



ACEEE Hot Water Forum 2017

*Preliminary Benefit/Cost
Analysis of Residential DWHR for
California's Title 24*

NegaWatt Consulting

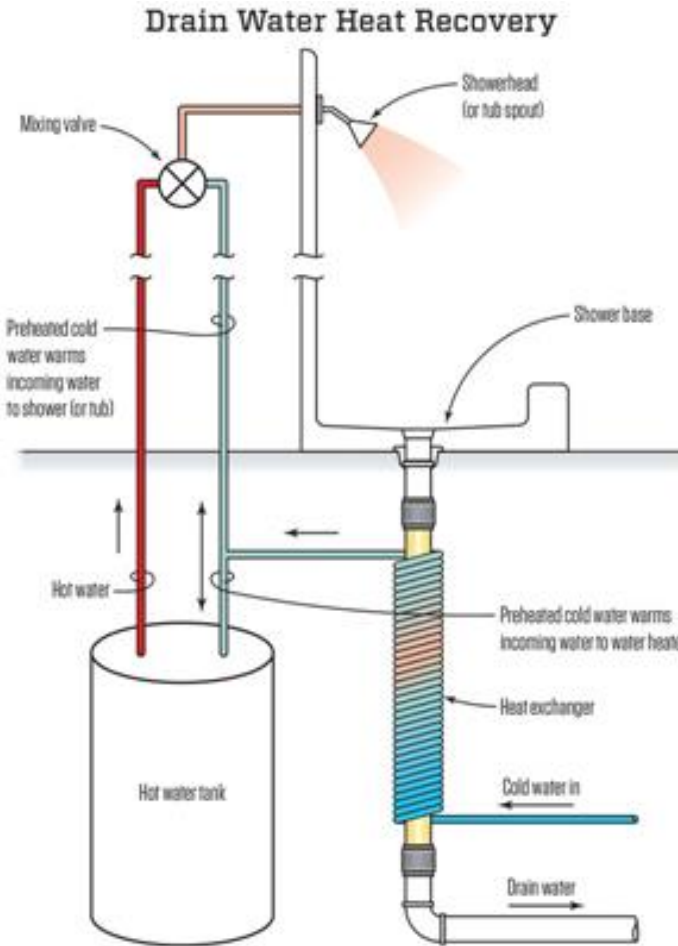


Outline

- Background
 - Drain water heat recovery diagram
 - California Climate Zone map
 - Prototype buildings
 - Hot water draw schedules
- Preliminary cost effectiveness calculations
- Related California code topics



