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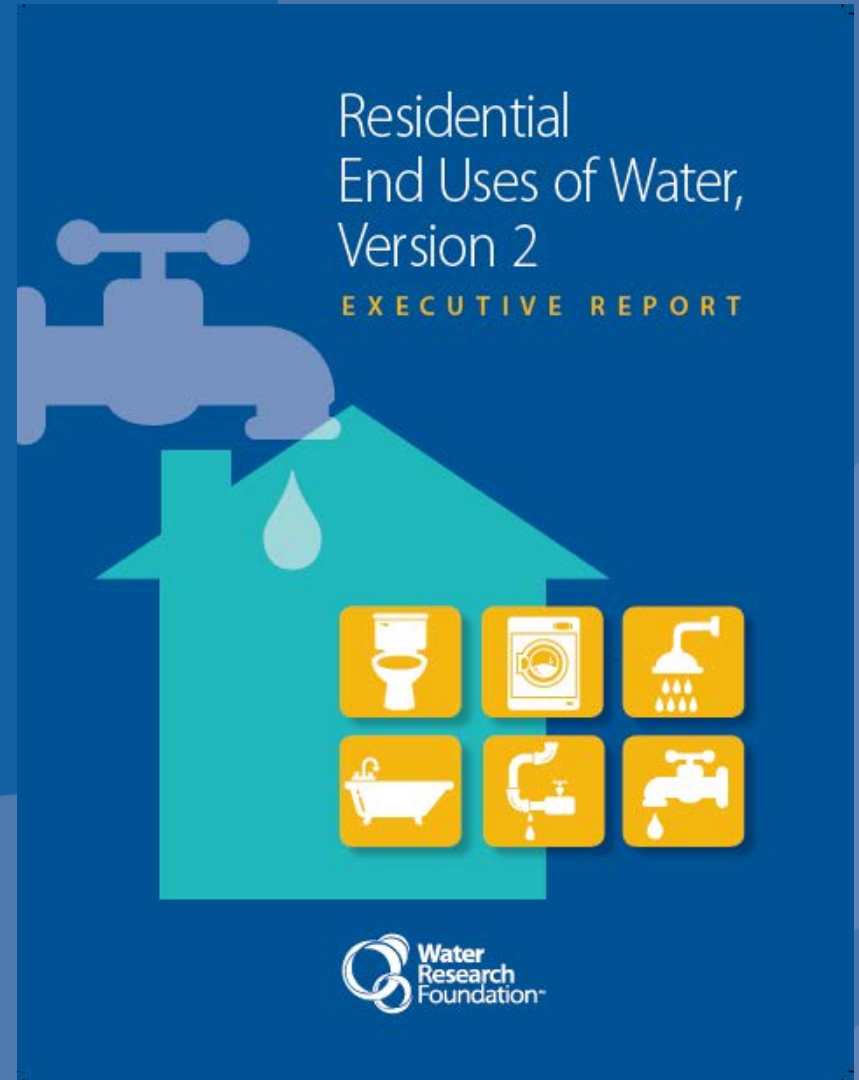


**Water
Research
Foundation®**

**Celebrating 50 Years
1966–2016**

Residential End Uses of Water, Version 2 Final Results

**Peter Mayer, P.E.
Principal
WaterDM**



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- Benedykt Dziegielelewski, University of Southern Illinois
- Jack Kiefer, Hazen and Sawyer, P.C.

Sponsors

- Water Research Foundation
- City of Fort Collins Utilities
- City of Scottsdale Water Department
- Clayton County Water Authority
- Denver Water
- Portland Water Bureau
- Region of Peel
- Region of Waterloo
- San Antonio Water System
- Tacoma Public Utilities
- Toho Water Authority
- Tampa Bay Water
- Alliance for Water Efficiency

