

Comparing old vs. new data on estimated water use per bedroom in MF buildings

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ACEEE Hot Water Forum
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Overview

- First, does it matter?
- Focus and findings of several studies
- Use in modeling
- Variations across studies

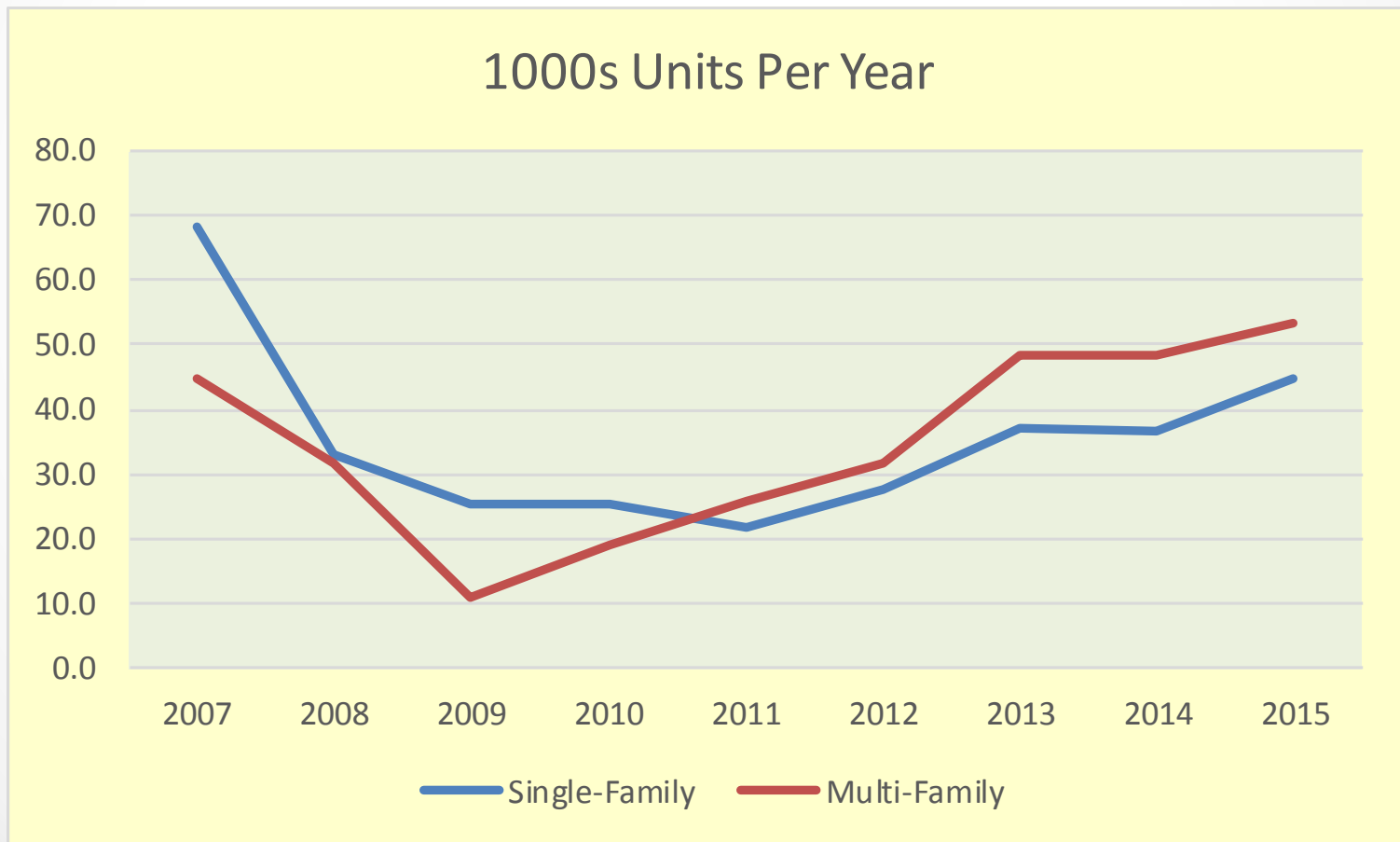
Yes, It Matters to Our Children & Grandchildren



