



# Total System Performance Ratio - TSPR

Online Webinar, June 2020

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# Logistics & Agenda

## *Agenda* - 12:00 - 1:15

- About the presenters
- About TSPR
- TSPR Tool Click Through
- TSPR Tool Output Report
- Next Steps
- Q & A

## *Logistics:*

- Please stay muted during presentation
- Add questions in the Q&A section –
- We will publish unique questions
- You can “upvote” on questions you hope to be answered at the end in the Q&A
- We will not address questions in the “chat”

# About the Presenters



*Heather Burpee is a Research Associate Professor at the University of Washington and co-directs the Integrated Design Lab. She is a nationally recognized scholar in energy efficiency and high performance buildings.*



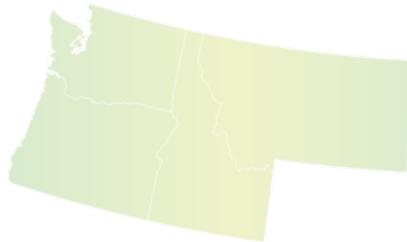
*Supriya Goel is a Senior Research Engineer at Pacific Northwest National Laboratory. Her current research is focused on development of building energy codes and standards and simulation tools for analysis of buildings.*



*Duane Lewellen is the Owner of Lewellen Associates, LLC, an energy consulting firm located in Lynnwood, Washington. Duane has been involved in energy code development and support since 1985 in various roles.*



# Thanks to our Sponsor, NEEA



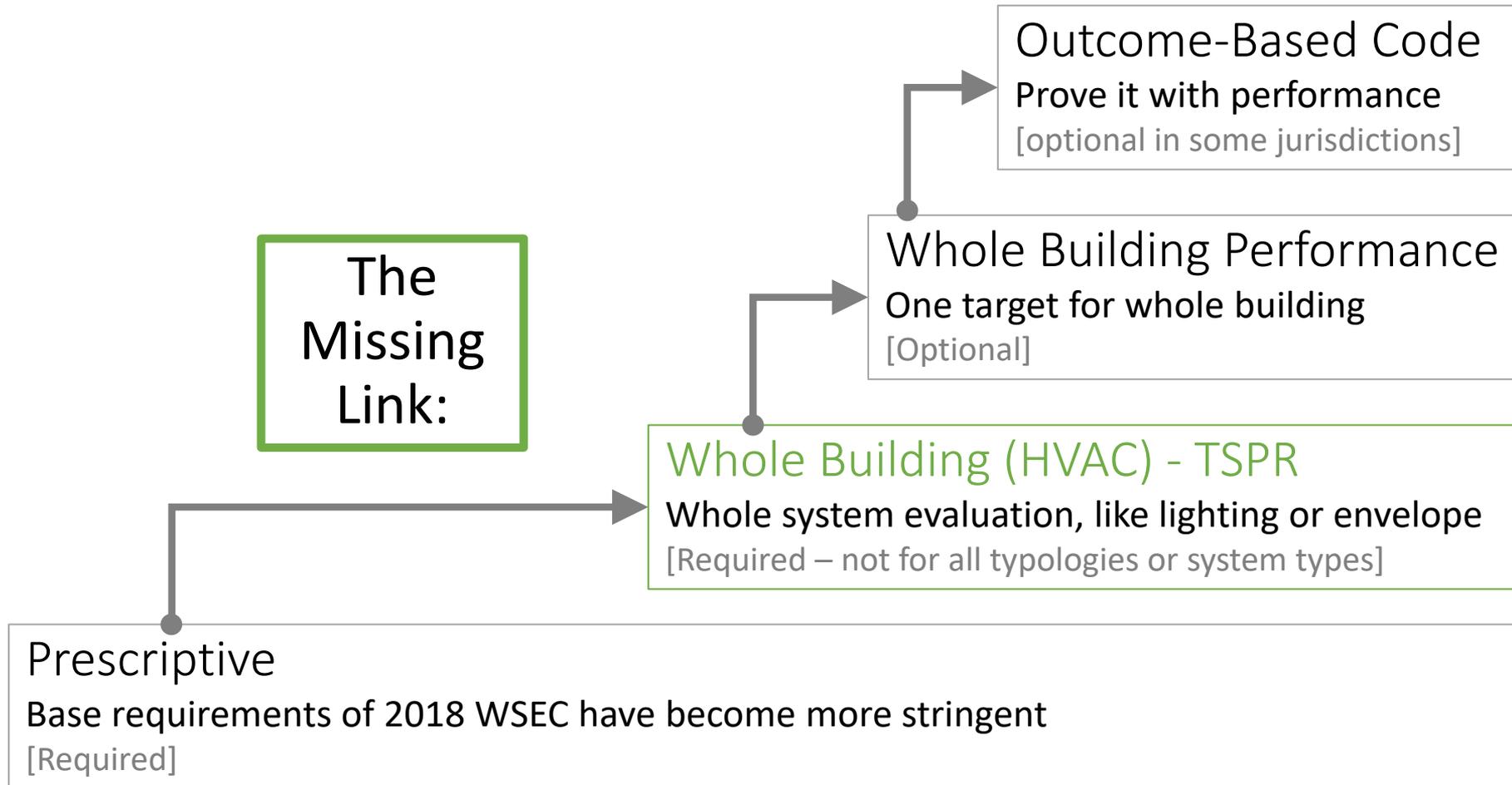
# What is TSPR?