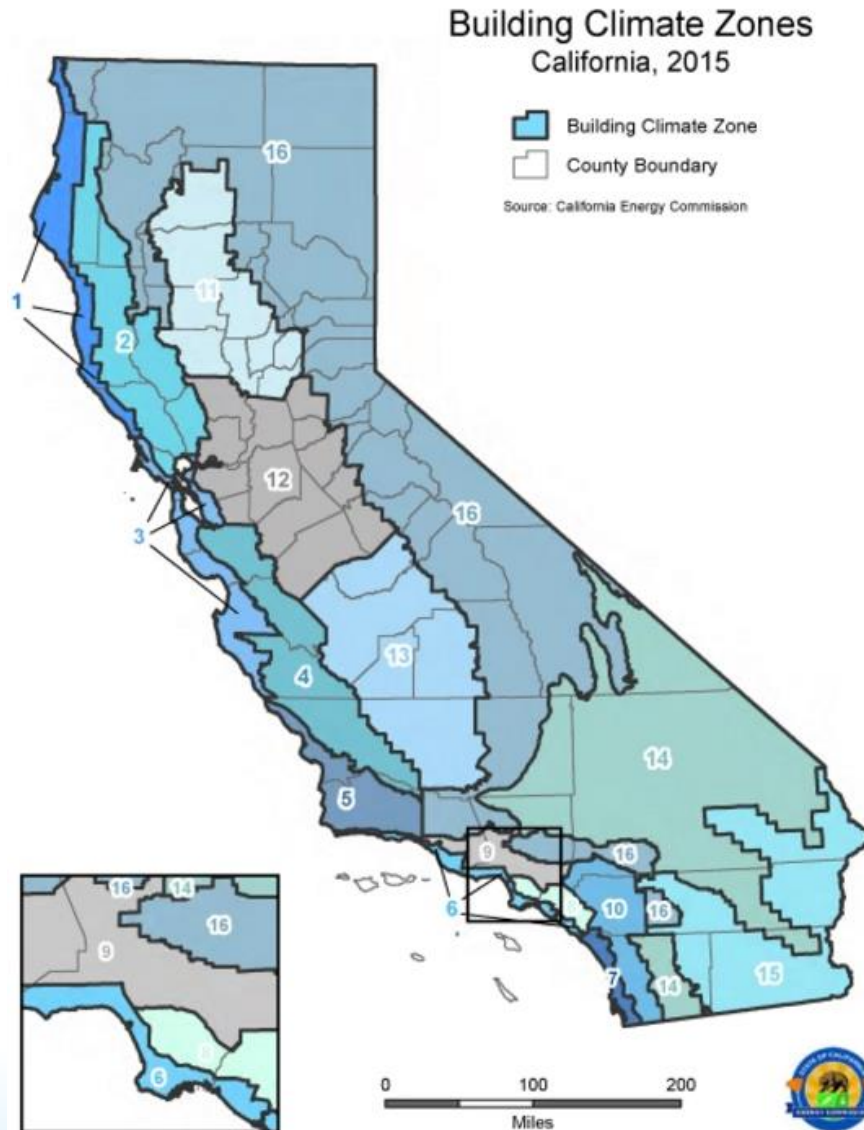
DWHR in Equal Flow Configuration



Sources: DEG/PG&E (left);
Journal of Light Construction,
September 2016 (right)



California Title 24 Climate Zones





California Title 24 Prototype Res. Buildings

Figure A-4: Two-Story Prototype Front View



Figure A-5: Two-Story Prototype Back View

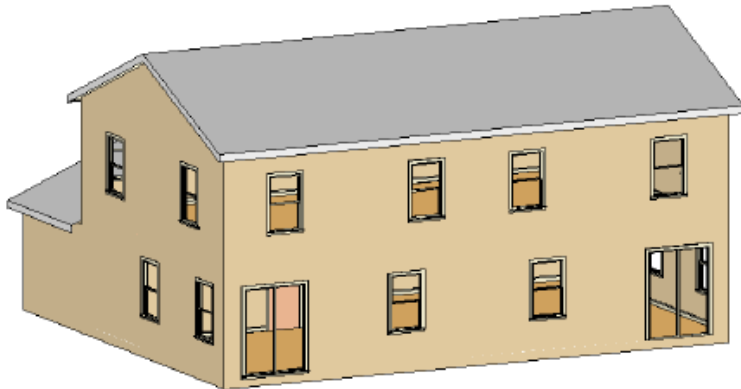


Figure A-8: Multifamily Prototype Front View

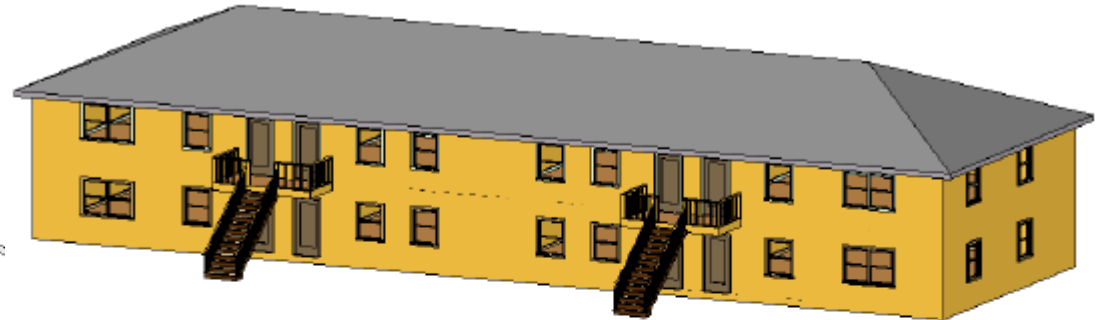
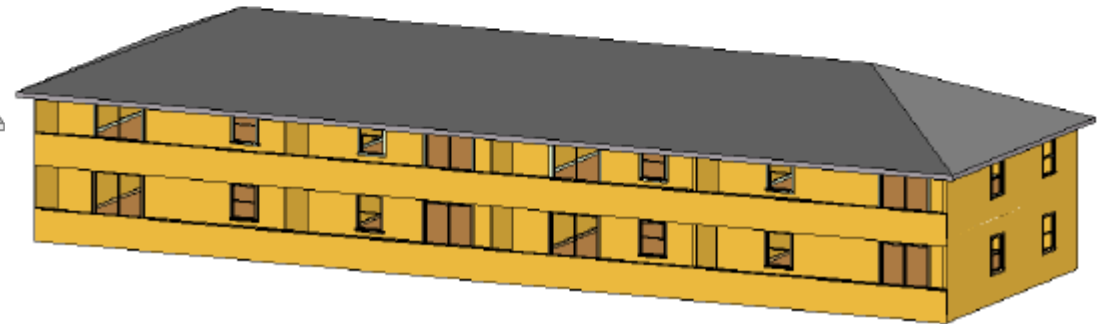