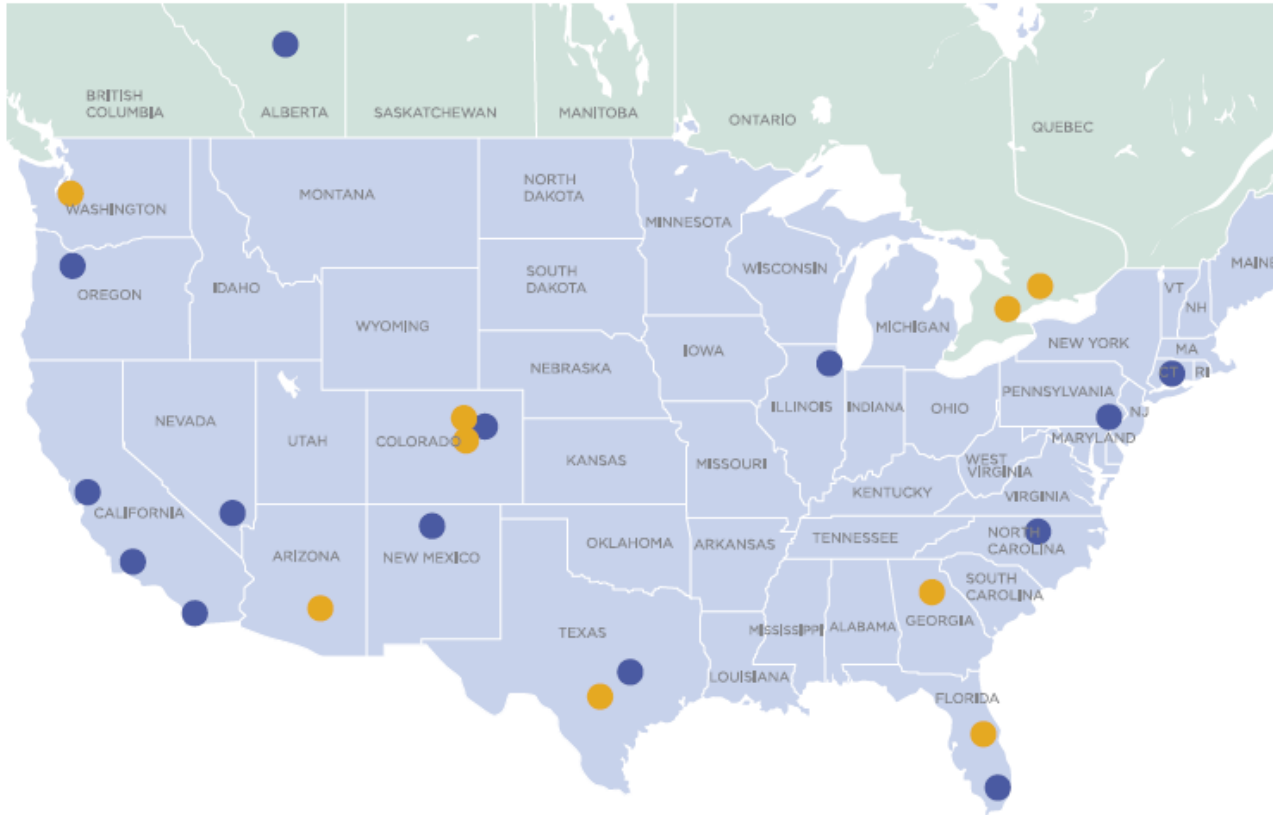
Project Advisory Committee

- Doug Bennett, Southern Nevada Water Authority
- David Bracciano, Tampa Bay Water
- Robert Day, San Jose Water Company
- Mary Ann Dickinson, Alliance for Water Efficiency
- Warren Liebold, New York City DEP
- Maureen Hodgins - Water Research Foundation

Research Objective

Residential End Uses of Water Study Update - Version 2 provides an updated and expanded assessment of water use in single-family households across North America, and presents detailed information and data about how water use has changed since REU1999.