***Total System Performance Ratio** is a ratio of annual heating and cooling loads to the annual carbon emissions associated with the energy consumed by the HVAC system.*

$$TSPR = \frac{\text{Annual HVAC Loads}}{\text{Annual HVAC Carbon Emissions}}$$

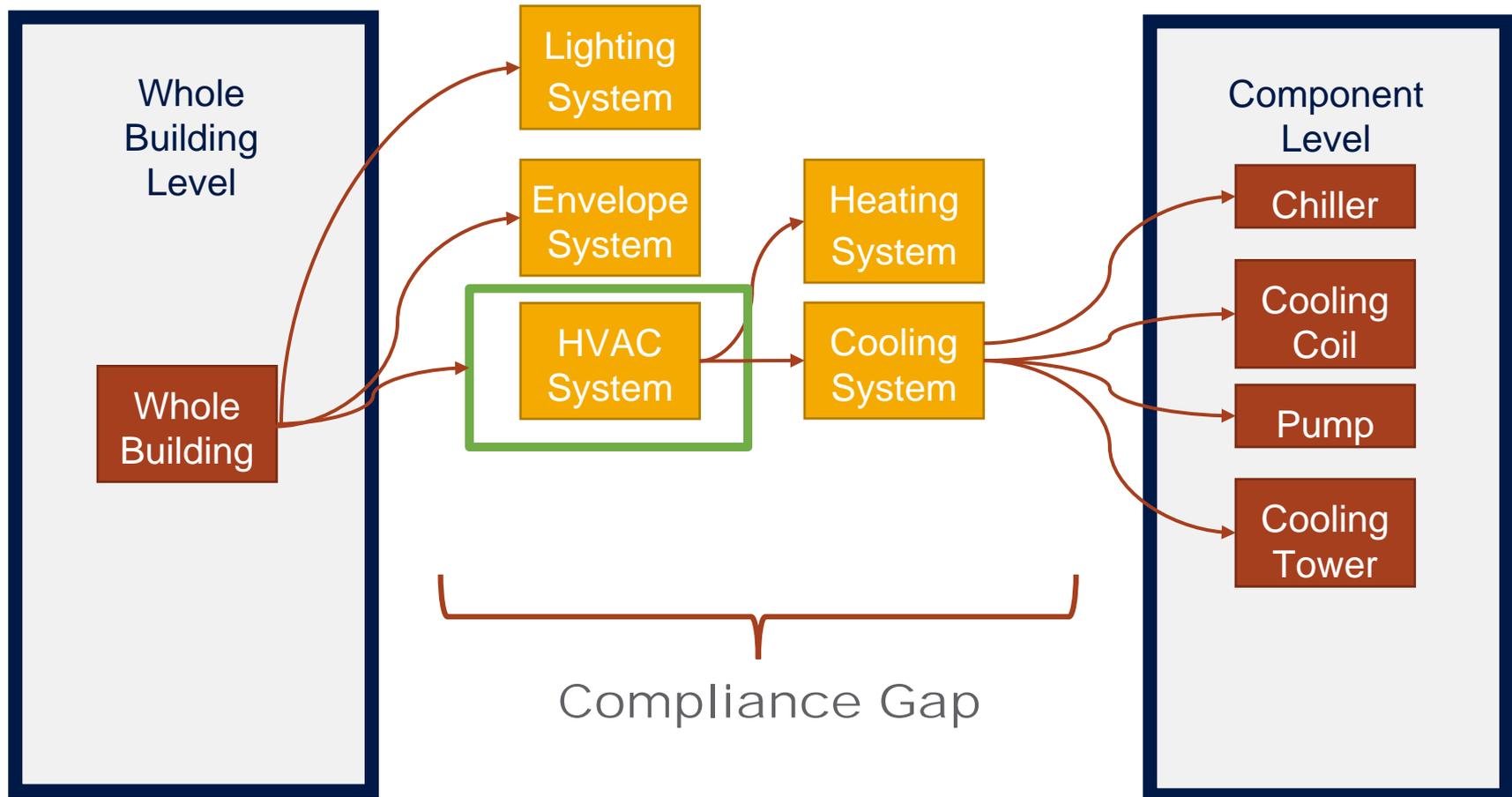
- **Main goal:** encourage low emission systems, in Washington that is electric systems
- Aligned with WA State policy goals of low carbon emissions
- New to 2018 Washington State Energy Code
- Will apply to projects permitted after October 31, 2020

# Where Does TSPR Fit into Code Compliance?



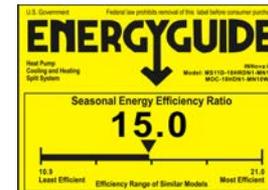
# TSPR – concept of system-level performance

Compliance was either at the Whole Building Level or at the Component Level  
**TSPR evaluates the HVAC system as a whole**



# Whole Building HVAC System Rating

$$TSPR = \frac{\text{Annual HVAC Loads}}{\text{Annual HVAC Carbon Emissions}}$$



...for the whole building  
(more like a seasonal heat pump rating than a boiler rating)

# Development of TSPR

## Stakeholders and Timeline

- 2012 - PNNL envisioned idea of HVAC system efficiency based on ratio of annual heating/cooling loads compared to annual energy use.
- 2015 - Concept was implemented in the Asset score tool in 2015
- 2017 - in meetings in Seattle and Portland sponsored by NEEA, with WSEC developers, PNNL presented the idea of TSPR to the group and they decided to support it as one of the measures NEEA would advance.
- 2018-2020+ – NEEA led stakeholder engagement, including:
  - WSEC stakeholders meetings including architects, engineers, building scientists, developers, energy modelers, and others to discuss TSPR. The group chose baseline systems and finalized other details of the approach.
  - CCE program led meetings with utilities and other code stakeholders on quarterly basis to provide updates on TSPR development and possible connection to utility incentive programs
  - WSEC TAG meetings with PNNL, NEEA, and other stakeholders led to some modifications, including switch from energy cost to carbon emissions as denominator for metric
  - Ongoing engagement will help align code, utility programs, and market needs and best practice

