
Supriya Goel, Senior Research Engineer
supriya.goel@pnnl.gov

REFERENCE SLIDES

Project Budget

Project Budget: 700K/Year, 3 Years
Variances: Received 900K in FY21
Cost to Date: 65% of the funding to date. 50% of the overall funding
Additional Funding: None.

Budget History					
10.01.2019– FY 2020 (past)		FY 2021 (current)		FY 2022 – 09.30.2022 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$700K	$0	$900K	$0	$500K	$0K

Project Plan and Schedule