Figure A-9: Multifamily Prototype Back View



Source: CEC, 2016 ACM Approval Manual

Note: One-story prototype not shown



CBECC-Res Hot Water Draw Schedules

Table 28. Model predicted, single family average daily water use by dwelling size at fixture (and at water heater, for CTZ 12, Sacramento)

Number of Bedrooms	Assumed CFA [ft ²]	Faucet [gal/day]	Shower [gal/day]	Bath [gal/day]	Clothes Washer [gal/day]	Dishwasher [gal/day]	Total [gal/day]	% Shower
2	922	22.4 (11.2)	20.7 (19.7)	2.6 (2.4)	23.3 (5.1)	1.7 (1.7)	70.7 (40.1)	29% (49%)
3	2100	25.1 (12.6)	23.4 (25.2)	3.1 (3.3)	27.4 (6.0)	1.9 (1.9)	80.9 (49)	29% (51%)
4	2240	26.8 (13.4)	26.7 (29.1)	3.7 (4.0)	27.7 (6.1)	1.9 (1.9)	86.8 (54.5)	31% (53%)
5	2831	30.6 (15.3)	31.1 (34.5)	3.6 (4.0)	32.0 (7.0)	2.2 (2.2)	99.5 (63)	31% (55%)

Table 29. Model predicted, multi-family average daily water use by dwelling size at fixture (and at water heater, for CTZ 12, Sacramento)

Number of Bedrooms	Assumed CFA [ft ²]	Faucet [gal/day]	Shower [gal/day]	Bath [gal/day]	Clothes Washer [gal/day]	Dishwasher [gal/day]	Total [gal/day]	% Shower
0	600	18.3 (9.2)	12.8 (11.6)	0.9 (0.8)	17.9 (3.9)	1.1 (1.1)	51 (26.6)	25% (44%)
1	780	19.9 (10.0)	15.5 (14.5)	1.4 (1.3)	19.1 (4.2)	1.3 (1.3)	57.2 (31.3)	27% (46%)
2	960	23.6 (11.8)	21.4 (20.5)	2.6 (2.5)	26.9 (5.9)	1.8 (1.8)	76.3 (42.5)	28% (48%)
3	1160	25.5 (12.7)	25.3 (24.8)	3.9 (3.8)	26.5 (5.8)	1.8 (1.8)	83 (48.9)	30% (51%)
4	1380	33.0 (16.5)	32.8 (33.1)	3.7 (3.8)	32.0 (7.0)	2.3 (2.3)	103.8 (62.7)	32% (53%)
5	1620	30.5 (15.3)	29.8 (30.8)	4.0 (4.1)	29.1 (6.4)	2.2 (2.2)	95.6 (58.8)	31% (52%)

Source: "California Residential Domestic Hot Water Draw Profiles", <http://www.bwilcox.com/BEES/reference.html>



Annual Gas Savings [therms/yr] (preliminary; 3"ø, 46.6% effectiveness)

