CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Residential Water Heater
Drain Water Heat Recovery (DWHR)

March 23, 2017

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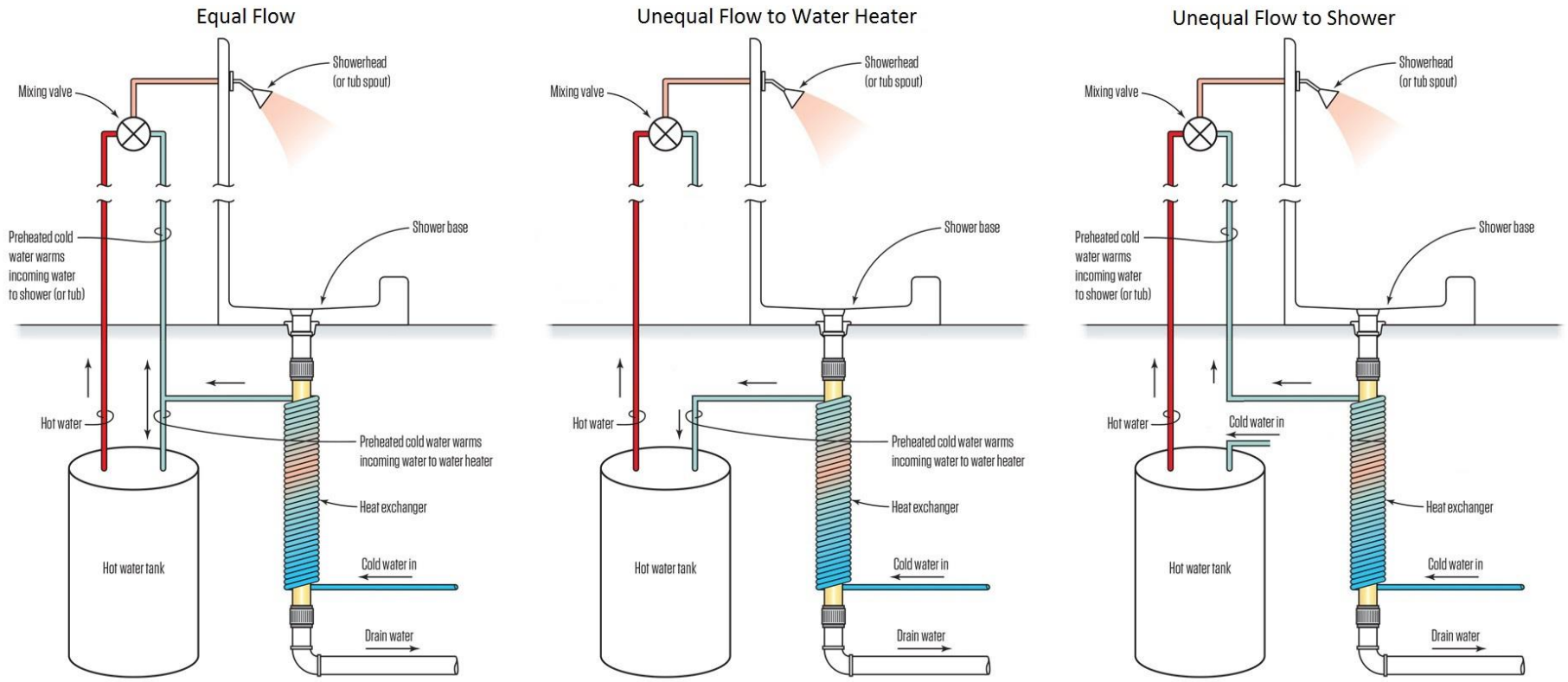
Los Angeles Department of Water & Power | SMUD | SDGE A Sempra Energy utility | SoCalGas A Sempra Energy utility | Southern California Edison An EDISON INTERNATIONAL Company | Pacific Gas and Electric Company

1. Background

Introduction to DWHR



Source: Journal of Light Construction, September 2016 (edited)

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Relevant Code History

- Not yet included in Title 24, Part 6
- Other Relevant Code Requirements
  - CSA B55.1
  - CSA B55.2
  - IAPMO PS 92
  - CPC Appendix L 606.1
  - Senate Bill 7

Source: DEG/PG&E

What do you think?