# WHY TSPR

- TSPR drives down real HVAC energy use and carbon emissions
- Rewards *integrated & efficient* system design
- Provides free calculation tool for simple, streamlined scoring
- Tailor it for your jurisdiction or utility program:
  - Just pick a more ambitious target score



# TSPR Calculation Ratio

$$TSPR = \frac{\text{Annual HVAC Loads}}{\text{Annual HVAC Carbon Emissions}}$$

- Annual HVAC Loads** = Sum of HVAC coil loads
- “Ideal Loads” in Energy Plus
  - “Sum Zone Loads” in DOE2
- Annual HVAC Carbon** = Sum of annual carbon emissions for heating, cooling, fans, pumps, energy recovery & heat rejection

## Passing =

1. Proposed ratio  $\geq$  Baseline ratio
2. And, meet all other HVAC code requirements

# Carbon Assumptions

Type	CO2e (lb/unit)	Unit
Electricity	0.70	kWh
Natural Gas	11.70	Therm
Oil	19.20	Gallon
Propane	10.50	Gallon
Other	195	mmBtu

*WSEC Table C407.1 Specifies the Carbon Emission Factors to be used to Determine Compliance*

# Similar to ASHRAE Appendix G

- Baseline is a “reasonably efficient” system for each building type
  - Your city’s code baseline will be different
- Just one stable baseline
  - Not changing for each system type or code edition

## ...with some differences

- Trades within HVAC system only
  - Not trading better HVAC for worse envelope
- Free calculation tool
  - Uses simplified building geometry & defaults



ANSI/ASHRAE/IES Standard 90.1-2016  
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2013)  
Includes ANSI/ASHRAE/IES addenda listed in Appendix H

## Energy Standard for Buildings Except Low-Rise Residential Buildings (I-P Edition)

See Appendix H for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IES Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website ([www.ashrae.org](http://www.ashrae.org)) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website ([www.ashrae.org](http://www.ashrae.org)) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: [orders@ashrae.org](mailto:orders@ashrae.org). Fax: 404-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to [www.ashrae.org/permissions](http://www.ashrae.org/permissions).

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# What Projects Require TSPR Analysis?

## Requirement:

### **C403.1.1 Total System Performance Ratio.**

For systems serving office, retail, library, and education occupancies subject to the requirements of Section C403.3.5, the Total System Performance Ratio (TSPR) of the proposed design HVAC system shall be greater than or equal to the TSPR of the standard reference design as calculated according to Normative Appendix A, Calculation of Total System Performance Ratio.

+Multifamily typologies in Seattle.

## Exceptions:

1. Buildings with conditioned floor area less than 5,000 square feet.
2. HVAC systems using district heating water, chilled water or steam.
3. HVAC systems not included in Table D601.11.1.
4. HVAC systems with chilled water supplied by absorption chillers, heat recovery chillers, water to water heat pumps, air to water heat pumps, or a combination of air and water cooled chillers on the same chilled water loop.
5. HVAC systems served by heating water plants that include air to water or water to water heat pumps.
6. Underfloor air distribution HVAC systems.
7. Space conditioning systems that do not include mechanical cooling.
8. Alterations to existing buildings that do not substantially replace the entire HVAC system.
9. HVAC systems meeting all the requirements of the standard reference design HVAC system in Table D602.11, Standard Reference Design HVAC Systems.

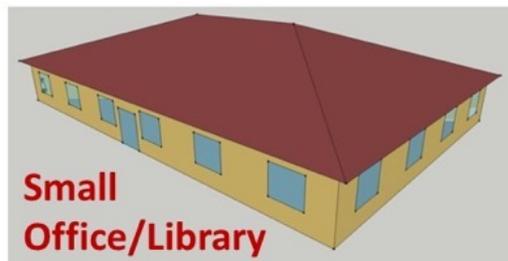
# HVAC Systems Supported by TSPR Tool

**Table D601.11.1**  
**Proposed Building HVAC Systems Supported by HVAC TSPR Simulation Software**

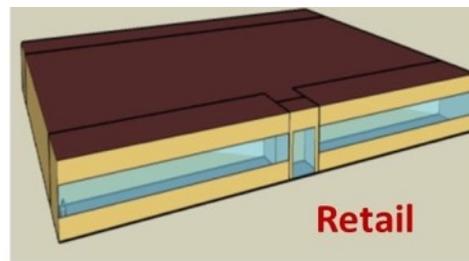
<u>System No.</u>	<u>System Name</u>	<u>System Abbreviation</u>
1	<u>Packaged Terminal Air Conditioner</u>	<u>PTAC</u>
2	<u>Packaged Terminal Air Heat Pump</u>	<u>PTHP</u>
3	<u>Packaged Single Zone Gas Furnace</u>	<u>PSZGF</u>
4	<u>Packaged Single Zone Heat Pump (air to air only)</u>	<u>PSZHP</u>
5	<u>Variable Refrigerant Flow (air cooled only)</u>	<u>VRF</u>
6	<u>Four Pipe Fan Coil</u>	<u>FPFC</u>
7	<u>Water Source Heat Pump</u>	<u>WSHP</u>
8	<u>Ground Source Heat Pump</u>	<u>GSHP</u>
9	<u>Packaged Variable Air Volume (dx cooling)</u>	<u>PVAV</u>
10	<u>Variable Air Volume (hydronic cooling)</u>	<u>VAV</u>
11	<u>Variable Air Volume with Fan Powered Terminal Units</u>	<u>VAVFPTU</u>
12	<u>Dedicated Outdoor Air System (in conjunction with systems 1-8)</u>	<u>DOAS</u>

