STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Log No. _047
Proponent Rev
05/13/22_

Washington State Energy Code Development

Standard Energy Code Proposal Form

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # ______R406.3_Option 5.6___________

Brief Description:

Compact Hot Water Distribution Systems for R406.3 additional energy credit.

For this proposal, utilizing the language in separately submitted "Short Water Volume Determination" proposal, our team expanded the analysis and performed LCC savings and Simple Paybacks. This proposal was found to have net positive savings for all scenarios with the 16-ounce or 1 pint language as proposed.

This analysis was done to introduce a new potential energy efficiency measure for section R406 and Table R406.3 that aligns with savings already included in section R405 for simulated performance.

This proposal recognizes that for this measure to be both effective and efficient, a useful hot water temperature of at least 105°F must be achieved in reasonable time at the tap. The analysis used savings estimates for this scenario.

Proposed code change text: (Copy the existing text from the Integrated Draft, linked above, and then use underline for new text and ~~strikeout~~ for text to be deleted.)

OPTION	DESCRIPTION	All Other	Group R-2
5.6	~~Not greater than 16 ounces of water volume shall be stored in the piping between the hot water source and any hot water fixture when calculated in accordance with Section R403.5.4.~~ ~~One of the following checks must be done to verify that the system meets the prescribed limit:~~ ~~1. At plan review, by referencing ounces of water per foot of tube on plans per Table R403.5.4.1.~~ ~~2. At rough in (plumbing), by referencing ounces of water per foot of tube installed per Table R403.5.4.1.~~ ~~3. At final inspection, in accordance with Department of Energy's Zero Energy Ready Home National Specification (Rev. 07 or higher) footnote on Hot water delivery systems.~~ For Compact Hot Water Distribution system credit, the volume shall store not more than 16 ounces of water between the nearest source of heated water and the termination of the fixture supply pipe where calculated using section	0.5	N/A

	R403.5.4 *Construction documents* shall indicate the ounces of water in piping between the hot water source and the termination of the fixture supply.		

[note: remainder of table unchanged in this proposal]

Purpose of code change:

Inefficient hot water distribution systems have been recognized as a problem for many years as they result in energy and water waste, and result in long hot water delay times that are the cause of a considerable number of complaints by new home buyers. Recirculation systems are a solution to two of the three problems (water and wait time), but the thermal energy impact of different recirculation system options has already been addressed in section **R403.5.1.1 Circulation system.**[1]

In all non-recirculation distribution options, water heater energy consumption and hot water waste are correlated. A decrease in water heater energy consumption follows a reduction in wasted water; therefore, improving insulation and reducing the piping length and/or pipe diameter have equal benefits for energy and water waste. In recirculation systems, water heater energy consumption and wasted hot water are independent, and often have an inverse effect (when recirculation is not demand based).[2]

This distribution system problem exists for a variety of factors including:

- An outdated pipe sizing methodology in the plumbing code that results in oversized hot water distribution systems since the assumed fixture flow rates are much higher than current requirements.
- Municipalities with design recommendations that force plumbers and designers to assume low supply water pressure, resulting in larger distribution piping, which waste more water and energy.
- Increasing efforts to conserve water has resulted in the realization of water savings due to improvements in showerhead and lavatory maximum flow rates; however, reduced flow rates often result in increased wait times if the hot water distribution system is not designed to accommodate lower flows.
- Increasing popularity of gas instantaneous water heaters, which offer improved operating efficiency, but can result in increased water waste when starting from a “cold start up” situation.
- Inefficient plumbing installations that are not focused on minimizing pipe length or pipe diameters.

The WSEC-R has already addressed pipe insulation and Circulation systems in the 2018 WSEC-R prescriptive and Table 406.3 additional energy credits.

1Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility Farhad Farahmand, TRC Companies and Yanda Zhang, ZYD Energy

2 Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models E. Weitzel and M. Hoeschele, Alliance for Residential Building Innovation

Your amendment must meet one of the following criteria. Select at least one:

☐ Addresses a critical life/safety need.

☒ The amendment clarifies the intent or application of the code.