- Do you understand DWHR and how it saves energy?
- What do you expect will be the challenges to adoption in CA?

2. Proposed Code Changes

Proposed Code Change

- High-level description of the proposed code change includes:
  - Prescriptive compliance options
  - Buildings types impacted: low-rise residential
  - Does not apply to additions and alterations
  - Some differences in comparison to IECC and RESNET

Why Are We Proposing This Code Change

- Support ZNE goals
- Achieve significant energy savings
- Provide builders with flexible means of compliance

What do you think?

What about the proposed code changes?

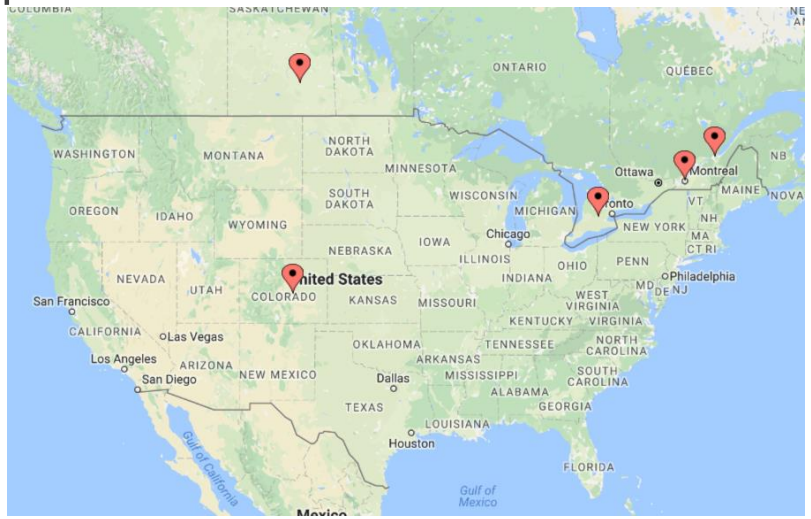
3. Technical and Market Barriers

Technical and Market Barriers

- Accurate Installation
  - Units installed at an angle can negatively impact performance
  - In practice, this is extremely rare
  - Manitoba and Ontario codes stipulate “no more than five degrees from the vertical”
  - Training is the solution, and training materials are available from manufacturers

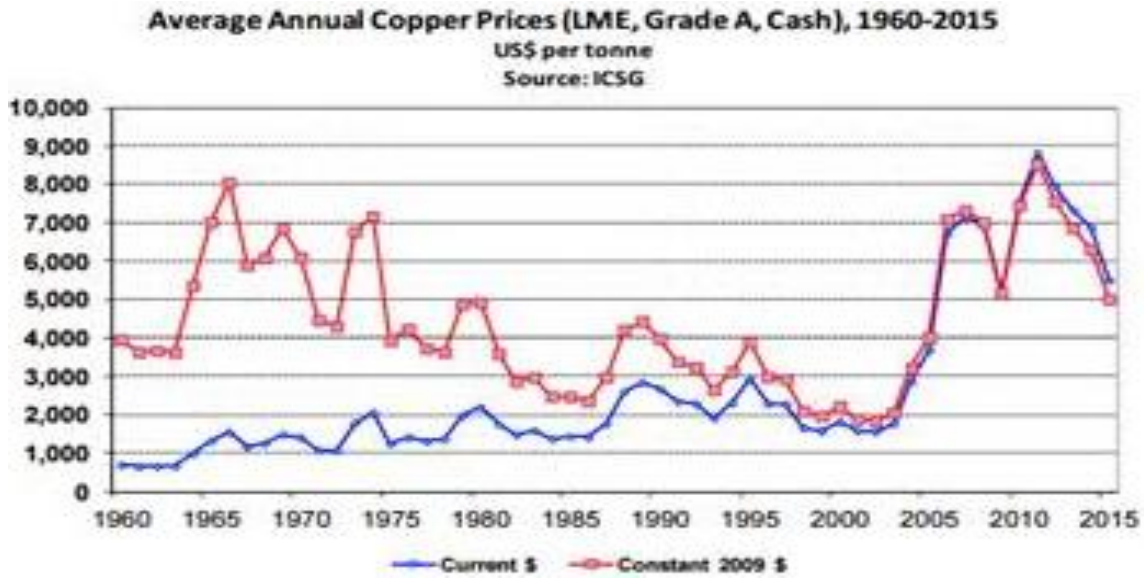
Technical and Market Barriers

- Product Availability
  - DWHR market is strong in Canada, namely Ontario
  - All products manufactured and shipped from Canada
  - U.S. consumers can purchase online through Home Depot
  - Minimal concern over product availability
  - Manufacturers able to forecast and prepare for expanded markets in the U.S. and Canada
  - Two of four manufacturers considering U.S. manufacturing facilities