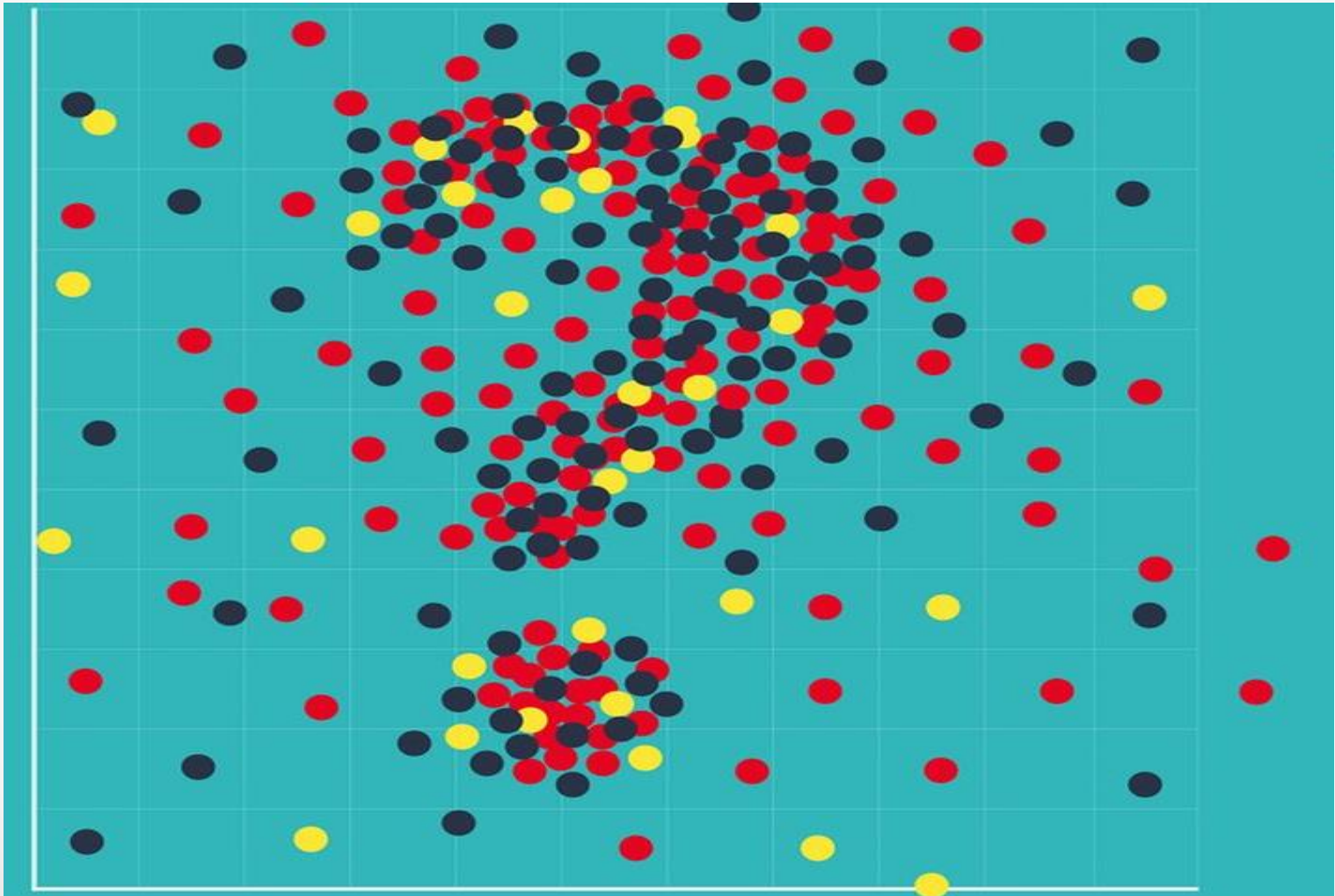
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Need and Purpose

Over ½ of residential new construction in California is MF

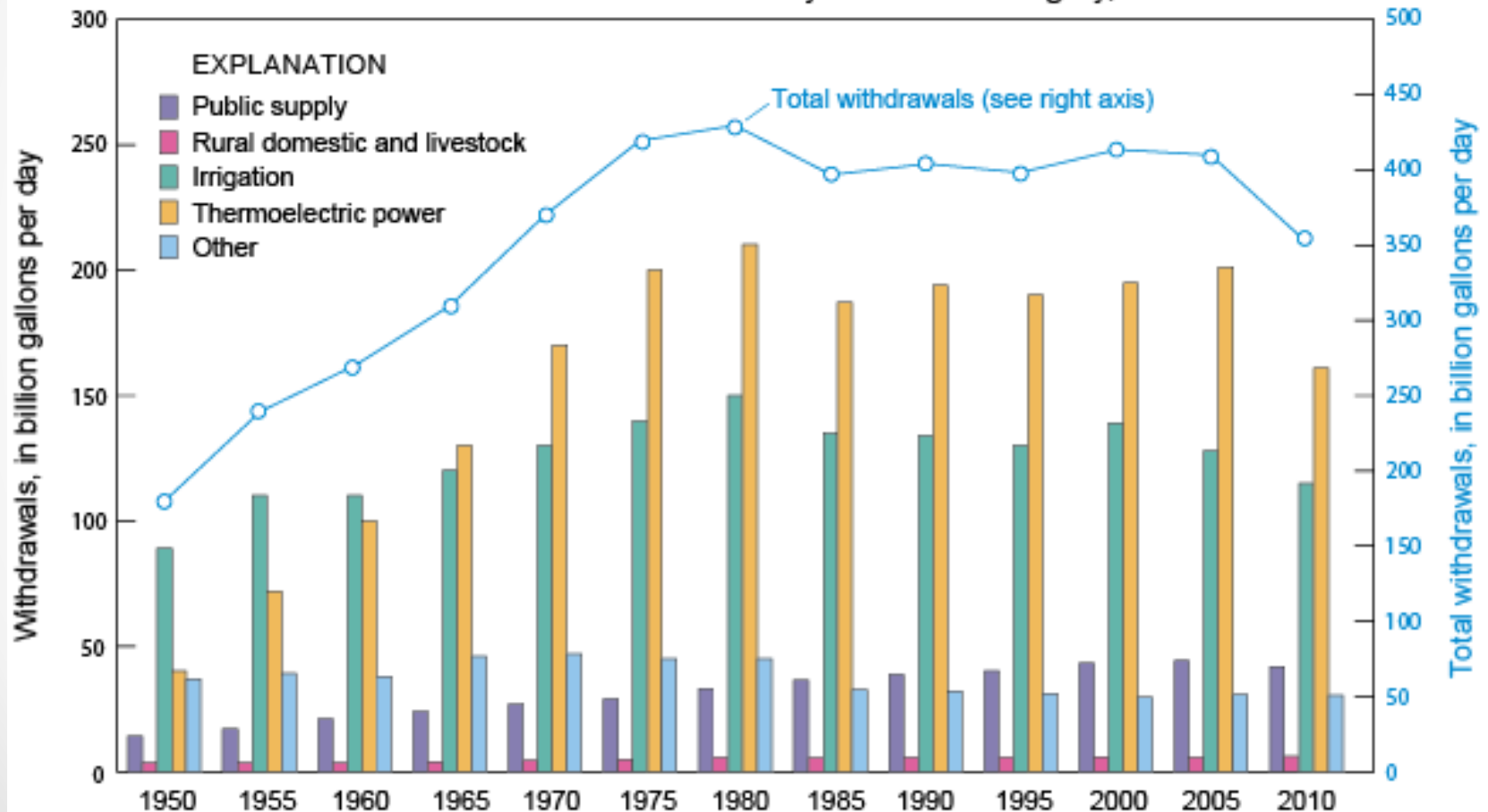


What Do the Data Show?