# TSPR Baseline HVAC Systems

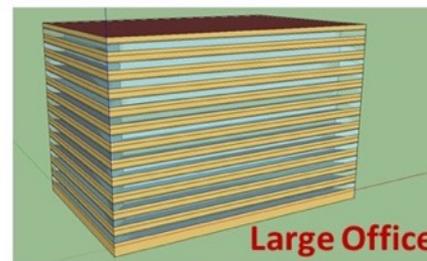
- Determined by group of expert stakeholders in a series of working group meetings (designers, engineers, modelers)
- Efficient, meets {new} WSEC requirements for DOAS combined with cycling space conditioning system and ERV
- Baseline written into WSEC



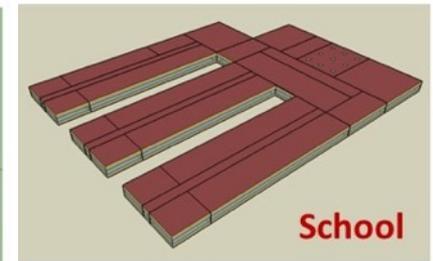
Cycling Heat Pump  
with DOAS/ERV



Cycling Heat Pump  
with DOAS/ERV



Water Loop Heat Pump  
with DOAS/ERV



Cycling Heat Pump  
with DOAS/ERV

# Baseline System Definition Detail

Parameter	Building Type			
	Large Office <sup>1</sup>	Small Office <sup>1</sup>	Retail	School
System Type	Water-source Heat Pump	Packaged air-source Heat Pump	Packaged air-source Heat Pump	Packaged air-source Heat Pump
Fan control	Cycle on load	Cycle on load	Cycle on load	Cycle on load
Space condition fan power (W/cfm)	0.528 (2.5", 65% fan, 85.5% motor)	0.528 (2.5", 65% fan, 85.5% motor)	0.522 (2.5", 65% fan, 86.5% motor)	0.528 (2.5", 65% fan, 85.5% motor)
Cooling Source	DX (heat pump)	DX (heat pump)	DX (heat pump)	DX (heat pump)
Heat source	Heat Pump	Heat Pump	Heat Pump	Heat Pump
Supplemental heating availability	NA	<40°F	<40°F	<40°F
Modeled cooling/heating COP (Net of fan)	4.46/4.61 17-65 MBh: 13 EER/4.3 COP	3.83/3.81 <65 MBh: 14 SEER/8.0 HSPF	4.25/3.57 65-135 MBh: 12.2 EER/3.3 COP	3.83/3.81 <65 MBh: 14 SEER/8.0 HSPF 14.0
OSA Economizer	No	No	Yes	Yes
Occupied ventilation source	DOAS	DOAS	DOAS	DOAS
DOAS Fan Power (W/cfm)	0.979 (2.29", 65% fan, 81% motor)	0.979 (2.29", 65% fan, 81% motor)	0.873 (2.29", 65% fan, 81% motor)	0.887 (2.29", 65% fan, 81% motor)
DOAS temperature control	Bypass	Wild	Bypass	Bypass
ERV efficiency (sensible only)	70%	70%	70%	70%

*WSEC Table D602.11: Standard Reference Design HVAC Systems*

# Transition to Supriya



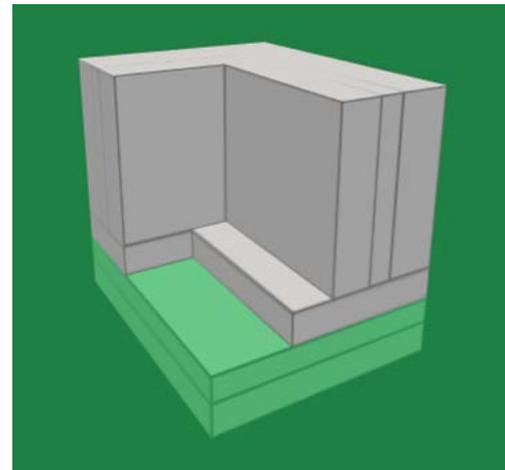
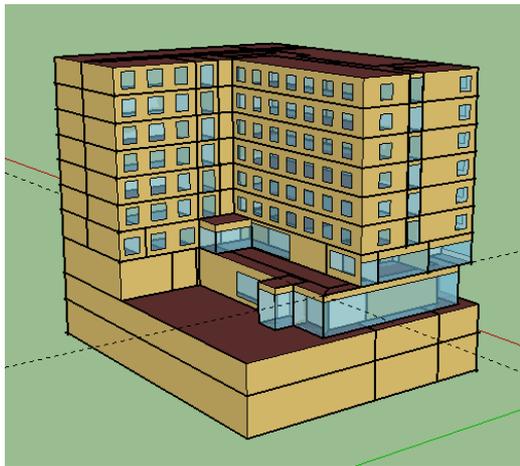
*Supriya Goel is a Senior Research Engineer at Pacific Northwest National Laboratory. Her current research is focused on development of building energy codes and standards and simulation tools for analysis of buildings.*

*She also led the development of an Asset Rating system for buildings and the DOE's Building Energy Asset Score rating tool. She is a member of the IBPSA-USA Board of Directors, chair of ASHRAE Standard 229, a voting member of ASHRAE Standard 211 and a consultant to ASHRAE Standard 90.1. She was awarded the Emerging Professional Award by IBPSA-USA in 2018.*