Regionally Diverse Study Sites

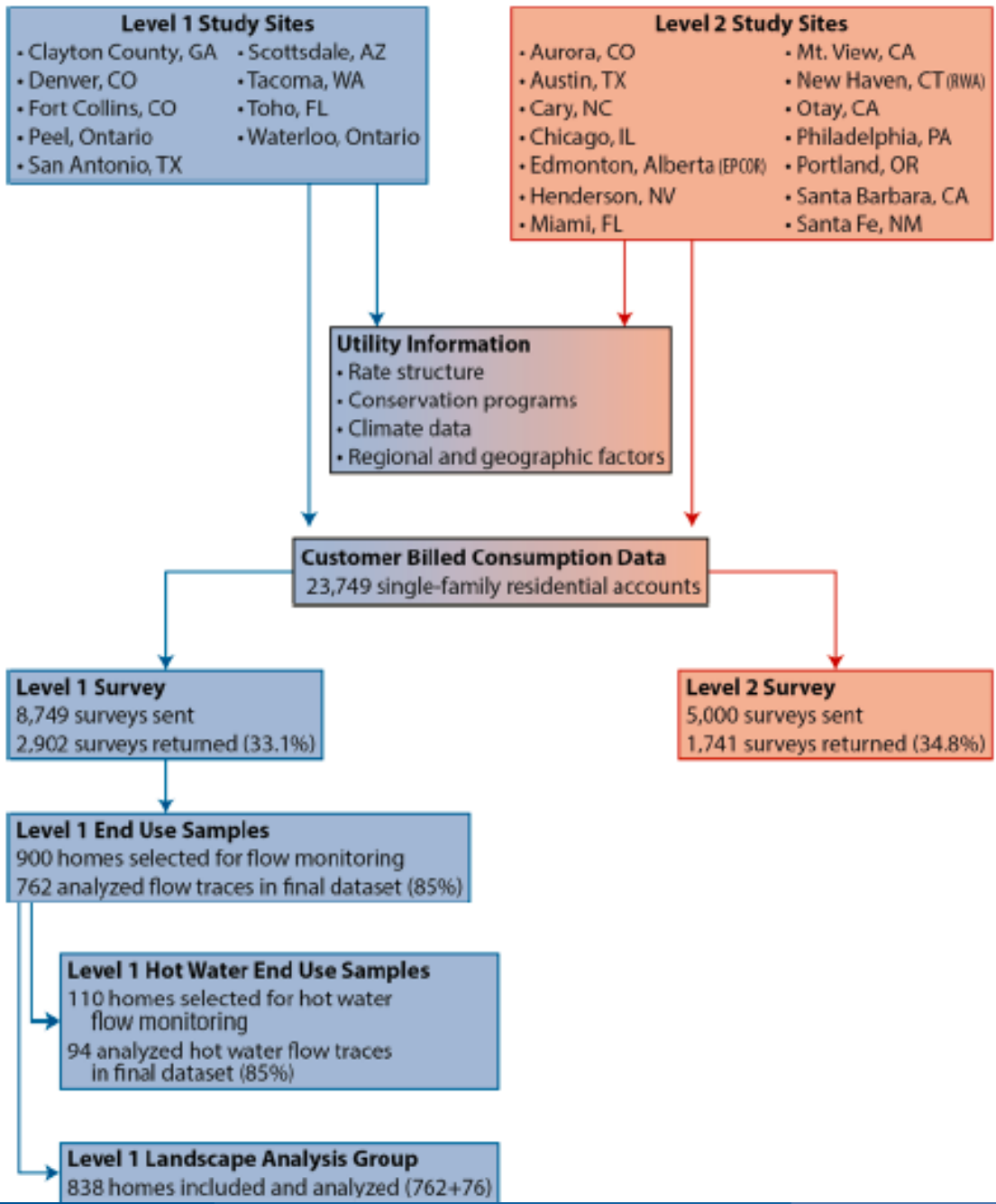


LEVEL 1 STUDY SITES: Clayton County, GA • Denver, CO • Fort Collins, CO • Peel, Ontario • San Antonio, TX
Scottsdale, AZ • Tacoma, WA • Toho, FL • Waterloo, Ontario

LEVEL 2 STUDY SITES: Aurora, CO • Austin, TX • Cary, NC • Chicago, IL • Edmonton, Alberta
Henderson, NV • Miami, FL • Mt. View, CA • New Haven, CT • Otay, CA • Philadelphia, PA • Portland, OR
Santa Barbara, CA • Santa Fe, NM

Research Approach

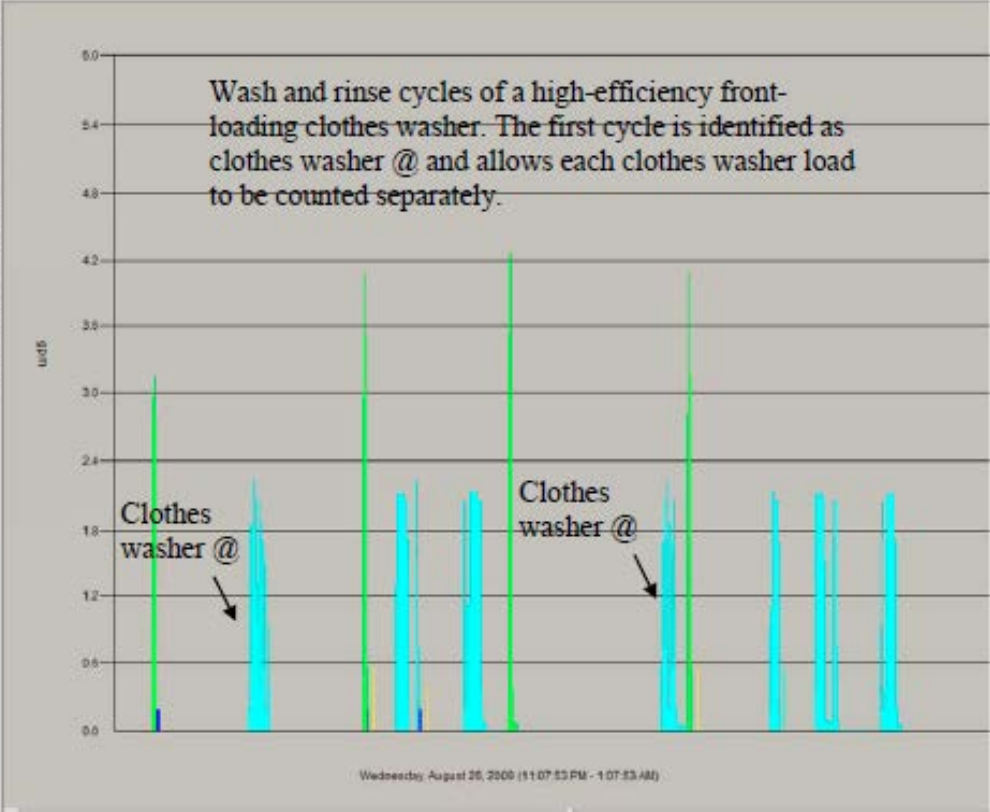
- 9 utilities - end use analysis
- 24 utilities - contributed data and information
- Mail survey sent to 13,749 homes - 5,574 returned (34%)
- Billed consumption data from ~ 23,749 homes
- End use data from 762 homes
- Paired hot water and cold water data from 94 homes
- Detailed landscape and outdoor use analysis for 838 homes
- Modeling
- Benchmarking