☐ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

Check the building types that would be impacted by your code change:

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Dan Wildenhaus	Email address	dwildenhaus@trccompanies.com
Your organization	TRC, BetterBuiltNW	Phone number	772.932.4994
Other contact name	Click here to enter text.		

3Economic Impact Data Sheet

Is there an economic impact: ☒ Yes ☐ No

Briefly summarize your proposal's primary economic impacts and benefits to building owners, tenants, and businesses. If you answered "No" above, explain your reasoning.

The proposal states that this would neither increase nor decrease the cost of construction. Similar to bringing ducts inside the conditioned space, some research has estimated a net cost decrease after design changes due both to labor and materials reductions. For the analysis performed and used in the LCC, we did assume a slight $300 first cost increase to recognize that not scenarios will have the same cost reduction.

Provide your best estimate of the **construction cost** (or cost savings) of your code change proposal? (See OFM Life Cycle Cost **Analysis tool** and **Instructions;** use these **Inputs**. **Webinars on the tool can be found Here and Here**)

$0.14/square foot (CFA)(For residential projects, also provide **$300/ dwelling unit**)

Show calculations here, and list sources for costs/savings, or attach backup data pages

Incremental cost findings from the California Energy Commission's Energy Research and Development Division Final Project Report: Code Changes and Implications of Residential Low-Flow Hot Water Fixtures, September 2021, CEC-500-2021-043 indicate that there may be up to $1,500 cost savings for designing and installing a system with less materials and with greater work efficiency due to reduced plumbing layout. The Codes and Standards Enhancement (CASE) Initiative, Compact Hot Water Distribution – Final Report, Measure Number: 2019-RES-DHW1-F reported that incremental cost is highly scenario dependent, but overall determined that there would be little to no cost increase.

For the purposes of this analysis, we assumed that while incremental costs are likely to be neither higher, nor lower than standard plumbing designs, a small incremental cost of $300 would cover the bases for an increased number of potential scenarios.

Provide your best estimate of the **annual energy savings** (or additional energy use) for your code change proposal?

$0.05 KWH/ square foot (or) Click here to enter text.KBTU/ square foot

(For residential projects, also provide **111.2 KWH**/KBTU / dwelling unit)

Show calculations here, and list sources for energy savings estimates, or attach backup data pages

This analysis focused on kWh and Water Savings as it is estimated that over 80% of Residential New Construction Water Heaters installed are Heat Pump Water Heaters in Washington where many of the savings have already been accepted and analyzed.

SAVINGS

The two California assessments found slightly higher energy savings than did modeling in REM/Rate v16.0.6. For the purposes of this assessment, the more conservative REM/Rate values were used.

Climate Zone	Savings in kWh for 1 Pint	Savings in kWh for 1 Quart	Savings dollars 2021 Electric Rates for WA at 0.1007 $/kWh Pint	Savings dollars 2021 Electric Rates for WA at 0.1007 $/kWh Quart
4	117	83	11.78	8.36
5	130	92	13.09	9.26

Max Potential Savings as calculated in the Energy Research and Development Division, FINAL PROJECT REPORT, Code Changes and Implications of Residential Low-Flow Hot Water Fixtures September 2021 | CEC-500-2021-043 were found to be on average 322.3 kWh.

CZ/volume-based savings	1 pint savings in kWh/yr (translated from Therms/yr)	1 quart savings in kWh/yr (translated from Therms/yr)
CZ 3 through 5	556.7	322.3

Savings connected with maximum approach (1 pint in pipe + low-flow) and average approach (1.5 to 2 pint + federal minimum flow fixtures) and were analyzed in a 2,100 sq ft single story home and a 2,700 sq ft two-story home.

The Codes and Standards Enhancement (CASE) Initiative, 2019 California Building Energy Efficiency Standards, Compact Hot Water Distribution – Final Report, Measure Number: 2019-RES-DHW1-F found savings for a 1 Quart system to be approximately 117.2 kWh when converted from Therm savings.