The Good News: Most Use is Trending Down

Trends in total water withdrawals by water-use category, 1950-2010



Test

- “On average, multifamily households use more water than single-family households...”
 - A. ...because they don't pay for it.
 - B. ...because they have more people per dwelling.
 - C. ...for unknown reasons.
 - D. ...for all of the above reasons.
 - E. The statement is not true.

Multifamily Focus

- According to studies done by Santa Barbara and Burbank (2009, 2011, respectively), water use in single-family households is 2.5 times the water use in multifamily households. 21% more even if you eliminate landscape water.
- But...
- Most studies lump single-family and multifamily in one category: Residential.
- Some studies have only looked at single-family water usage.



Partial List of Studies Cited

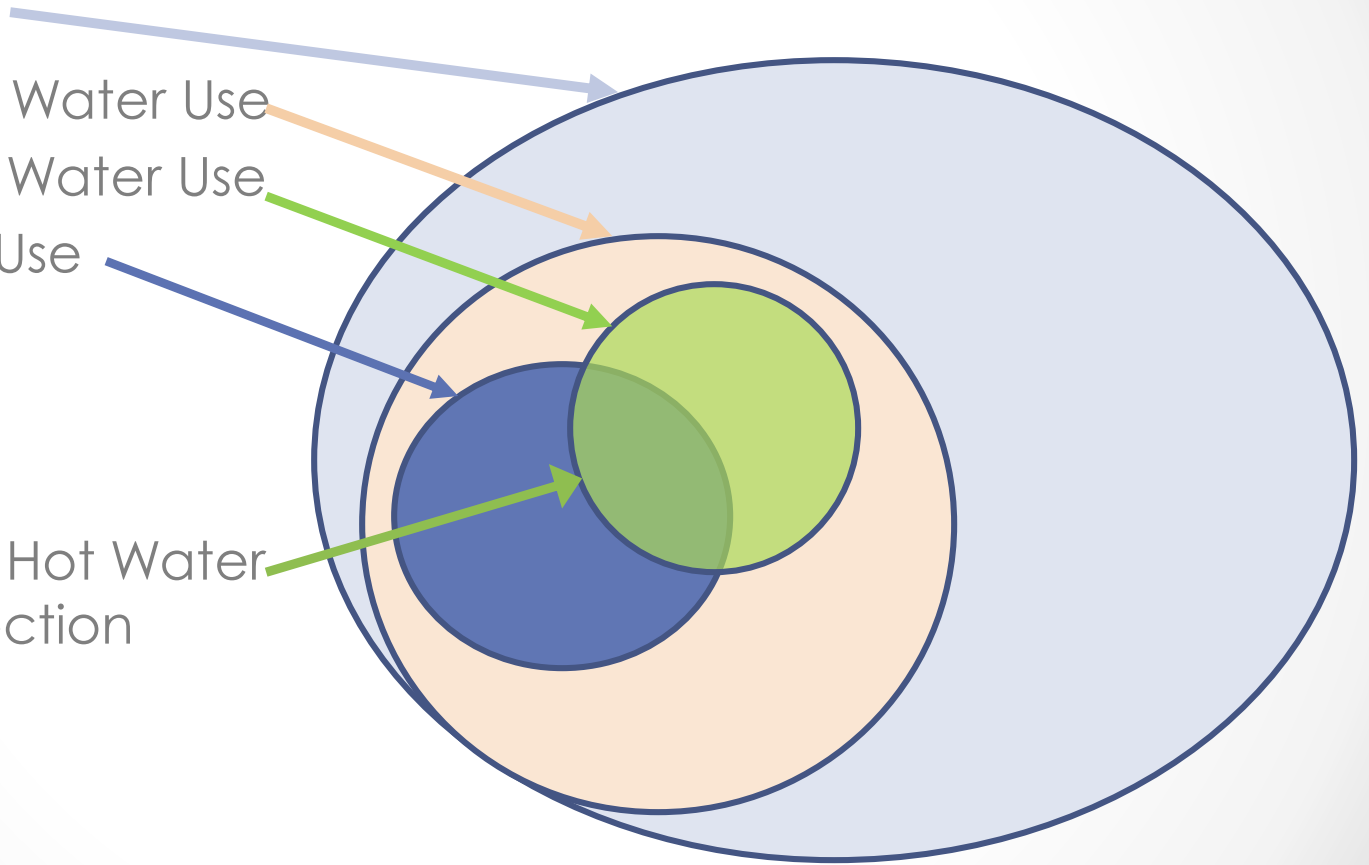
- CA Single-Family Water Use Study. Auquacraft. 2011
- Per Capita Daily Water Use Numbers. State Water Boards. 2014
- A Study of Individual Household Water Consumption. M. Borg, O. Edwards, S. Kimpel. 2012
- Urban Water Conservation and Efficiency Potential In California. Pacific Institute & NRDC. 2014
- Residential End Uses of Water. AWWA Research Fnd. 1999
- Description of 2005-2010 Domestic Water Use for Selected U.S. Cities... USGS. 2012
- Transforming Multifamily Housing. Fannie Mae. 2014
- Water Conservation: Overview of Retrofit Strategies, a Guide for Multifamily Owners and Managers. HUD 2002