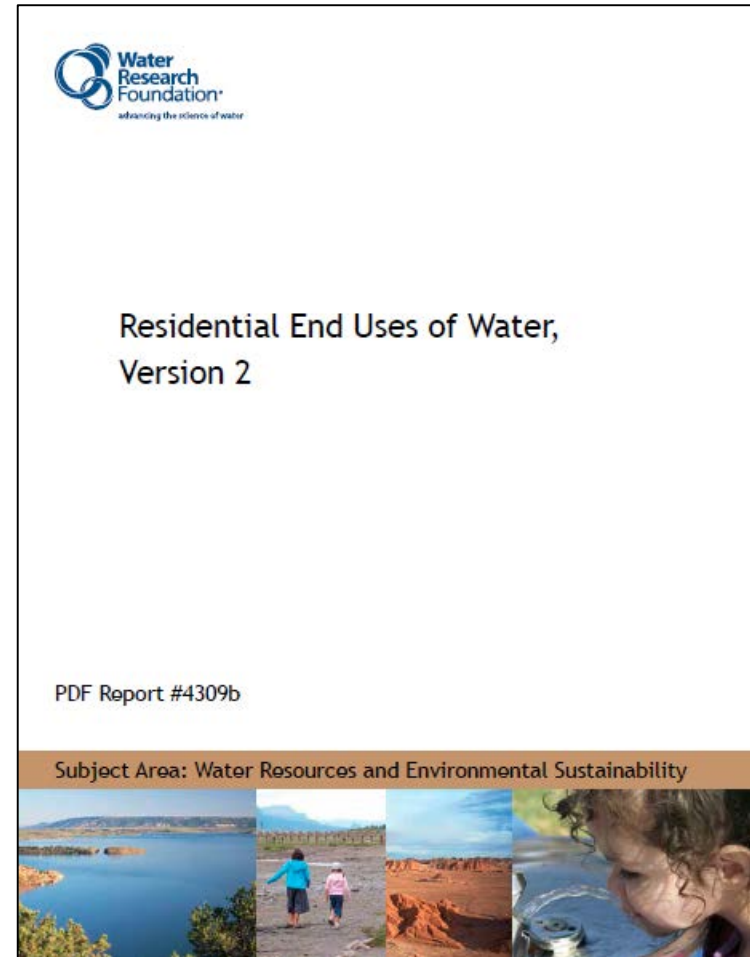
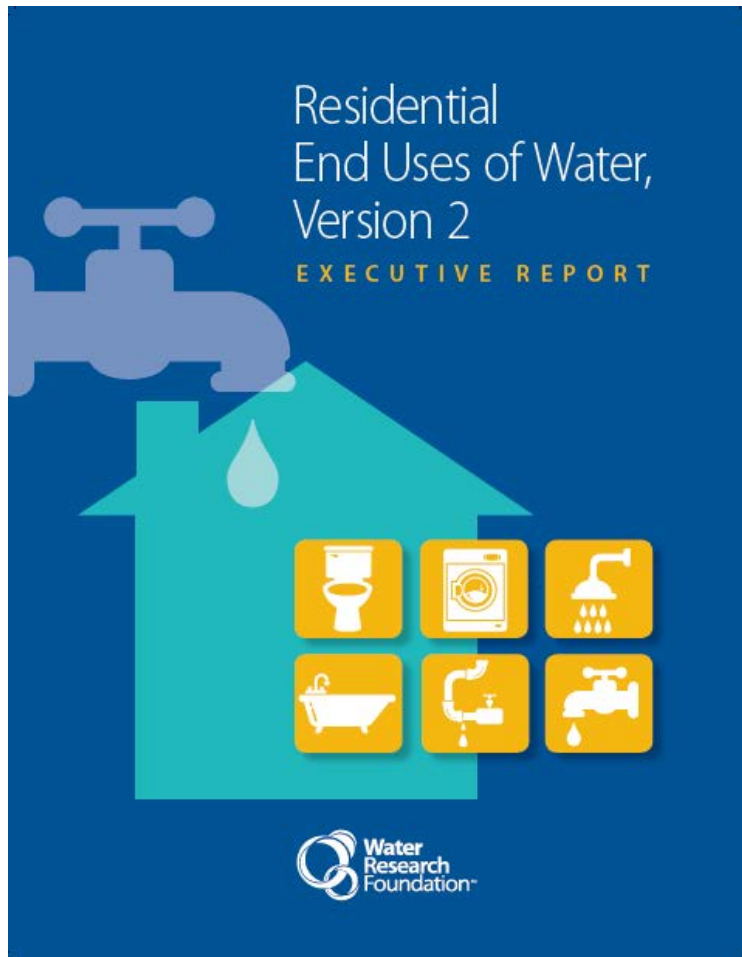
End Use Disaggregation