First year weighted average residential energy savings (translated from Therms/yr to Mmbtu/yr) are estimated to be per Single Family Home: Climate Zone Savings in Therms Savings in Mmbtu[2] are estimated to be per Single Family Home:

Climate Zone	Savings in kWh (translated from Therm savings) 1 quart volume	Savings dollars 2021 EIA Washington electric rate of 0.1007 $/kWh
3c through 5	163.2	16.43

These estimates come from assumption of a 2,430 sq ft home with 3.5 bedrooms.

Considering these varying, but same order of magnitude savings numbers, a savings number has been generated for 1.5 pints or 24 ounces of water, across Washington to be: **106.5 kWh.**

Water Savings

Estimated impacts on water use are presented in the table below. Water use savings estimates are challenging given that hot water usage behaviors among individuals and households are highly variable and can depend strongly on the demographics of the household (Parker, D.; Fairey, P.; and Lutz, J.; 2015). In addition, the proposed compliance option approach ensures that compliant hot water distribution systems will be smaller than a conventional non-compact system but cannot precisely specify the design and configuration and hence the impacts on water waste. To provide a best approximation of water savings impacts, the Statewide CASE Team in California relied on detailed distribution simulation study completed under the U.S. Department of Energy's Building America program (Weitzel, E.; Hoeschele, M. 2014). In these estimates, it was assumed that all water savings occur indoors.

An average cost of $3/1000 gallons was used to estimate water savings.

Impacts on Water Use Table:

Title 24 CASE Report	**On-Site Indoor Water Savings (gal/yr)**
Per Dwelling Unit Impacts (single family)	962
Per Dwelling Unit Impacts (multifamily)	321

CEC Code Implications Report	**On-Site Indoor Water Savings (gal/yr)**
Per Dwelling Unit Impacts (single family)	1,750

Analysis	1 pint	1 quart	**$/year**

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All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

CEC report	1750		(1750/1000)*3=5.25
CASE		962	(962/1000)*3=2.89

In lieu of attempting to convert water savings and costs for water from California to Washington, this analysis has chosen to utilize an embedded energy in wasted water that adds an **additional 4.7kWh/yr.**

Table : Impacts on Water Use

	Impacts on Water Use On-Site Indoor Water Savings (gal/yr)	Embedded Electricity Savings[a] (kWh/yr)
Per Dwelling Unit Impacts (single family)	962	4.7

a. Assumes embedded energy factor of 4,848 kWh per million gallons of water (CPUC 2015).

The choice to use a 4.7 kWh/yr adder to electricity savings produced a more conservative LCC calculation that did the option to individually subtract water savings costs independently.

LCC

Life-cycle costs were calculated using the IECC-Residential LCC Calculator.

A blended annual savings averaged across both climate zones in Washington and averaging savings between both 16- and 32-ounce cases led to the use of **111.2 kWh savings per year**.

Using these energy savings and a $300 first cost, the LCC shows Simple Payback of 17.15 years for LCC with social cost of carbon (SCC) included. The LCC without SCC showed a Simple Payback of 19.66 years.

Measure Incremental LCC in both scenarios were found to be as follows:

Blended Savings:

LCC Calculator - IECC Residential

Enter values into blue boxes

Proposal information

Proposal number	REPI-142-21	
CDP ID#		
Proponent	Wildenhaus, Dan; Rose, Kevin	
Climate zone(s) analyzed	4C, 5B,	Enter specific climate zone or zones included in the analysis below
Additional Notes	Averaged over 8 climate zones	

Methodology

Description of measure cost methodology	Utilized reporting and analysis from 3 sources. Title 24 CASE Report (2017), CEC Code Chage and Implications of Residential Low-Flow Hot Water Fixtures (2021), REM/Rate energy modeling (2022)
Description of savings calculation methodology. Include information about climate zones and fuel types where appropriate.	Compact desing practices with savings calculated in CBECC-Res for two CA reports, RESNET/IECC/ANSI 301 defaults vs CHWD in REM/Rate v16.0.6. Averaged savings across climate zones from 3

Inputs

Net measure cost	300	2020$, measure cost to consumer, including markup, less tax credits or other incentives
Measure electric savings	111.2	kWh/year
Measure natural gas savings		therms/year
Measure propane savings		gallons/year
If applicable:		
Change in maintenance or other non-energy operating costs	0	2020$/year (+ for increased cost, - for decreased cost)
Replacement cost		2020$
Year of first replacement		For measures with life <30 years, # of years from date of construction
Year of second replacement		For measures with life <30 years, # of years from date of construction