	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Equal Flow																
1BR	17.5	15.7	15.8	15.0	16.2	14.3	14.1	13.6	13.6	13.5	13.6	14.5	13.4	13.8	9.4	17.2
2BR	20.4	18.3	18.4	17.5	18.9	16.6	16.3	15.9	15.8	15.7	15.9	16.9	15.6	16.1	10.9	20.0
3BR	22.9	20.6	20.7	19.6	21.2	18.7	18.4	17.8	17.8	17.6	17.9	19.0	17.5	18.1	12.4	22.5
4BR	26.1	23.4	23.5	22.3	24.1	21.3	20.9	20.3	20.2	20.0	20.4	21.6	19.9	20.6	14.0	25.6
5BR	29.7	26.7	26.9	25.5	27.5	24.3	23.9	23.1	23.1	22.9	23.2	24.7	22.8	23.5	16.0	29.2
MF	60.8	54.5	54.8	52.0	56.2	49.6	48.7	47.3	47.1	44.6	45.3	48.1	44.4	45.9	31.2	57.1
Unequal Flow to WH																
1BR	16.3	14.5	14.6	13.8	15.0	13.1	12.9	12.4	12.4	12.3	12.5	13.3	12.2	12.6	8.3	16.0
2BR	19.0	16.9	17.0	16.1	17.5	15.3	15.0	14.5	14.4	14.3	14.5	15.5	14.2	14.7	9.7	18.6
3BR	21.4	19.0	19.1	18.1	19.6	17.2	16.9	16.3	16.3	16.1	16.4	17.5	16.0	16.6	11.0	21.0
4BR	24.3	21.7	21.8	20.6	22.4	19.5	19.2	18.6	18.5	18.3	18.7	19.9	18.3	18.9	12.5	23.9
5BR	27.8	24.8	24.9	23.6	25.6	22.4	21.9	21.2	21.2	21.0	21.4	22.8	20.9	21.7	14.3	27.3
MF	57.3	51.1	51.4	48.6	52.7	46.1	45.3	43.8	43.7	41.3	42.1	44.8	41.1	42.6	28.2	53.8
Unequal Flow to Showers																
1BR	11.3	10.4	10.5	10.1	10.7	9.7	9.6	9.3	9.3	9.2	9.3	9.8	9.1	9.3	6.7	11.0
2BR	13.2	12.2	12.3	11.8	12.5	11.3	11.2	10.9	10.9	10.8	10.8	11.4	10.6	10.9	7.8	12.9
3BR	14.9	13.8	13.8	13.3	14.1	12.8	12.6	12.3	12.3	12.1	12.2	12.9	12.0	12.3	8.9	14.5
4BR	17.0	15.7	15.8	15.1	16.1	14.6	14.4	14.0	14.0	13.9	13.9	14.7	13.7	14.1	10.1	16.6
5BR	19.6	18.1	18.2	17.4	18.5	16.8	16.5	16.1	16.1	15.9	16.0	16.9	15.7	16.2	11.6	19.1
MF	40.5	37.3	37.5	35.9	38.2	34.6	34.1	33.3	33.1	31.4	31.6	33.3	31.0	31.9	22.8	37.8



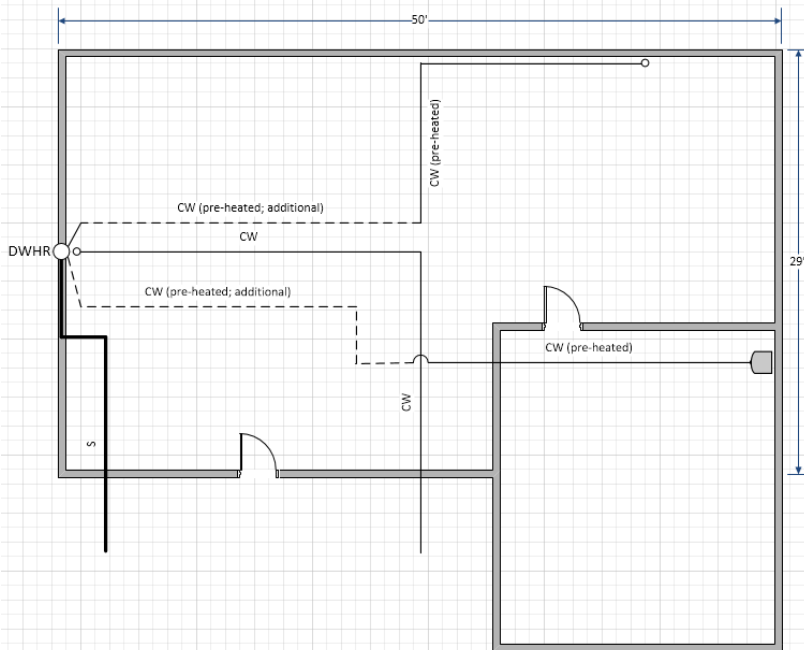
Ratio of Unequal to Equal Savings (preliminary; 3"ø, 46.6% effectiveness)