Event Properties	
Min.	Max.
Vol	3.02 4.90
Peak	1.75 2.91
Dur	00:01:20 00:02:20
Mode	1.75 2.91
Model	

Event Properties	
Min.	Max.
Volume	4.05
Peak	2.13
Duration	00:02:50
Mode	2.13
Model	4
Run	1909
Start	8/26/2009 11:05:23
End	8/26/2009 11:06:13
Class	Boor

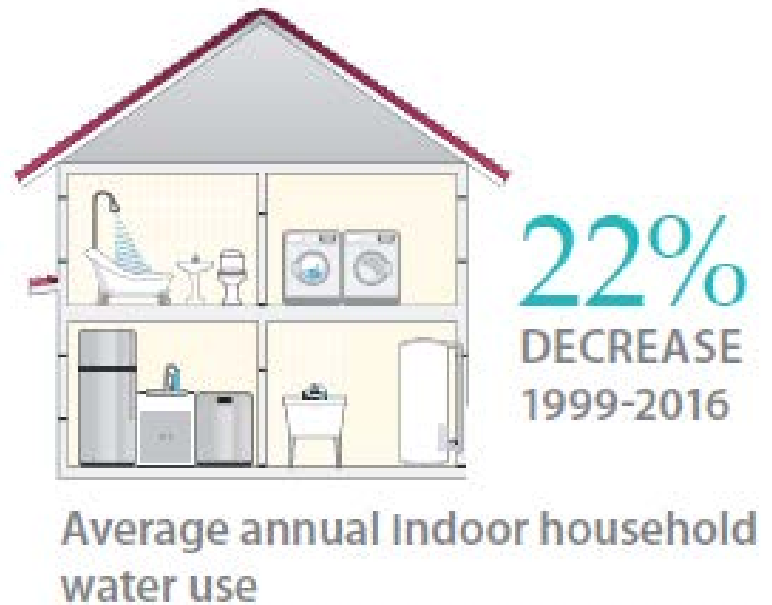