Technical and Market Barriers

- Product Cost Variability
  - Copper prices fluctuate over time, relatively low in 2017
  - Wide variation in installation costs was documented by industry
  - Small changes in costs can impact viability as a compliance option
  - Contractors and builders can cut costs by purchasing in bulk
  - Industry notes that theft increases as copper prices rise



What do you think?

- Did we capture technical and market barriers accurately?
- Are there barriers that we didn't identify?
- Can you think of other solutions to address the barriers?

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase?
  - DWHR incorporated in the plumbing design layout
  - CSA certification considered and confirmed
  - DWHR equipment specified in the construction documents
  - DWHR inputted into energy software (performance path)

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - New lines added to a plumbing compliance form
  - DWHR discussion expected to take less than 10-minutes
  - Any additional permitting line items are expected to be included as part of the plumbing inspection
  - Updating the permitting forms will require minimal labor and expense

Compliance Process

Construction Phase

- What happens in construction phase?
  - DWHR installed simultaneously with the plumbing system
  - Connections to shower drain and cold water piping required
  - Product is left exposed for inspection
  - Installation by a licensed plumber usually takes less than two hours

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - Performed by either a home energy rater or building department staff as part of the plumbing inspection
  - No standardized field verification process in place
  - Modification of all forms is expected to be minimal
  - Inspector looks for manufacturer, model and performance certification information on product
  - Inspector runs shower and checks connections and looks for any leaks at the top and bottom of the DWHR unit

Compliance and Enforcement Barriers

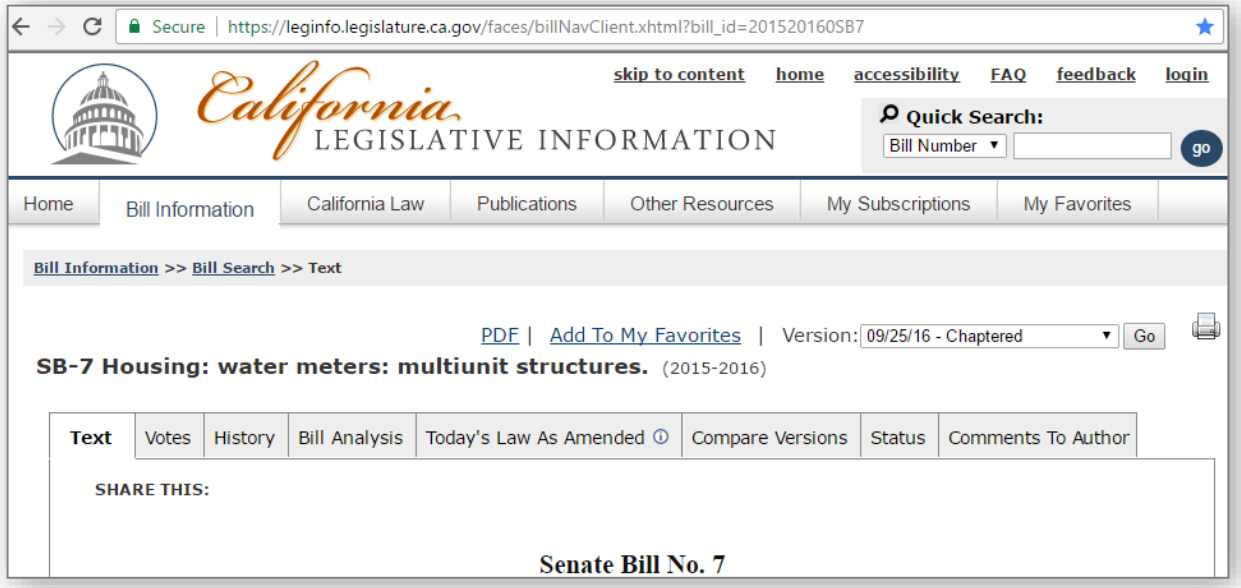
- Accessibility
  - Some local jurisdictions may require accessibility post-installation/occupancy
  - DWHR manufacturer reports of product failure are negligible