	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Unequal Flow to WH / Equal Flow																
1BR	93%	92%	92%	92%	93%	92%	92%	91%	91%	91%	91%	92%	91%	92%	89%	93%
2BR	93%	92%	92%	92%	93%	92%	92%	91%	91%	91%	92%	92%	91%	92%	89%	93%
3BR	93%	92%	93%	92%	93%	92%	92%	91%	91%	91%	92%	92%	91%	92%	89%	93%
4BR	93%	93%	93%	92%	93%	92%	92%	92%	92%	91%	92%	92%	92%	92%	89%	93%
5BR	93%	93%	93%	92%	93%	92%	92%	92%	92%	92%	92%	92%	92%	92%	89%	93%
MF	94%	94%	94%	93%	94%	93%	93%	93%	93%	93%	93%	93%	93%	93%	90%	94%
Unequal Flow to Showers / Equal Flow																
1BR	65%	66%	66%	67%	66%	68%	68%	69%	69%	69%	68%	67%	68%	68%	71%	64%
2BR	65%	67%	67%	67%	66%	68%	68%	69%	69%	69%	68%	68%	68%	68%	72%	64%
3BR	65%	67%	67%	68%	66%	68%	69%	69%	69%	69%	68%	68%	68%	68%	72%	65%
4BR	65%	67%	67%	68%	67%	69%	69%	69%	69%	69%	68%	68%	69%	68%	72%	65%
5BR	66%	68%	68%	68%	67%	69%	69%	70%	70%	70%	69%	69%	69%	69%	72%	65%
MF	67%	68%	68%	69%	68%	70%	70%	70%	70%	70%	70%	69%	70%	69%	73%	66%

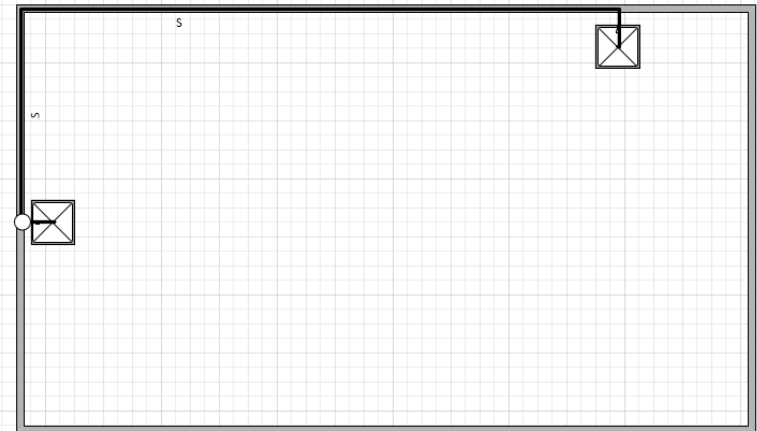


Example DWHR Piping Diagram for 2-story Single-Family (preliminary)