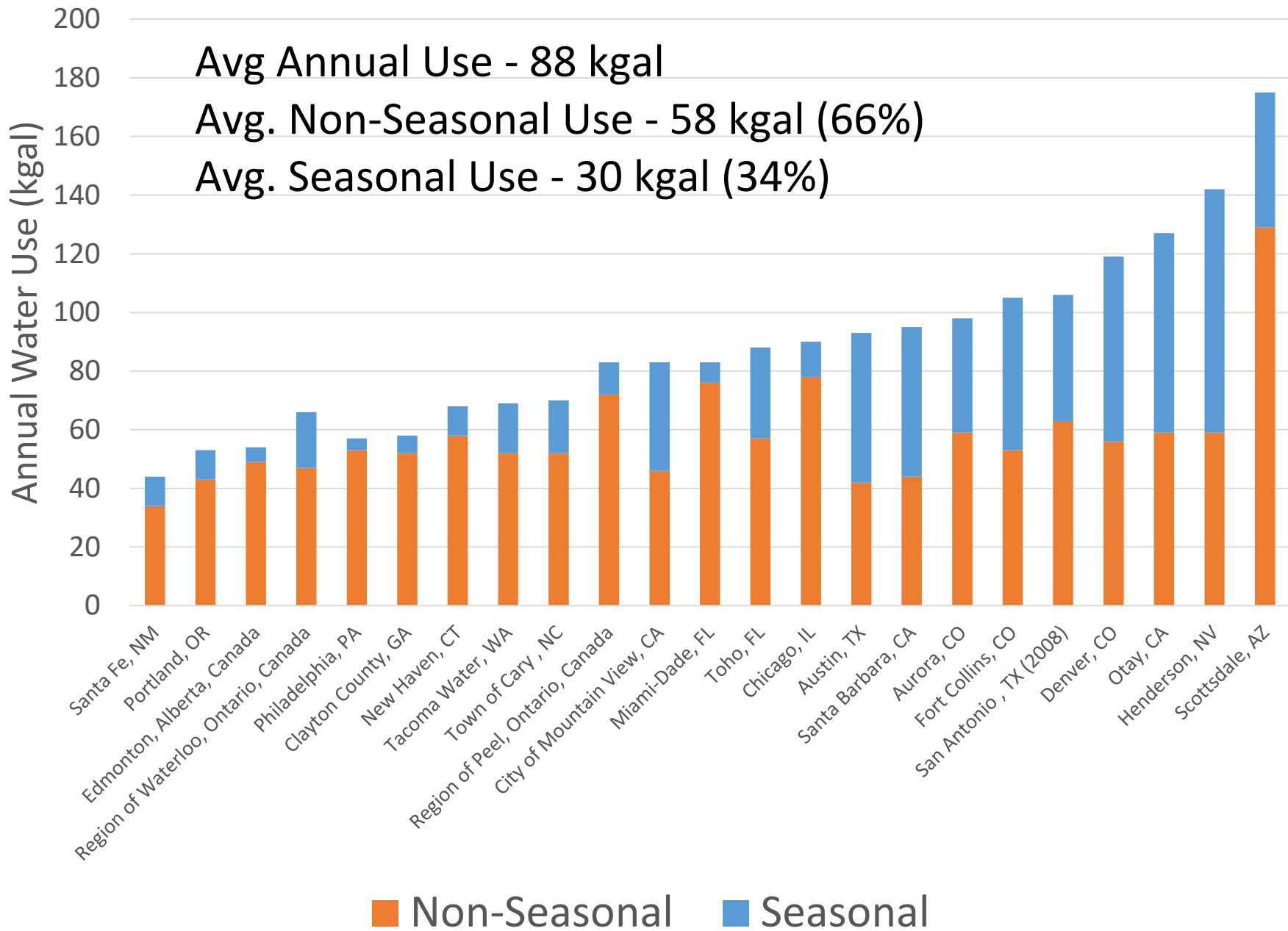
Final Reports & Database



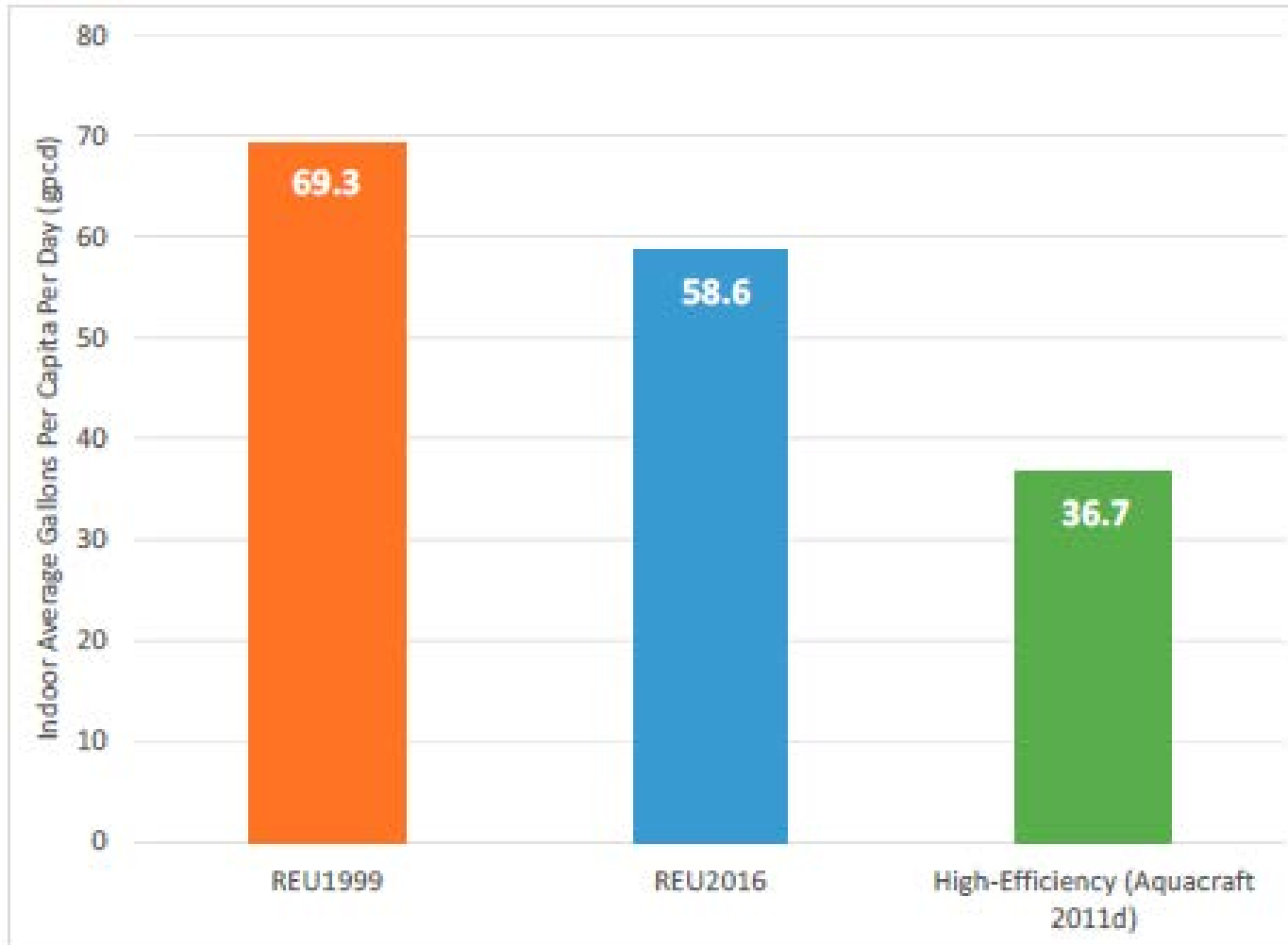
Summary Results

- Single-family homes typically use the most water of any utility customer sector.
- Key comparisons between 1999 and 2016 studies.
- Substantial decreases in water use documented