Typology

- Water Use
- Residential Water Use
- Multifamily Water Use
- Hot Water Use

- Multifamily Hot Water
-the intersection



Goldner, 1992: MF DHW

The number of persons per apartment in the building set ranged from 1.5 to 3.4 people/apt, with an average of 2.2 people/apt. Using a per occupied apartment analysis, the levels differed by 3.8-fold **from a low of 52.57 to a high of 198.87 gallons per occupied apartment, the average being 115.46.**

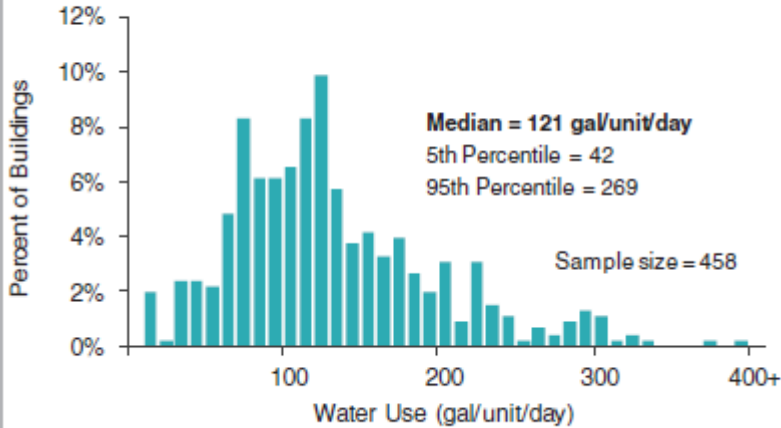
Table 4. Average Gallons of DHW Per Day

Monitored Data			ASHRAE ⁵	
Total Apts.	Per Capita	Per Occup. Apt.	# of Apts.	Per Apt.
23	49.70	72.29	20 or less	42.0
30	58.61	198.87		
34	45.98	123.57		
49	76.44	166.18	50	40.0
60	40.42	74.45		
80	31.23	52.57	75	38.0
90	53.61	137.85		
102	54.92	109.85	100	37.0
Average	51.04	115.46		39.25

When population density is considered, the usage ranges from **31.23 to 76.44 gallons per capita, with an average of 51.04 gal/capita, a difference of 2.4-fold.**

There Is Obviously Variance by User, and by State

FIGURE 5: DISTRIBUTION OF WHOLE PROPERTY WATER USE (PER UNIT)



Source: Fannie Mae Multifamily Energy and Water Market Research Survey.

“The least efficient properties use over three times as much energy and **six times as much water** per square foot as the most efficient properties.”
Fannie Mae, 2014 study

California uses the most water, but this is total water use; not per capita and not just domestic use.