Two-Story Prototype Floor Plan – 1st Floor



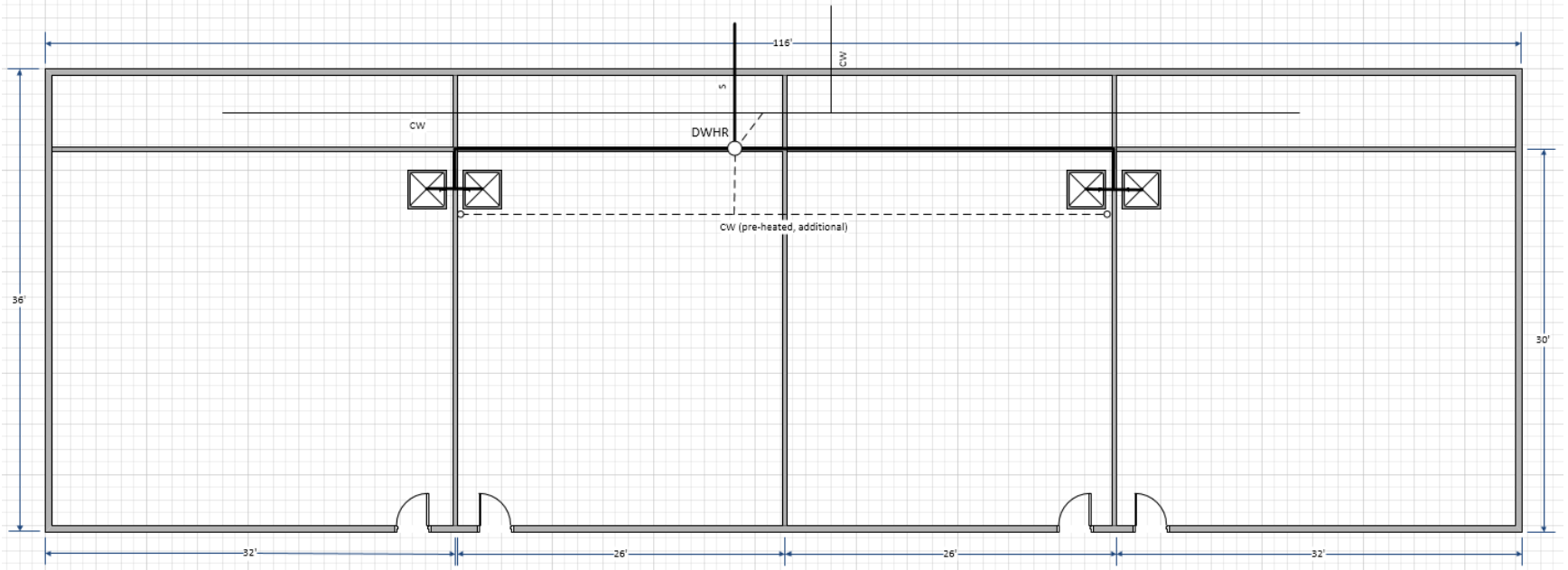
Two-Story Prototype Floor Plan – 2nd Floor





Example DWHR Piping Diagram for Multifamily (preliminary)

Multifamily Prototype Floor Plan – 2nd Floor





Cost (preliminary)

Item	Prototype 2700, 3" ø	Prototype 2700, 2" ø	Prototype 6960, 3" ø
DWHR size	3"x48"	2"x60"	3"x48"
DWHR Unit Price	\$400.00	\$325.00	\$400.00
(60') of ¾" PEX	\$55.20	\$55.20	\$55.20
(8) PEX couplings	\$5.76	\$5.76	\$5.76
ABS couplings	\$3.46	\$3.46	\$3.46
Labor	\$108.37	\$108.37	\$108.37
Plumbing Overhead and Profit	\$118.13	\$118.13	\$118.13
Sales Tax @ 8% of materials	\$37.15	\$31.15	\$37.15
Location Adjustment Factor markup	\$43.21	\$43.21	\$43.21
Total Cost	\$771.28	\$690.28	\$771.28



Benefit/Cost (preliminary; 3"ø, 46.6% effectiveness)