Residential Indoor GPCD



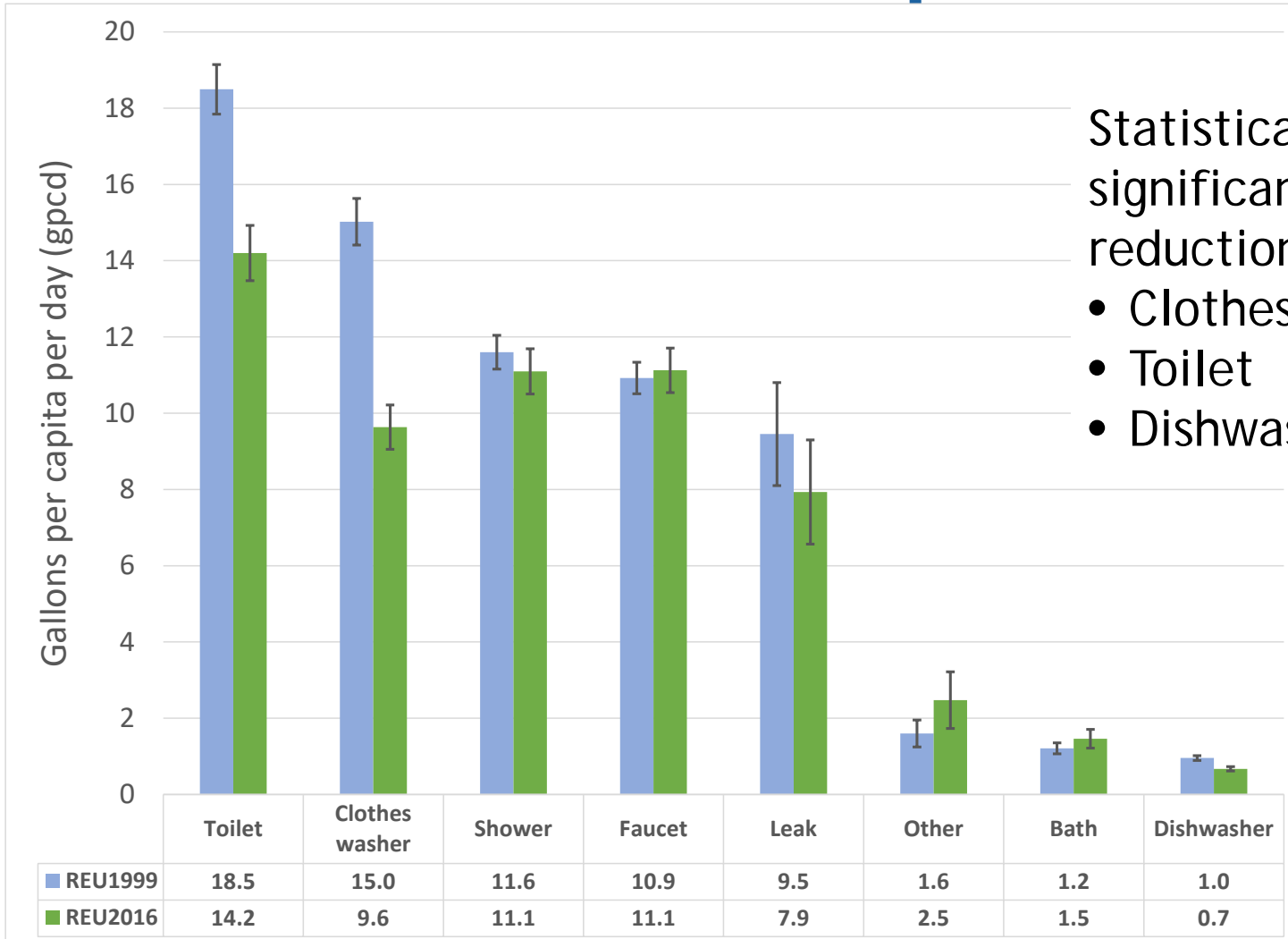
1999 vs. 2016 =
15.4% reduction

2016 vs. HE =