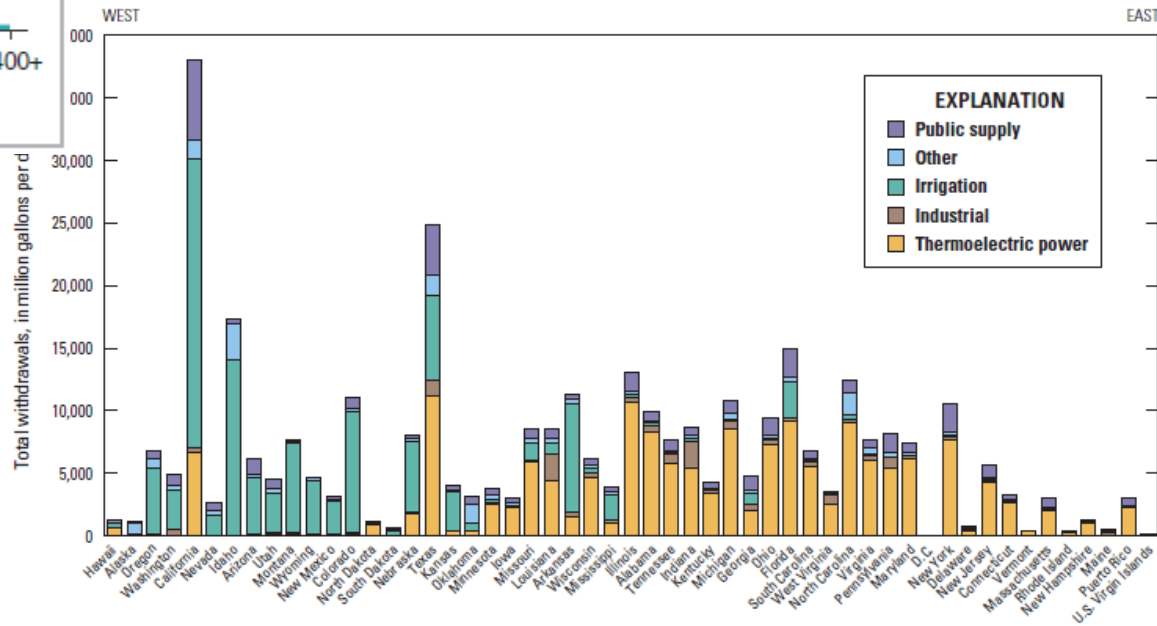


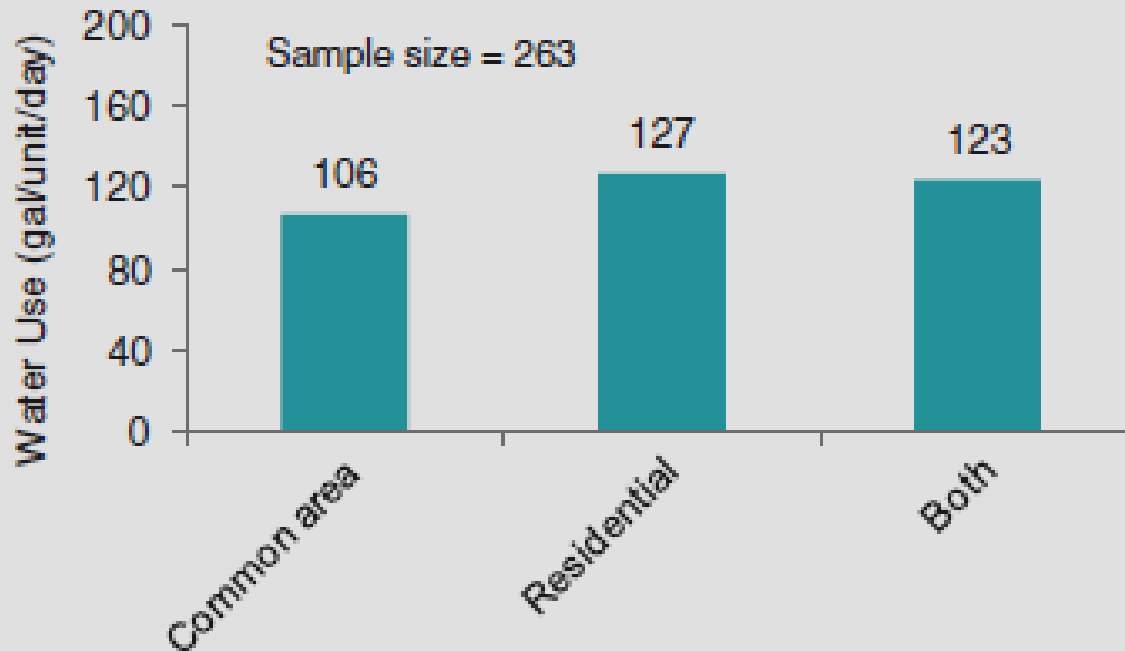
Figure 2. Total water withdrawals by State and barchart showing categories by State from west to east, 2010.

Domestic Water Use: Well vs Water Agency, and Variance by County - 2015

COUNTY	G/P/D		Well as % of Agency
	Well	Wtr Agency	
Fresno County	73	159	46%
Imperial County	32	115	28%
Los Angeles County	70	100	70%
Riverside County	58	159	36%
Sacramento County	37	141	26%
San Bernardino County	34	130	26%
San Diego County	75	98	77%
San Francisco County	N/A	52	N/A
San Joaquin County	70	117	60%
Santa Clara County	75	83	90%
Yolo County	74	134	55%
Average	67	122	55%

Sidebar on Laundry

FIGURE 48: WATER USE BY LAUNDRY HOOK-UP LOCATION



Source: Fannie Mae Multifamily Energy and Water Market Research Survey.

Providing in-unit laundry hook-ups increases water usage by 20% over common area laundry alone. Having both only saves 3% compared to in-unit only.

Domestic Water Per Person (Gallons/Person/Day)

Source: USGS Water Use Data 2010

Rank	State/Territory	Gal/Day/ Person
1	Wisconsin	51
2	Maine	55
3	Pennsylvania	59
4	U.S. Virgin Islands	60
5	Minnesota	62
6	Puerto Rico	62
7	Vermont	64
8	Iowa	65
9	Massachusetts	65
10	Ohio	66
11	Kentucky	67
12	New Hampshire	70
13	North Carolina	70
14	Rhode Island	72
15	Kansas	73
16	Connecticut	75
17	Virginia	75
18	Alabama	76
19	Indiana	76
20	Georgia	79
21	Michigan	79
22	New York	79
23	Delaware	80
24	Illinois	80
25	New Jersey	80
26	North Dakota	80
27	Tennessee	80
28	West Virginia	80
29	Oklahoma	85
30	Florida	87
31	Missouri	88
n.a.	TOTAL	88
32	Alaska	90
33	New Mexico	90
34	Texas	92
35	South Dakota	93
36	Nebraska	95
37	Mississippi	100
38	South Carolina	100
39	Maryland	103
40	Louisiana	104
41	Arkansas	106
42	Montana	107
43	California	108
44	Colorado	111
45	Washington	111
46	Oregon	113
47	District Of Columbia	125
48	Nevada	134
49	Hawaii	144
50	Wyoming	144
51	Arizona	147
52	Utah	167
53	Idaho	168

Domestic Water Per Person (Gallons/Person/Day)

Source: USGS Water Use Data 2010

Rank	State/Territory	Gal/Day/ Person
1	Wisconsin	51
2	Maine	55
3	Pennsylvania	59
...
15	Kansas	73
16	Connecticut	75
...
21	Michigan	79
22	New York	79
...
29	Oklahoma	85
30	Florida	87
31	Missouri	88
n.a.	TOTAL	88
32	Alaska	90
33	New Mexico	90
34	Texas	92
...
43	California	108
44	Colorado	111
45	Washington	111
46	Oregon	113
...
51	Arizona	147
52	Utah	167
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HUD 2002