Compliance and Enforcement Barriers

- California Plumbing Code Appendix L, 606.1
  - Appendix L, 606.1 states “Drain water heat exchangers must comply with IAPMO PS 92. The heat exchanger shall be accessible.”
  - Manitoba and Ontario codes do not address accessibility
  - CSA B55.2 should be allowed as a substitute to IAPMO PS 92

Compliance and Enforcement Barriers

- Senate Bill 7
  - Creates new requirements for sub-metering of water usage per dwelling unit in multifamily buildings
  - Effective January 1, 2018
  - Could nullify cost-effectiveness in some multifamily buildings



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Compliance and Enforcement Barriers

- Coordination needed from design through final inspection phase
  - Design and construction teams need to coordinate drain piping layout, DWHR configuration, and DWHR make/model to eliminate any modifications that could reduce ultimate energy savings

Compliance and Enforcement Barriers

- Local Building Department Impact
  - The added time for permitting and inspection, although minor overall, may be burdensome for some local building departments with limited staff and resources
  - Additional training will most likely be provided at the expense of utilities or DWHR manufacturers themselves

What do you think?

- Did we capture compliance and enforcement barriers accurately?
- Are there barriers that we didn't identify?
- Can you think of other solutions to address the barriers?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2016 Standards
- 2,700 ft^2 and 6,960 ft^2 residential prototypes
- 8760 operating hours
- 16 climate zones
- 115 ^{0}F at hot-side of shower valve
- CBECC-Res hot water schedules
- Hourly weather dependent cold water temperatures

Proposed Conditions

- Lab derived DWHR effectiveness algorithms
- 46.6% CSA rated effectiveness
- All shower fixtures in single family prototype located on the 2nd floor and connected to one device in equal flow configuration
- All shower fixtures on the 2nd floor of the multifamily prototype connected to one device in unequal to shower configuration
- No water meters included

