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I've attached minority reports from member(s) of the TAG on proposals 050 and 141 and suggested code change language in the event that the MVE Committee chooses to accept the changes.

Both of these code change proposals would use carbon emissions rather than energy cost or energy use to comply with code. Both methods (TSPR and ASHRAE 90.1, Appendix G) were originally and carefully designed to use energy cost as the metric. Although using carbon emissions can be a perfectly valid method for evaluating compliance with the energy code, using the wrong carbon emissions factor (too high or too low) will result in system choices that could result in higher rather than lower emissions. In addition, the TSPR proposal would introduce a computer simulation component to the Prescriptive Path that would render it not a truly prescriptive path and add time, complexity and cost.

Using carbon emissions is a controversial issue and one that should be made by the SBCC rather the TAG. The electric emissions factor approved by the TAG was developed by one of the TAG members based on his assumptions. It is the work of one individual and has not been well-vetted and we believe is too low. We are recommending a different electric emissions factor based on a March 2018 NWPCC report on marginal emissions. The EPA and ASHRAE also support the marginal emissions methodology recommended by our minority report.

Please do not hesitate to contact me if you have any questions about these reports and recommendations. Thanks for your careful consideration.

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Comments on proposal 050-2018, Total System Performance Ratio;

This proposal would add a requirement to the prescriptive path compliance option for systems serving occupancies subject to section C403.3.5 and would use energy use and carbon emissions to generate a Total System Performance Ratio (TSPR) to determine compliance. There are several issues/concerns/problems with this proposal:

1. It would add the requirement for a simulation to generate the TSPR. The prescriptive path for the occupancies subject to this section would no longer be truly prescriptive and would require additional steps, documentation, time and expense to show compliance.
2. The Standard Reference Design HVAC Systems against which the proposed design HVAC systems would be compared are either a water source heat pump system for large office or air source heat pump systems for the other occupancies (small office/library, retail, schools). Although these are legitimate systems for these occupancies, they would not be considered the prevalent standard practice systems for these occupancies. I question how these Standard Reference Designs were chosen.
3. The TSPR is calculated by dividing the annual heating and cooling load by the annual carbon emissions from energy consumption of the building HVAC systems. The emissions factor for electricity is proposed to be .55 lbs/kwh. This factor was generated

using an ad hoc methodology that is seriously flawed in its assumptions. It is well-accepted by organizations like the EPA, ASHRAE and the NWPCC that the correct factor to use to evaluate energy efficiency/conservation is the marginal resource emissions factor. In a 2018 report from the NWPCC, "In the Northwest, the average CO2 production rate from all electricity generation is low in comparison to other parts of the Western Electric Coordinating Council region (WECC). This is because there are vast hydroelectric and wind generation resources in the Pacific Northwest. These resources have low operating costs, no CO2 emissions, and dispatch before coal-fired or natural gas-fired generating units. However, since the next megawatt of generation avoided would be available from the marginal unit, not an average of all the units online, the emissions of the marginal unit would best represent the avoided carbon risk of serving the last unit of load." The table below is taken from the report. The marginal resource does not include any renewables or conservation and is primarily based on natural gas combustion turbines. The significant drop in emissions between 2016 and 2021 is primarily due to coal plant retirements.

Table 1: Annual Average Avoided $CO_2$ Emissions Rate

| **Scenario** | **Average Annual Avoided Emissions Rate (lbs. of CO2 per kWh)** |
|---|---|
| 2016 | 1.83 |
| 2021 Plan DR | 0.91 |
| 2026 | 0.93 |
| 2031 | 0.97 |

4.

| | Base System: WSHP/ DOAS/ ERV 70% | Minimum FCU: DOAS/ ERV 50% | Improved FCU: DOAS/ ERV 70% +eff: CH/HW/ Pump | Minimum VAV: HW RH | High-Eff.+ VAV: HW RH; DCV; MDP +eff: CH/HW/ Pump | Minimum VAV: Elec RH | High-Eff.+ VAV: Elec RH; DCV; MDP +eff: CH/HW/ Pump |
|---|---|---|---|---|---|---|---|
| TSPR (Energy Cost) | 74.65 | 69.41 | 77.78 | 80.73 | 100.27 | 55.72 | 80.62 |
| TSPR (CO2e- Electric 0.55 lb./kWh, Gas 11.7 lb./Therm) | 14.92 | 13.21 | 15.4 | 12.63 | 16.73 | 11.35 | 16.42 |
| TSPR (CO2e- Electric 0.46 lb./kWh, Gas 11.7 lb./Therm) | 17.71 | 15.41 | 18.23 | 13.88 | 18.72 | 13.57 | 19.63 |
| TSPR (CO2e- Electric 0.82 lb./kWh, Gas 11.7 lb./Therm) | 10.13 | 9.25 | 10.52 | 9.95 | 12.69 | 7.61 | 11.01 |
| TSPR (CO2e- Electric 1.0 lb./kWh, 11.7 lb./Therm) | 8.34 | 7.71 | 8.68 | 8.71 | 10.93 | 6.24 | 9.03 |