NON-CONSERVING

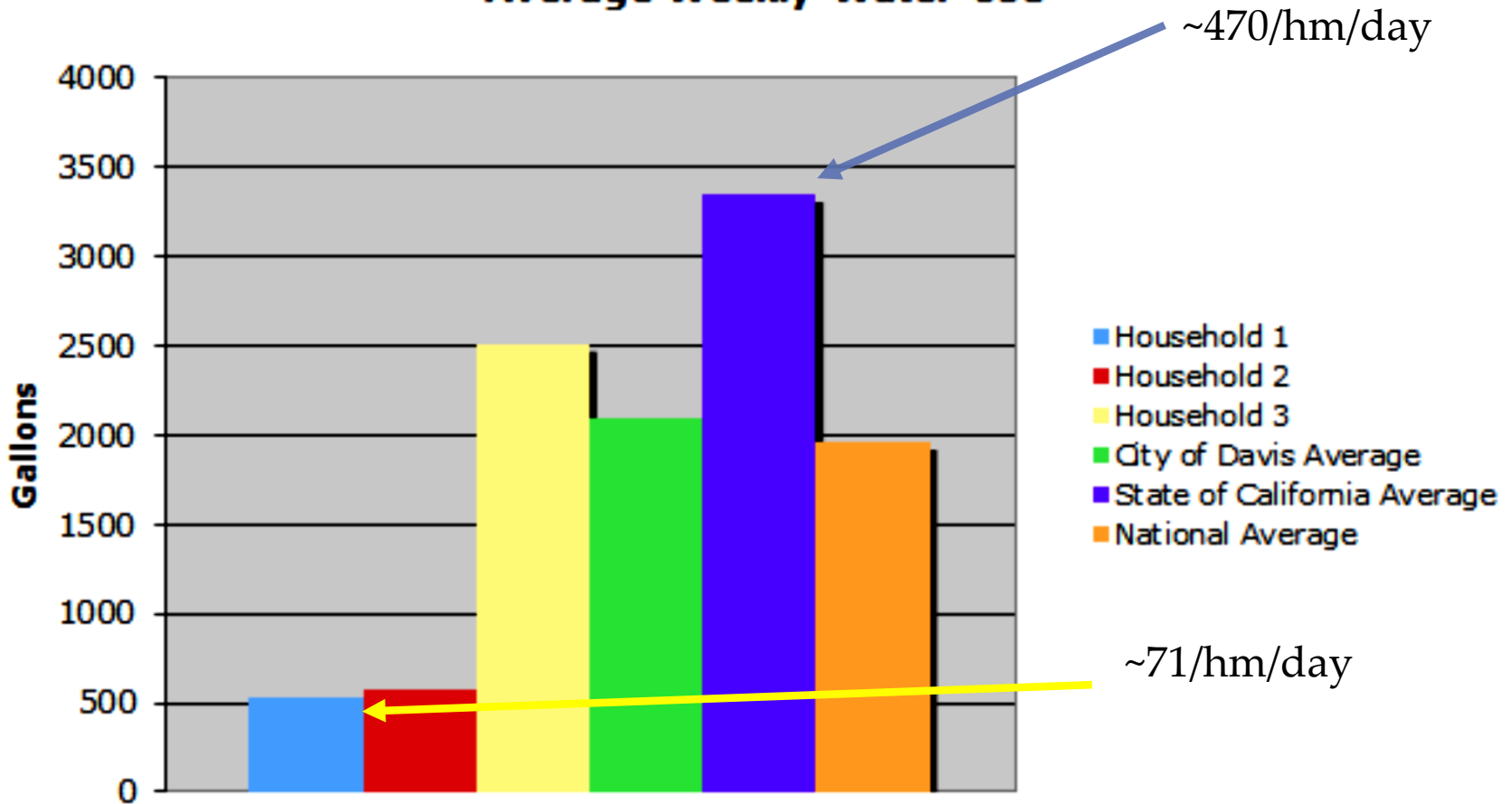
Fixture	GPCD
<i>Tollet</i>	<i>14.0</i>
<i>Faucets</i>	<i>14.0</i>
<i>Shower</i>	<i>11.3</i>
<i>Clothes Washer</i>	<i>12.0</i>
<i>Dishwasher</i>	<i>1.0</i>
<i>Leaks</i>	<i>3.4</i>
	<hr/>
<i>Total</i>	<i>55.7</i>

CONSERVING

<i>Tollet</i>	<i>8.0</i>
<i>Faucets</i>	<i>10.5</i>
<i>Shower</i>	<i>6.8</i>
<i>Clothes Washer</i>	<i>7.5</i>
<i>Dishwasher</i>	<i>0.5</i>
	<hr/>
<i>Total</i>	<i>33.3</i>