Prototypes

Figure A-4: Two-Story Prototype Front View

Figure A-5: Two-Story Prototype Back View

Figure A-8: Multifamily Prototype Front View

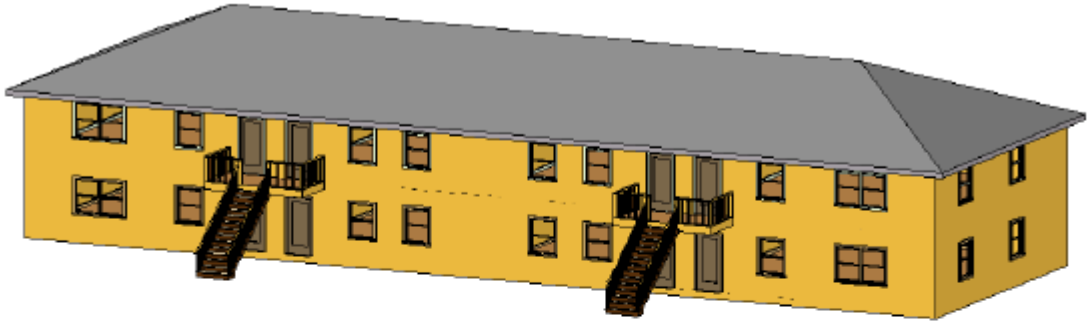
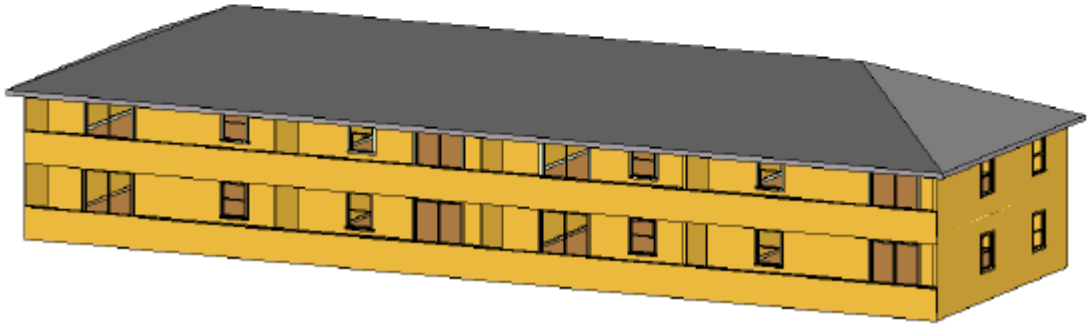
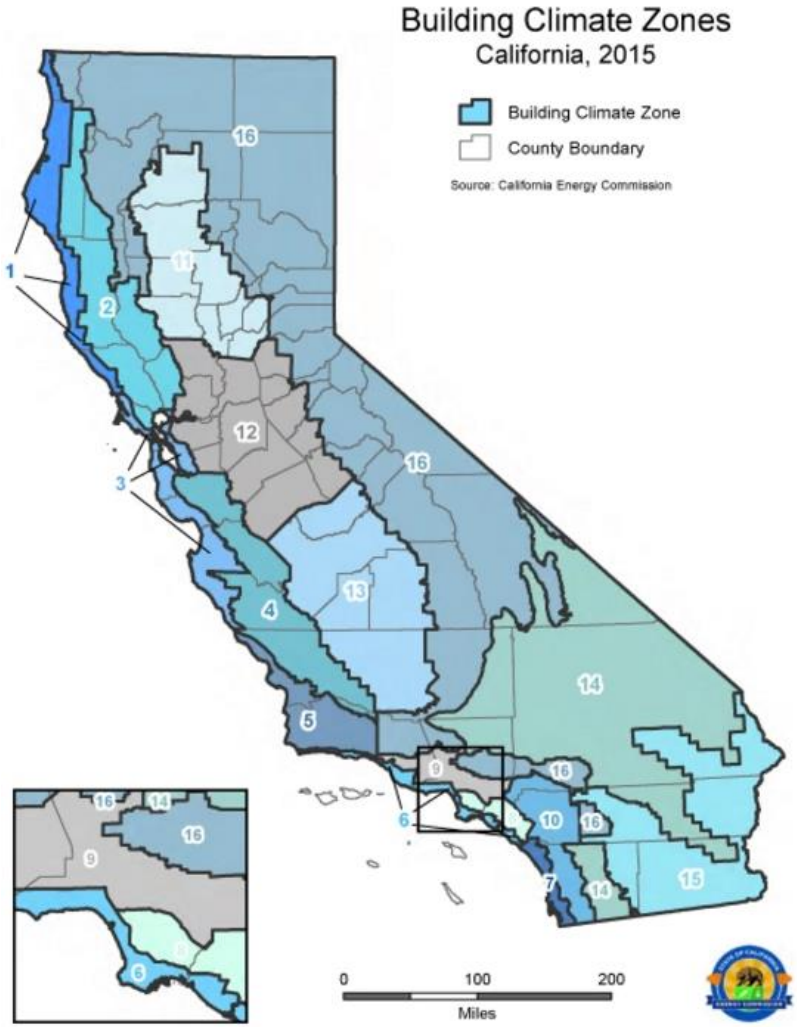


Figure A- 9: Multifamily Prototype Back View



Source: CEC, 2016 ACM Approval Manual

California Climate Zones



Source: CEC,
http://www.energy.ca.gov/maps/renewable/building_climate_zones.html

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Cost-Effectiveness Analysis

Cost Item	Prototype 2700, 2” ø	Prototype 2700, 3” ø	Prototype 6960, 3” ø
DWHR size	**2"x60"**	**3"x48"**	**3"x48"**
Incremental First Cost			
DWHR Unit Price	$325.00	$400.00	$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	$118.37	$118.37	$118.37
Plumbing Overhead and Profit	$100.63	$108.13	$108.13
Sales Tax @ 8% of materials	$31.15	$37.15	$37.15
Location Adjustment Factor markup	$42.31	$43.21	$43.21
Total Incremental First Cost	**$681.88**	**$771.28**	**$771.28**
Total Incremental Maintenance Cost	**$0.00**	**$0.00**	**$0.00**
Total Incremental Cost over 30 years	**$681.88**	**$771.28**	**$771.28**