This table was provided by Michael Rosenberg and it compares the Base System to 6 other potential systems. The red numbers indicate that the particular proposed system shown would not pass the TSPR test. The green numbers indicate a passing TSPR. The comparisons were made based on Energy Cost and then different electric emissions rates of .55, .46, .82 and 1.0 lbs/kwh respectively. Note in particular that the Minimum VAV: HW RH system which uses a standard efficiency natural gas boiler would outperform the Base System based on energy cost and using an emissions rate of 1.0 lbs/kwh which is very close to the NWPCC factors of .91-.97 lbs/kwh. I had previously proposed using an emissions factor in the .91-.97 lbs/kwh for amendment proposal 141 that will adopt ASHRAE 90.1, Appendix G as the performance path.

In summary, the prescriptive path is meant to keep things as simple as possible to show compliance with the code. Adding the TSPR will complicate the process and will add time and possibly expense. However, if it is determined that the TSPR provides enough value, using the correct factor in the denominator is critical. Using a factor too high or too low will skew the results toward a system choice that may not be the best for that building or for Washington's emissions reduction goals. My recommendation would be to disapprove the proposal. If that were to fail, I would recommend adopting either energy cost or an emissions rate for electricity in the .91-.97 lbs/kwh range.

**Option 2: TSPR modified to use energy cost.**

## Appendix D
## Calculation of HVAC Total System Performance Ratio[BK(1]

**D101 Scope.** This appendix establishes criteria for demonstrating compliance using the *HVAC total system performance ratio* (HVAC TSPR) for office, retail, library, and education occupancies. For those occupancies, HVAC systems shall comply with Section C403 and this appendix as required by Section C403.1.1.

**D201 Compliance.** Compliance based on *total system performance ratio* requires that the provisions of Section C403.3 are met and the *total system performance ratio* of the *proposed design* is more than or equal to the *total system performance ratio* of the *standard reference design*. The TSPR is calculated according to the following formula:

HVAC TSPR = annual heating and cooling load /annual ~~carbon emissions~~ energy cost from energy consumption of the building HVAC systems

Where:

| | | |
|---|---|---|
| Annual ~~carbon emissions~~ energy cost from energy consumption of the building HVAC systems | = | sum of the annual ~~carbon emissions in pounds~~ energy cost in dollars for heating, cooling, fans, energy recovery, pumps, and heat rejection calculated by multiplying site energy consumption by the ~~carbon emission~~ energy cost factors from Table C407.1 |
| Annual heating and cooling load | = | sum of the annual heating and cooling loads met by the building HVAC system in thousands of Btus. |

**Table C407.1**
**~~Carbon Emissions~~Energy Cost Factors**

| Type | ~~CO2e (lb~~Energy cost ($/unit) | Unit |
|---|---|---|
| Electricity | ~~0.55~~$0.112 | kWh |
| Natural Gas | ~~11.70~~$1.158 | Therm |
| Oil | ~~19.2~~current rate | Gallon |
| Propane | ~~10.5~~current rate | Gallon |

**Option 3: TSPR modified to use different electricity emissions factor**

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HVAC TSPR = annual heating and cooling load /annual carbon emissions from energy consumption of the building HVAC systems

Where:

| | | |
|---|---|---|
| Annual carbon emissions from energy consumption of the building HVAC systems | = | sum of the annual carbon emissions in pounds for heating, cooling, fans, energy recovery, pumps, and heat rejection calculated by multiplying site energy consumption by the carbon emission factors from Table C407.1 |
| Annual heating and cooling load | = | sum of the annual heating and cooling loads met by the building HVAC system in thousands of Btus. |

**Table C407.1**
**Carbon Emissions Factors**

| Type | CO2e (lb/unit) | Unit |
|---|---|---|
| Electricity | ~~0.55~~0.94 | kWh |
| Natural Gas | 11.70 | Therm |
| Oil | 19.2 | Gallon |
| Propane | 10.5 | Gallon |