# Compliance Calculation Tool

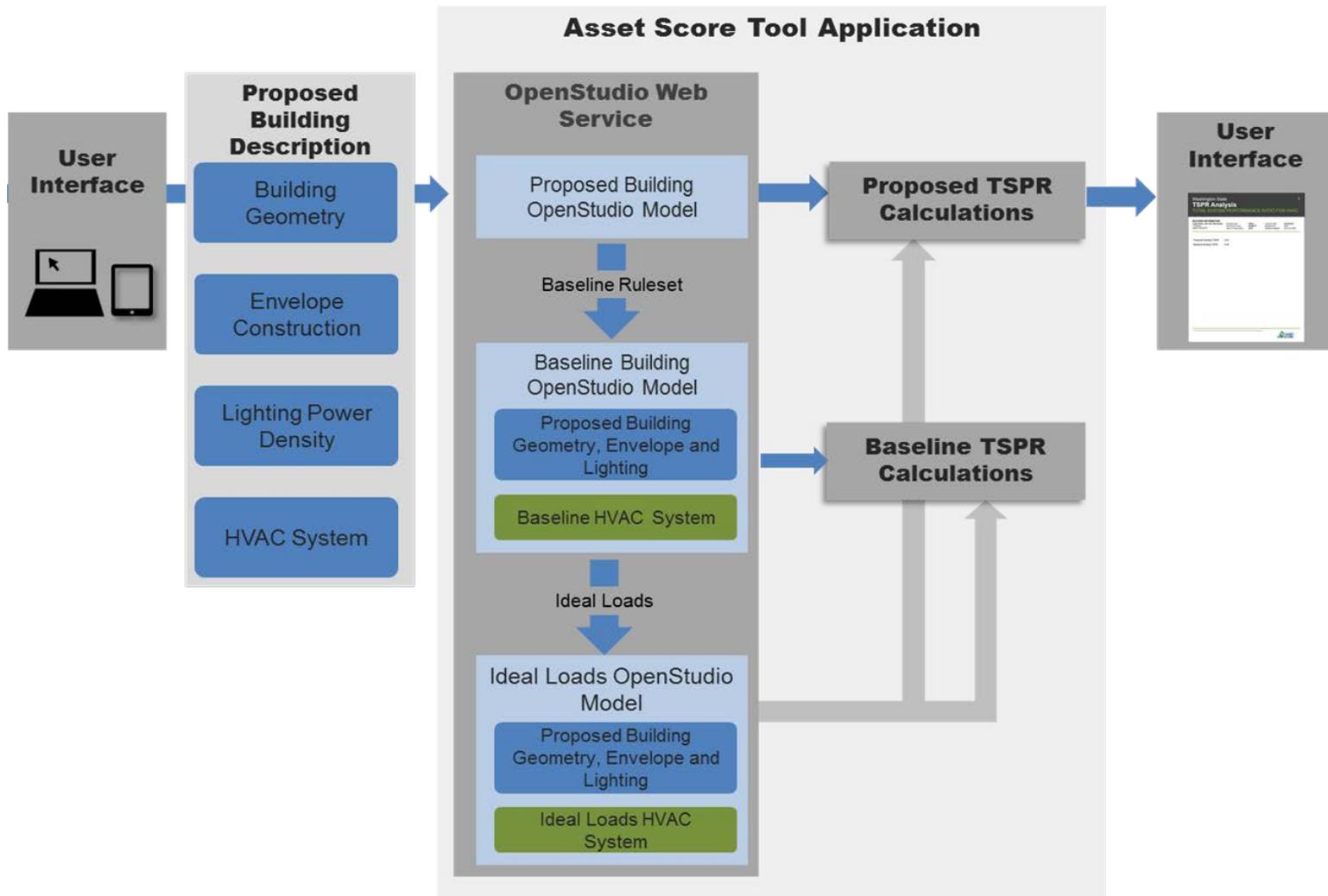
- New module on top of DOE's (free) *Asset Score Tool*
  - Simplified tool for assessing building energy efficiency



Typical C407 Energy Model      Asset Score Simplified Model

- Uses default loads and schedules
- Lighting and envelope loads same as baseline
- ~10% of the time as a full customized energy model