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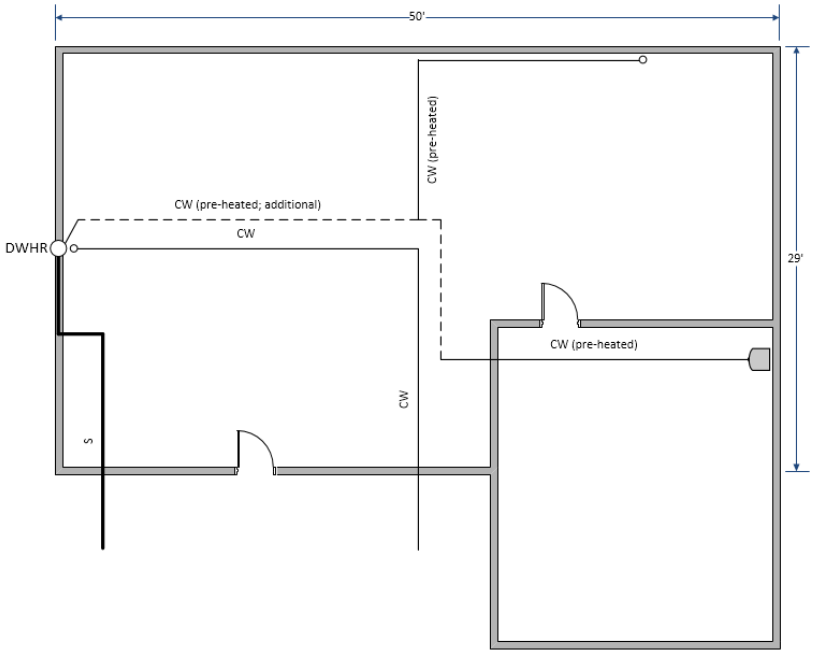
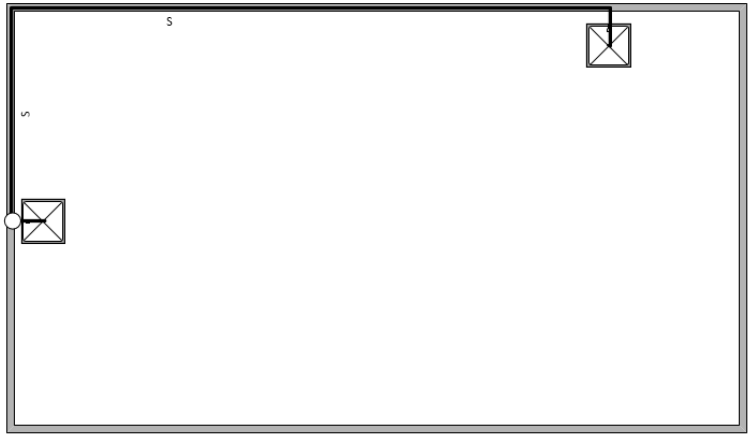
Note: Prototype 6960 does not include cost of water meters.