Davis Study

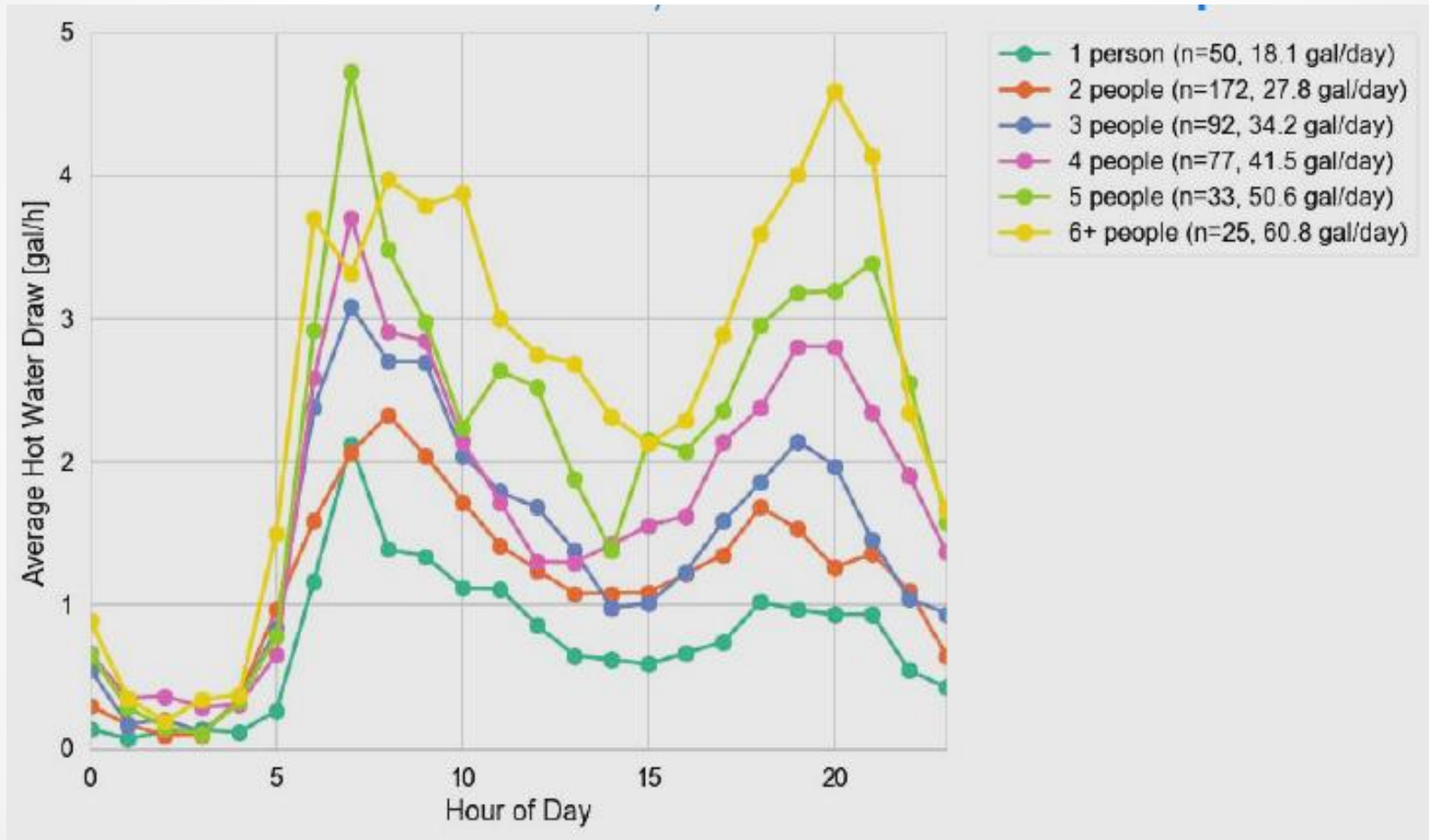
Average Weekly Water Use



Wilcox study for 2016 Title 24: Relating Occupants to Bedrooms

Weighted fraction of single family units by occupants and bedrooms						
	Number of Bedrooms					
Occupants	1	2	3	4	5	6
1	0.42	0.26	0.14	0.07	0.06	0.06
2	0.33	0.39	0.37	0.28	0.17	0.17
3	0.10	0.14	0.18	0.17	0.14	0.14
4	0.12	0.08	0.16	0.27	0.23	0.23
5	0.02	0.07	0.08	0.13	0.17	0.17
6	0.00	0.03	0.04	0.04	0.12	0.12
7	0.00	0.00	0.01	0.02	0.06	0.06
8	0.00	0.01	0.00	0.01	0.01	0.01

Wilcox study for 2016 Title 24: Hot Water Use Per Person



Summary of Estimates

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
1992	F. Golder	NYC MF	Indoor	DHW	115.5	51
1997	REUWS (CA)	SF	Indoor	All water	186	
1999	AWWA	SF and MF	Indoor	All water		72.6
2000	EPA Post Rtrft.	SF	Indoor	All water	107	
2002	US HUD	MF AH	Indoor	All water		55.7
2004	Aquacraft	SF and MF	Indoor + Outdoor	All water	146	
2004	EBMUD	SF	Indoor	All water		65
2009	Burbank, CA	MF	Indoor + Outdoor	All water		33
2009	Santa Barbara	MF	Indoor + Outdoor	All water	142	
2010	USGS	SF + MF	Indoor + Outdoor	All water		108-113*
2011	Aquacraft	SF only	Indoor	All water	175	
2012	Davis, CA	SF ony	Indoor	All water	172	34.4
2012	USGS	SF + MF	Indoor + Outdoor	All water		43 - 177
2013	CA Water Plan	SF + MF	Indoor + Outdoor	All water		63.5
2014	Phoenix, AZ	MF	Indoor	All water	166 - 169	
2014	USGS	SF + MF	Indoor + Outdoor	All water		88
2014	Fannie Mae	MF	Indoor + Outdoor	All water	121	
2014	CA Water Boards	SF + MF	Indoor + Outdoor	All water		85-252
2015	Wilcox/Lutz	SF + MF	Indoor	DHW	18 - 61	18**
2016	WRF	SF	Indoor	DHW	45.5	
• 2016	WRF	SF	Indoor	All water	138	•

All Residential – All Water

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
2004	Aquacraft	SF and MF	Indoor + Outdoor	All water	146	
2010	USGS	SF + MF	Indoor + Outdoor	All water		108-113*
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*	Data are for CA, OR, WA					