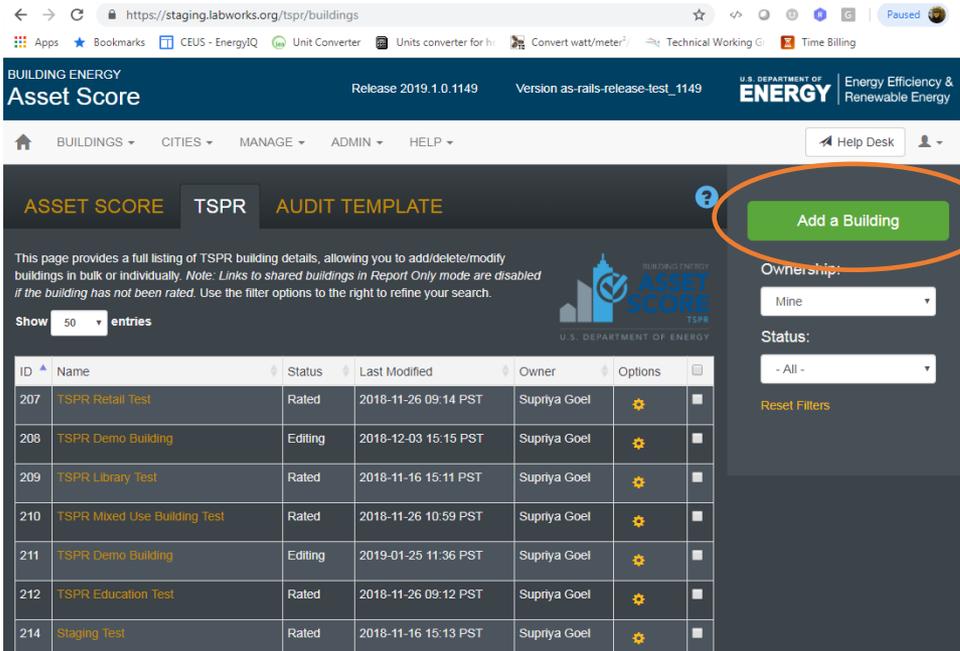
# TSPR Tool Workflow



# How Does the Tool Work?

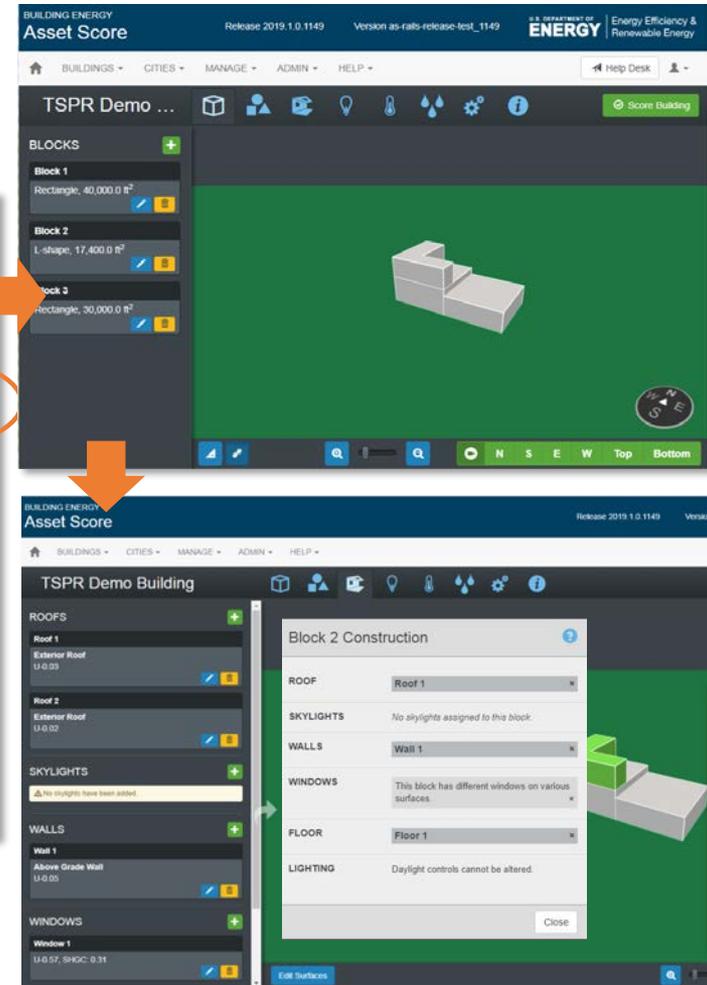
Web-based tool:

<https://buildingenergyscore.energy.gov/>



The screenshot shows the 'Asset Score' web application interface. At the top, there is a navigation bar with 'BUILDINGS', 'CITIES', 'MANAGE', 'ADMIN', and 'HELP' menus. Below this, there are tabs for 'ASSET SCORE', 'TSPR', and 'AUDIT TEMPLATE'. A green 'Add a Building' button is highlighted with an orange circle. Below the button, there are dropdown menus for 'Ownership' (set to 'Mine') and 'Status' (set to '- All -'). A table lists building entries with columns for ID, Name, Status, Last Modified, Owner, and Options.

ID	Name	Status	Last Modified	Owner	Options
207	TSPR Retail Test	Rated	2018-11-26 09:14 PST	Supriya Goel	⚙️
208	TSPR Demo Building	Editing	2018-12-03 15:15 PST	Supriya Goel	⚙️
209	TSPR Library Test	Rated	2018-11-16 15:11 PST	Supriya Goel	⚙️
210	TSPR Mixed Use Building Test	Rated	2018-11-26 10:59 PST	Supriya Goel	⚙️
211	TSPR Demo Building	Editing	2019-01-25 11:36 PST	Supriya Goel	⚙️
212	TSPR Education Test	Rated	2018-11-26 09:12 PST	Supriya Goel	⚙️
214	Staging Test	Rated	2018-11-16 15:13 PST	Supriya Goel	⚙️



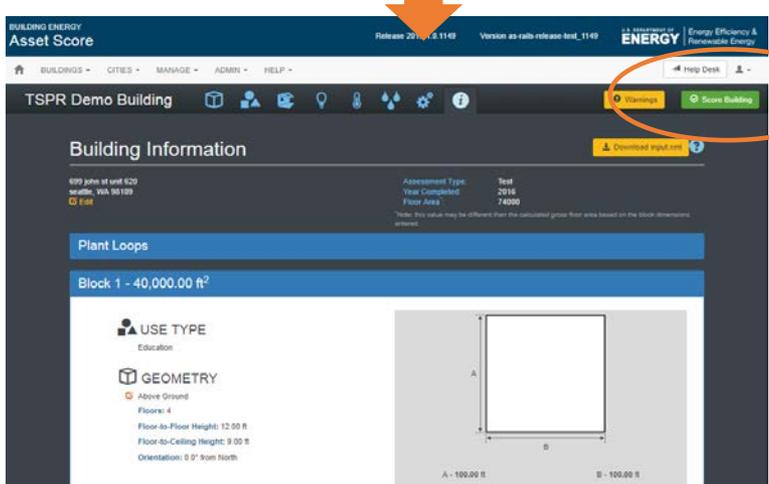
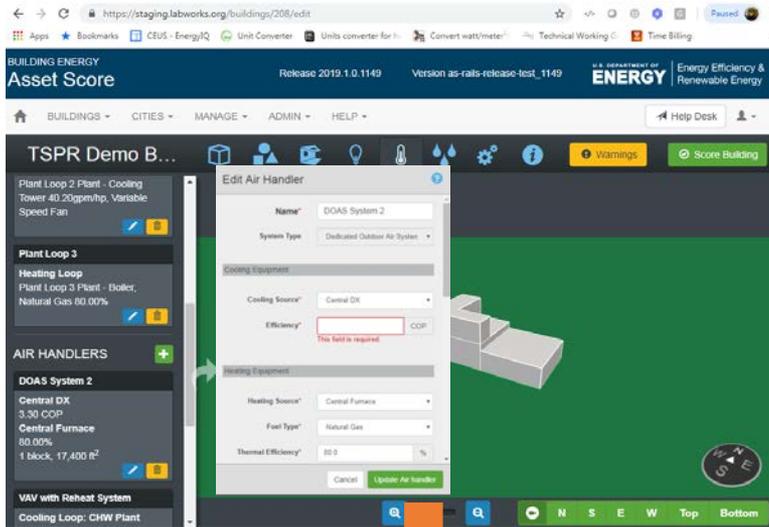
The top screenshot shows the 'TSPR Demo Building' interface with a 3D model of a building. A sidebar on the left lists 'BLOCKS' with details for Block 1 (Rectangle, 40,000.0 R²), Block 2 (L-shape, 17,400.0 R²), and Block 3 (Rectangle, 30,000.0 R²). An orange arrow points from the 'Add a Building' button in the previous screenshot to this interface. The bottom screenshot shows the 'Block 2 Construction' configuration panel, which includes dropdown menus for 'ROOF' (Roof 1), 'WALLS' (Wall 1), 'FLOOR' (Floor 1), and 'LIGHTING' (Daylight controls cannot be altered). An orange arrow points from the 3D model in the top screenshot to this configuration panel.