Results

	Discount Rate				
	3% nominal DOE	3% real OMB	7% real OMB		
With SCC value					
Measure incremental LCC	$149.95	$107.41	$67.72		2020$ (+ for savings, - for increased cost)
Simple payback				17.15	Years
With SCC = $0					
Measure incremental LCC	$94.64	$52.11	$12.41		2020$ (+ for savings, - for increased cost)
Simple payback				19.66	Years

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16-ounce or 1-pint scenario:

Results					
	Discount Rate				
	3% nominal	3% real	7% real		
	DOE	OMB	OMB		
With SCC value					
Measure incremental LCC	$218.38	$159.77	$104.20		2020$ (+ for savings, - for increased cost)
Simple payback				14.90	Years
With SCC = $0					
Measure incremental LCC	$154.72	$96.11	$40.54		2020$ (+ for savings, - for increased cost)
Simple payback				17.08	Years

32-ounce or 1 quart scenario:

Results					
	Discount Rate				
	3% nominal	3% real	7% real		
	DOE	OMB	OMB		
With SCC value					
Measure incremental LCC	$71.74	$47.57	$26.02		2020$ (+ for savings, - for increased cost)
Simple payback				20.73	Years
With SCC = $0					
Measure incremental LCC	$25.99	$1.82	($19.73)		2020$ (+ for savings, - for increased cost)
Simple payback				23.77	Years

COST EFFECTIVENESS

As indicated in the LCC as seen above and using energy savings for 16-ounce (1 pint) and water savings for 32-ounce scenarios, the LCC shows Simple Payback of 17.15 years for LCC with social cost of carbon (SCC) included. The LCC without SCC showed a Simple Payback of 19.66 years.

CZ\Metric	Net Cost	Measure Savings	Discount 3% Real w/SCC	Discount 3% Real w/o SCC	Simple Payback w/ SCC	Simple Payback w/o SCC
4 and 5	$300	111.2 kWh	$107.41	$52.11	17.15	19.66

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List any **code enforcement** time for additional plan review or inspections that your proposal will require, in hours per permit application:

If confirmed at time of both plan review and inspection, this may require up to 1/2 hour per application per floor plan and ¼ hour per site inspection per home.

Small Business Impact. Describe economic impacts to small businesses:

There is not anticipated to be any positive or negative impacts unique to small businesses.

Housing Affordability. Describe economic impacts on housing affordability:

Affordable housing typically has a smaller footprint, smaller house size, and is configured with "wet walls" or plumbing locations in close proximity to each other. This increases the likelihood that this credit could be taken by affordable housing projects.

Other. Describe other qualitative cost and benefits to owners, to occupants, to the public, to the environment, and to other stakeholders that have not yet been discussed:

REFERENCES

- *Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility* Farhad Farahmand, TRC Companies; Yanda Zhang, ZYD Energy
- *Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* **E.** Weitzel and M. Hoeschele Alliance for Residential Building Innovation
- California Energy Codes & Standards Case Report for *Compact Hot Water Distribution;* Measure Number: 2019-RES-DHW1-F, Residential Plumbing
- Home Innovation Research Labs Annual Builder Practices Survey, 2021
- Department of Energy Zero Energy Ready Home National Program Requirements (Rev. 07) [footnote 15)
- Efficient hot water distribution system - USBGC **LEED** BD+C: Homes *v4*- **LEED** *v4*
- Residential Hot Water Distribution Systems: Roundtable Session; JD Lutz, Lawrence Berkely National Laboratory; G Klein, California Energy Commission; D Springer, Davis Energy Group; BO Howard, Building Environmental Science & Technology
- Code Changes and Implications of Residential Low-Flow Hot Water Fixtures – CEC-500-2021-043. Gary Klein, Jim Lutz, Yanda Zhang, John Koeller.
- Time-to-Tap and Volume-until-Hot – Water, Energy, and Time Efficient Hot Water Systems. 2020 Educational Institute, March 2020, Gary Klein presentation.

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