	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Equal Flow																
1BR	0.78	0.70	0.70	0.67	0.72	0.64	0.62	0.61	0.61	0.60	0.61	0.65	0.60	0.63	0.43	0.77
2BR	0.91	0.82	0.82	0.78	0.84	0.75	0.72	0.71	0.71	0.71	0.72	0.76	0.71	0.73	0.50	0.91
3BR	1.02	0.92	0.93	0.88	0.95	0.84	0.81	0.80	0.80	0.80	0.81	0.86	0.80	0.83	0.57	1.02
4BR	1.16	1.04	1.05	1.00	1.07	0.95	0.92	0.91	0.91	0.90	0.92	0.97	0.90	0.94	0.64	1.15
5BR	1.33	1.20	1.20	1.14	1.23	1.09	1.05	1.04	1.04	1.03	1.05	1.11	1.03	1.07	0.74	1.32
MF	2.71	2.44	2.45	2.33	2.50	2.23	2.15	2.13	2.12	2.02	2.05	2.16	2.01	2.09	1.44	2.58
Unequal Flow to WH																
1BR	0.72	0.65	0.65	0.62	0.67	0.59	0.57	0.56	0.56	0.55	0.56	0.60	0.55	0.57	0.38	0.72
2BR	0.85	0.76	0.76	0.72	0.78	0.69	0.66	0.65	0.65	0.65	0.66	0.70	0.65	0.67	0.45	0.84
3BR	0.95	0.85	0.86	0.81	0.88	0.77	0.75	0.74	0.74	0.73	0.74	0.79	0.73	0.76	0.51	0.95
4BR	1.08	0.97	0.97	0.92	0.99	0.88	0.85	0.83	0.83	0.83	0.84	0.89	0.83	0.86	0.58	1.08
5BR	1.24	1.11	1.11	1.06	1.14	1.01	0.97	0.96	0.96	0.95	0.97	1.03	0.95	0.99	0.66	1.24
MF	2.55	2.29	2.29	2.18	2.35	2.07	2.00	1.97	1.97	1.87	1.90	2.02	1.86	1.94	1.30	2.43
Unequal Flow to Showers																
1BR	0.50	0.46	0.47	0.45	0.47	0.43	0.42	0.42	0.42	0.41	0.42	0.44	0.41	0.42	0.31	0.49
2BR	0.59	0.55	0.55	0.53	0.56	0.51	0.49	0.49	0.49	0.49	0.49	0.51	0.48	0.50	0.36	0.58
3BR	0.66	0.62	0.62	0.59	0.63	0.57	0.56	0.55	0.55	0.55	0.55	0.58	0.54	0.56	0.41	0.66
4BR	0.76	0.70	0.70	0.68	0.72	0.65	0.63	0.63	0.63	0.62	0.63	0.66	0.62	0.64	0.46	0.75
5BR	0.87	0.81	0.81	0.78	0.83	0.75	0.73	0.73	0.72	0.72	0.72	0.76	0.71	0.73	0.53	0.86
MF	1.80	1.67	1.67	1.61	1.70	1.55	1.51	1.49	1.49	1.42	1.42	1.50	1.40	1.45	1.05	1.70



DWHR in CPC 2016

1.1.4 Appendices. Provisions contained in the appendices of this code shall not apply unless specifically adopted by a state agency or adopted by a local enforcing agency in compliance with Health and Safety Code Section 18901 et seq. for Building Standards Law, Health and Safety Code Section 17950 for State Housing Law and Health and Safety Code Section 13869.7 for Fire Protection Districts. See Section 1.1.8 of this code.

CALIFORNIA PLUMBING CODE – MATRIX ADOPTION TABLE APPENDIX L - SUSTAINABLE PRACTICES

(Matrix Adoption Tables are non-regulatory, intended only as an aid to the code user. See Chapter 1 for state agency authority and building applications.)

Adopting Agency	BSC	BSC-CG	SFM	HCD			DSA			OSHDP				BSCC	DPH	AGR	DWR	CA	CEC	SL	SLC
				1	2	1-AC	AC	SS	SS/C	1	2	3	4								
Adopt Entire Chapter																					
Adopt Entire Chapter as amended (amended sections listed below)																					
Adopt only those sections that are listed below																					
Chapter/Section																					

This state agency does not adopt sections identified with the following symbol: †

The Office of the State Fire Marshal's adoption of this chapter or individual sections is applicable to structures regulated by other state agencies pursuant to Section 1.11.

L 606.0 Drain Water Heat Exchangers.

L 606.1 General. Drain water heat exchangers shall comply with IAPMO PS 92. The heat exchanger shall be accessible.



Senate Bill 7

Secure | https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB7



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SB-7 Housing: water meters: multiunit structures. (2015-2016)

Text	Votes	History	Bill Analysis	Today's Law As Amended ⓘ	Compare Versions	Status	Comments To Author
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Senate Bill No. 7

CHAPTER 623



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Author Contact:

bo@negawattconsult.com

(619) 309-4191