Simplified geometry editor

Quick-Intuitive workflows for assigning building properties

# Running the Tool

## HVAC System Inputs: Robust error checking and input validation



## PDF Report



# TSPR Large Office Example

## HVAC Ideal Load Served per CO<sub>2</sub>e (kBtu /lb)

Electricity 0.7 lb/kWh, Gas 11.7 lb/Therm n



# Sample Output Report

- Provides
  - Proposed and Baseline building TSPR
  - Whole building HVAC Site Energy use by End use, Heating and cooling loads
  - System level loads, HVAC energy use by end use
  - Mechanical System Schedule information
  - Baseline system details



# Click Through Demonstration

- Access TSPR Tool @ <https://buildingenergyscore.energy.gov/>
- Use Chrome or Safari browser
- Use your email address to register

# Next Steps

## 1. Timeline

- June 2020 -- TSPR Tool widely available
  - <https://buildingenergyscore.energy.gov/>
- November 2020 – WSEC 2018 Adopted

## 2. Guides

- NEEA TSPR Intro Flyer
- TSPR Quick Start Guide
  - <https://buildingenergyscore.energy.gov/documents/TSPR%20Quick%20Start%20Guide.pdf>
- TSPR User Guide
  - <https://help.buildingenergyscore.com/support/solutions/8000049323>
- Simplification of Real Projects:
  - <https://help.buildingenergyscore.com/support/solutions/articles/8000081679-blocks>

# General Informational Flyer



## NEW ENERGY CODE REQUIREMENT: HVAC TOTAL SYSTEM PERFORMANCE RATIO



On November 1, 2020, the HVAC Total System Performance Ratio (TSPR) goes into effect in the 2018 Washington State Energy Code (WSEC). This code update will save energy by requiring building designers to use more efficient HVAC systems evaluated on whole-system performance.

### THE VALUE OF TPSR

The new TPSR requirement levels the playing field for efficient technologies and promotes more efficient design approaches in the process. TPSR will:

- Result in more efficient HVAC systems
- Avoid complex energy modeling
- Reduce operating costs once the building is finished and occupied

By accounting for full-system HVAC efficiency, TPSR represents an important improvement on the prior WSEC, which disincentivized energy-efficient HVAC system types and designs by treating high- and low-performing HVAC systems equally. Instead of evaluating the HVAC system performance holistically, prior code only looked at the efficiency of equipment within the same category and separately evaluated each individual equipment type within the HVAC system.

#### LEARN MORE

For more tools and resources on TPSR, including a Quick Start Guide and technical Help Desk, see the *Total System Performance Ratio* section at: [buildingenergyscore.energy.gov/resources](http://buildingenergyscore.energy.gov/resources).

### HOW TPSR IS CALCULATED

TSPR is a performance-based compliance path for HVAC systems. It is defined as the ratio of the sum of a building's annual heating and cooling load compared to the sum of the annual carbon emissions from energy consumption of the building's HVAC systems.

$$\text{TSPR} = \frac{\text{Annual HVAC Loads}}{\text{Annual HVAC Carbon Emissions}^1}$$

To comply with the WSEC, the proposed system TPSR must be greater than or equal to the baseline system TPSR and meet all other prescriptive code requirements.

The new code documentation includes an approach for engineers to calculate the performance ratio using simplified hourly building energy simulation by inputting the characteristics of the building and its mechanical systems into a software tool, developed by Pacific Northwest National Laboratory, as a module within the U.S. Department of Energy's Asset Scoring Tool.

» To access the tool, visit:  
[buildingenergyscore.energy.gov](http://buildingenergyscore.energy.gov)

<sup>1</sup>Carbon emissions factors are provided by the Washington State Department of Commerce.