Example DWHR Piping Diagram for 2-story Single-Family Prototype

Two-Story Prototype Floor Plan – 1st Floor

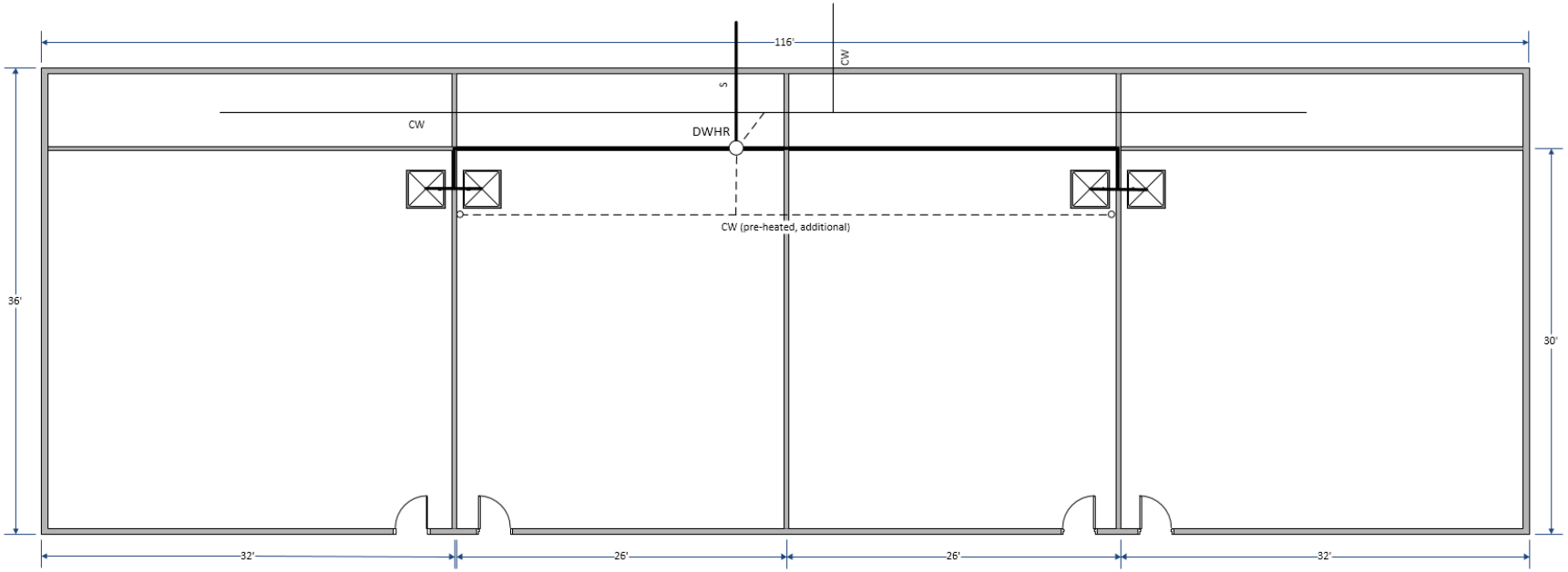


Two-Story Prototype Floor Plan – 2nd Floor



Example DWHR Piping Diagram for Multifamily Prototype

Multifamily Prototype Floor Plan – 2nd Floor



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Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits) over 30-year period of analysis

Prototype 2700 ft^2, Equal Flow, 2” diameter unit

- Total Energy Cost Savings = **$497 to $893** depending on climate zone
- Total Incremental Cost Savings (Benefit) = **-$185 to $212** depending on climate zone

Prototype 2700 ft^2, Equal Flow, 3” diameter unit

- Total Energy Cost Savings = **$497 to $893** depending on climate zone
- Total Incremental Cost Savings (Benefit) = **-$274 to $122** depending on climate zone

Prototype 6960 ft^2, Unequal to Shower, 3” diameter unit

- Total Energy Cost Savings = **$808 to $1389** depending on climate zone
- Total Incremental Cost Savings (Benefit) = **$36 to $618** depending on climate zone

Benefit-to-Cost Ratio

Climate Zone	B/C for Prototype 2700, Equal Flow, 2”ø	B/C for Prototype 2700, Equal Flow, 3”ø	B/C for Prototype 6960, Unequal to Showers, 3”ø
1	1.31	1.16	1.80
2	1.18	1.04	1.67
3	1.19	1.05	1.67
4	1.13	1.00	1.61
5	1.21	1.07	1.70
6	1.08	0.95	1.55
7	1.04	0.92	1.51
8	1.03	0.91	1.49
9	1.03	0.91	1.49
10	1.02	0.90	1.42
11	1.04	0.92	1.42
12	1.10	0.97	1.50
13	1.02	0.90	1.40
14	1.06	0.94	1.45
15	0.71	0.64	1.05
16	1.28	1.15	1.70

Note: Prototype 6960 does not include cost of water meters

Prototype 2700, Equal Flow, 2”ø

- Cost-effective in all CZs except 15

Prototype 2700, Equal Flow, 3”ø

- Cost-effective in CZs 1–5 and 16

Prototype 6890, Uneq. Shower, 3”ø

- Cost-effective in all climate zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective

Annual Energy Savings Per Prototype Building

Climate Zone	Prototype 2700; Equal Flow; 2”ø or 3”ø		Prototype 6960; Unequal to Shower; 3”ø	
	TDV Energy Savings (TDV kBtu/yr)	30 Year TDV Energy Cost Savings ($2020)	TDV Energy Savings (TDV kBtu/yr)	30 Year TDV Energy Cost Savings ($2020)
1	5,158	$893	8,021	$1,389
2	4,652	$806	7,416	$1,285
3	4,666	$808	7,445	$1,290
4	4,444	$770	7,152	$1,239
5	4,775	$827	7,583	$1,313
6	4,248	$736	6,915	$1,198
7	4,105	$711	6,709	$1,162
8	4,055	$702	6,654	$1,152
9	4,051	$702	6,642	$1,150
10	4,020	$696	6,303	$1,092
11	4,094	$709	6,339	$1,098
12	4,319	$748	6,662	$1,154
13	4,009	$694	6,237	$1,080
14	4,168	$722	6,441	$1,116
15	2,869	$497	4,664	$ 808
16	5,141	$890	7,577	$1,312

Annual Energy Savings Per Prototype Building

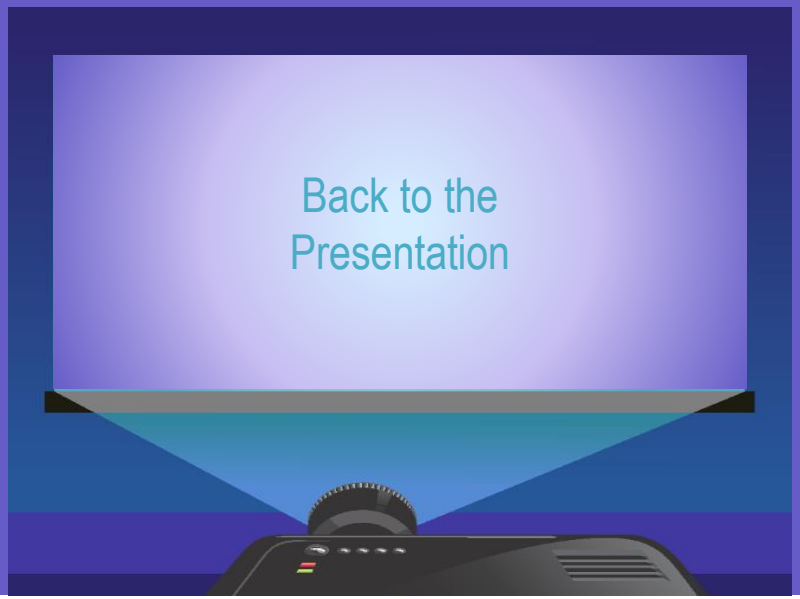
Climate Zone	Prototype 2700; Equal Flow; 2”ø or 3”ø Annual Natural Gas Savings (therms/yr)	Prototype 6960; Unequal to Shower; 3”ø Annual Natural Gas Savings (therms/yr)
1	26.1	40.5
2	23.4	37.3
3	23.5	37.5
4	22.3	35.9
5	24.1	38.2
6	21.3	34.6
7	20.9	34.1
8	20.3	33.3
9	20.2	33.1
10	20.0	31.4
11	20.4	31.6
12	21.6	33.3
13	19.9	31.0
14	20.6	31.9
15	14.0	22.8
16	25.6	37.8

What do you think?

What about cost savings?

Let's talk about…

Next Steps



6. Next Steps

Next Steps

- Please send any additional feedback within 2 weeks to:
  - CASE Author (see contact info at end of this presentation)
  - Info@title24stakeholders.com

- Keep an eye on Title24Stakeholders.com for:
  - Presentations from today's meeting
  - Draft Code Change Language
  - Notes from today's meeting
  - Draft CASE Report (will be posted in April)

Let's move on to…

Wrap Up

- **Bo White**
  NegaWatt Consulting
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- **George Burmeister,**
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Appendix:

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References

- Title24Stakeholders.com
- EnergyCodeAce.com
  - See Reference Ace for 2016 Standards, Appendices, and Compliance Manuals
- California Energy Commission 2019 Standards Webpage

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			OSHPD				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.

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 [ft²]	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 (49.0)**	**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 (63.0)**	**31% (55%)**

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

Number of Bedrooms	Assumed CFA [ft²]	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)	**51.0 (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)	**83.0 (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] (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 (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%

Benefit/Cost (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