Singe-Family Indoor Use

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
1997	REUWS (CA)	SF	Indoor	All water	186	
2000	EPA Post Rtrft.	SF	Indoor	All water	107	
2004	EBMUD	SF	Indoor	All water		65
2011	Aquacraft	SF only	Indoor	All water	175	
2012	Davis, CA	SF ony	Indoor	All water	172	34.4

MF Indoor Water Use

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
2002	US HUD	MF AH	Indoor	All water		55.7
2014	Phoenix, AZ	MF	Indoor	All water	166 - 169	

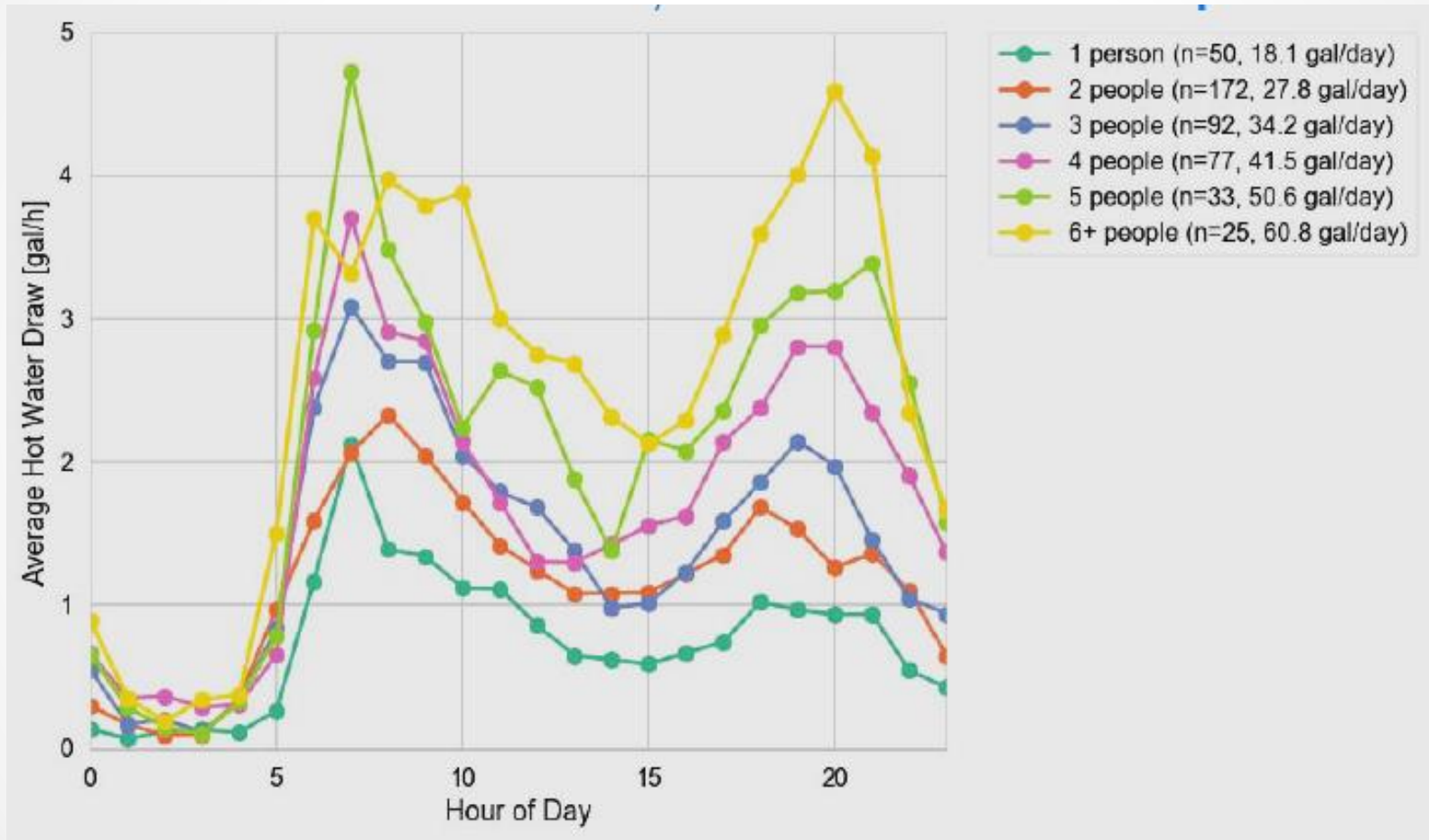
MF Indoor + Outdoor

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
2009	Burbank, CA	MF	Indoor + Outdoor	All water		33
2009	Santa Barbara	MF	Indoor + Outdoor	All water	142	
2014	Fannie Mae	MF	Indoor + Outdoor	All water	121	

Hot Water Only

Year	Study	Population	Indoor/Outdoor	All or DHW	Gal/Unit	Gal/Capita
1992	F. Golder	NYC MF	Indoor	DHW	115.5	51
2015	Wilcox/Lutz	SF + MF	Indoor	DHW	18 - 61	18**
2016	WRF	SF	Indoor	DHW	45.5	
**	For a 1-person household. As the household size increases DHW usage per person decreases; approaching 10 G/Person/Day for 5- and 6-person households.					

Wilcox study for 2016 Title 24: Hot Water Use Per Person



Current BIG/CEC Study

- 4 MF complexes with large HPs for hot water
- Extensive demographic information on occupants
- 1-year (2-years at one site) monitoring on hot and cold water usage, other electrical loads, AC, and heating
- Minute-level data
- kWh, kW, gallons, T-stat settings
- 2016 through 2020

Questions?

Thank you!

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