### BUILDING & HVAC REQUIREMENTS AND EXEMPTIONS

#### Requirements

TSPR is required for most libraries, office, educational, and retail occupancies. HVAC systems supported by the TPSR Tool (as referenced in WSEC C403.1.1) include:

1. Packaged Terminal Air Conditioner (PTAC)
2. Packaged Terminal Air Heat Pump (PTHP)
3. Packaged Single Zone Gas Furnace (PSZGF)
4. Packaged Single Zone Heat Pump, air to air only (PSZHP)
5. Variable Refrigerant Flow—air cooled only (VRF)
6. Four Pipe Fan Coil (FPFC)
7. Water Source Heat Pump (WSHP)
8. Ground Source Heat Pump (GSHP)
9. Packaged Variable Air Volume, dx cooling (PVAV)
10. Variable Air Volume, hydronic cooling (VAV)
11. Variable Air Volume with Fan Powered Terminal Units (VAVFPTU)
12. Dedicated Outdoor Air System, in conjunction with systems 1-8

#### Exceptions

Buildings and HVAC systems exempt from TPSR include:

1. Buildings with conditioned floor area less than 5,000 sq. ft.
2. HVAC systems using district heating water, chilled water or steam
3. HVAC systems not included in WSEC 2018 Table D601.11.1
4. HVAC systems with chilled water supplied by absorption chillers, heat recovery chillers, water to water heat pumps, air to water heat pumps, or a combination of air and water cooled chillers on the same chilled water loop
5. HVAC systems served by heating water plants that include air to water or water to water heat pumps
6. Underfloor air distribution HVAC systems
7. Space conditioning systems that do not include mechanical cooling
8. Alterations to existing buildings that do not substantially replace the entire HVAC system
9. HVAC systems meeting all the requirements of the standard reference design HVAC system in Table D602.11, Standard Design HVAC Systems



A commercial resource of Northwest Energy Efficiency Alliance (NEEA), BetterBricks helps building professionals gain a competitive edge in the market. Whether you design, build, manage, sell or operate commercial buildings, BetterBricks partners with Northwest utilities to provide the resources and tools you need to incorporate energy efficiency, and its many benefits, into your buildings and business practices.

To learn more, visit: [BetterBricks.com](http://BetterBricks.com)

# Next Steps

## 1. Timeline

- June 2020 -- TSPR Tool widely available
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## 2. Guides

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# Getting Started Guide

## Washington State TSPR Analysis

Total System Performance Ratio for HVAC

1

### Getting Started Guide

#### Accessing the Tool

The Total System Performance Ratio (TSPR) feature in Asset Score Tool may be accessed at:

<https://staging.labworks.org/>

New users would need to register to use the tool. The tool will verify the email used to register. Reports for buildings analyzed will be sent to the registered email address. After registering, send an email to 'asset.score-tspr@pnni.gov' to request access to the TSPR module in Asset Score Tool.

#### Getting Started with TSPR Module in Asset Score Tool

Step 1: From the home page, click on **TSPR**

- This opens up a list view of TSPR buildings. All TSPR buildings created by you or shared with you will be displayed over here.

Step 2: Select **Add a Building** to get started. Note: make sure to click on 'Add a Building' from within the TSPR view. Else, this will add an Asset Score or Audit Template building if selected from those list views.

Step 3: Provide Building Information and click **'Create Building'**

Step 4: Add building blocks to **Create Building Geometry**

#### Create Building Geometry

- Click on the '+' icon to add a building block.
- Simplify the building geometry using the pre-defined shapes available.
- Multiple blocks can be created to represent building geometry, use type and HVAC systems (explained in detail below).
- Specify a block name and dimensions
- Click 'Create Block' to add the block.
- Once created, click on the block to view block information.

Step 1



Step 2



Step 3



## Washington State TSPR Analysis

Total System Performance Ratio for HVAC

2

### Getting Started Guide

#### Navigation Using Multiple Blocks

- For a building model with multiple blocks, the blocks should be configured together to have the **same adjacencies as the actual building design**. This can be done using the 'toggle' and 'snap' features of the tool (See Figure 'Step 4(ii)')
- To move blocks, click on a block to select and drag to move the block.
- Use the **'Toggle'** button to display a ruler on the screen which can help with configuring adjacencies between blocks. (See Figure 'Step 4(ii)')
- The **dimensions** displayed on the 3D interface can be edited to enter specific dimensions to configure multiple blocks.
- The **'Snap'** button should always be enabled while creating building geometry to ensure block alignment.

#### Guidelines

- Each block can have only **one occupancy type** (office, library, education, or retail).
- Each block can be served by only **one type of HVAC system**. Multiple HVAC units of the same type may be represented in one block (further explained in Step 8).
- Each block can have a **single definition of floor-to-floor or floor-to-ceiling height**. Where floor heights differ by more than two feet, unique blocks should be created for the floors with varying heights.
- Each block can include **either above grade or below grade floors**. For buildings with both above grade and below grade floors, separate blocks should be created for each.
- For buildings with floors partially above grade and partially below grade, if the total wall area of the floor(s) in consideration is  $\geq 50\%$  above grade, then it should be simulated as a completely above grade block, otherwise it should be simulated as a below grade block.
- Each wall on a façade of a block shall have **similar vertical fenestration**. If the conditions specified in the WSEC are not met, then additional blocks shall be created consisting of floors with similar fenestration.
- Thermal Zoning:** See Step 8

Step 4(i)

Add blocks by specifying their shape and dimensions



Step 4(ii)

Use the 'toggle' and 'snap' feature to move blocks around.



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- Simplification of Real Projects:
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# Next Steps

## 3. Technical Questions

- Asset Score Help Desk

<https://help.buildingenergyscore.com/>

# Future Webinars

## 4. Future TSPR Training Opportunities

- Wednesday, July 1<sup>st</sup>
- Wednesday, August 5<sup>th</sup>
- Link to the registration here:  
[https://waenergycodes.com/compliance\\_training.php](https://waenergycodes.com/compliance_training.php)
- Stay tuned for a recorded version of a longer click-through training for your reference

## 5. We'd love your feedback!

- Look for an email asking you to fill out a very brief evaluation
- <https://catalyst.uw.edu/webq/survey/burpee/391953>

# Thank You!

## Questions?

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### **WSEC Commercial Technical Support Team**

WSEC Tech Support: 360-539-5300  
Website: [www.waenergycodes.com](http://www.waenergycodes.com)

### **TSPR Tool User Support**

Asset.score-tspr@pnl.gov