37.4% reduction

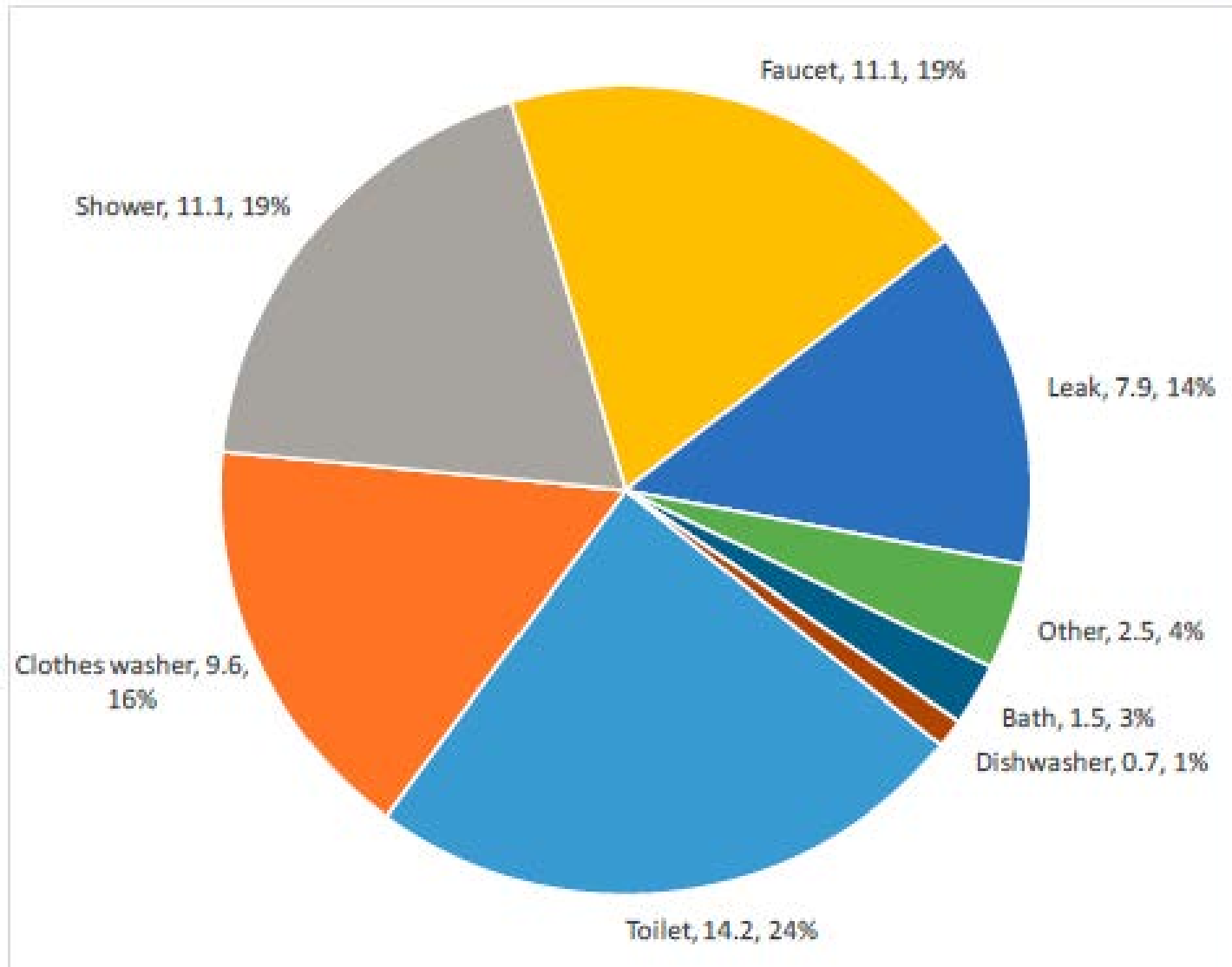
Indoor GPCD Comparison

Statistically significant reductions in:

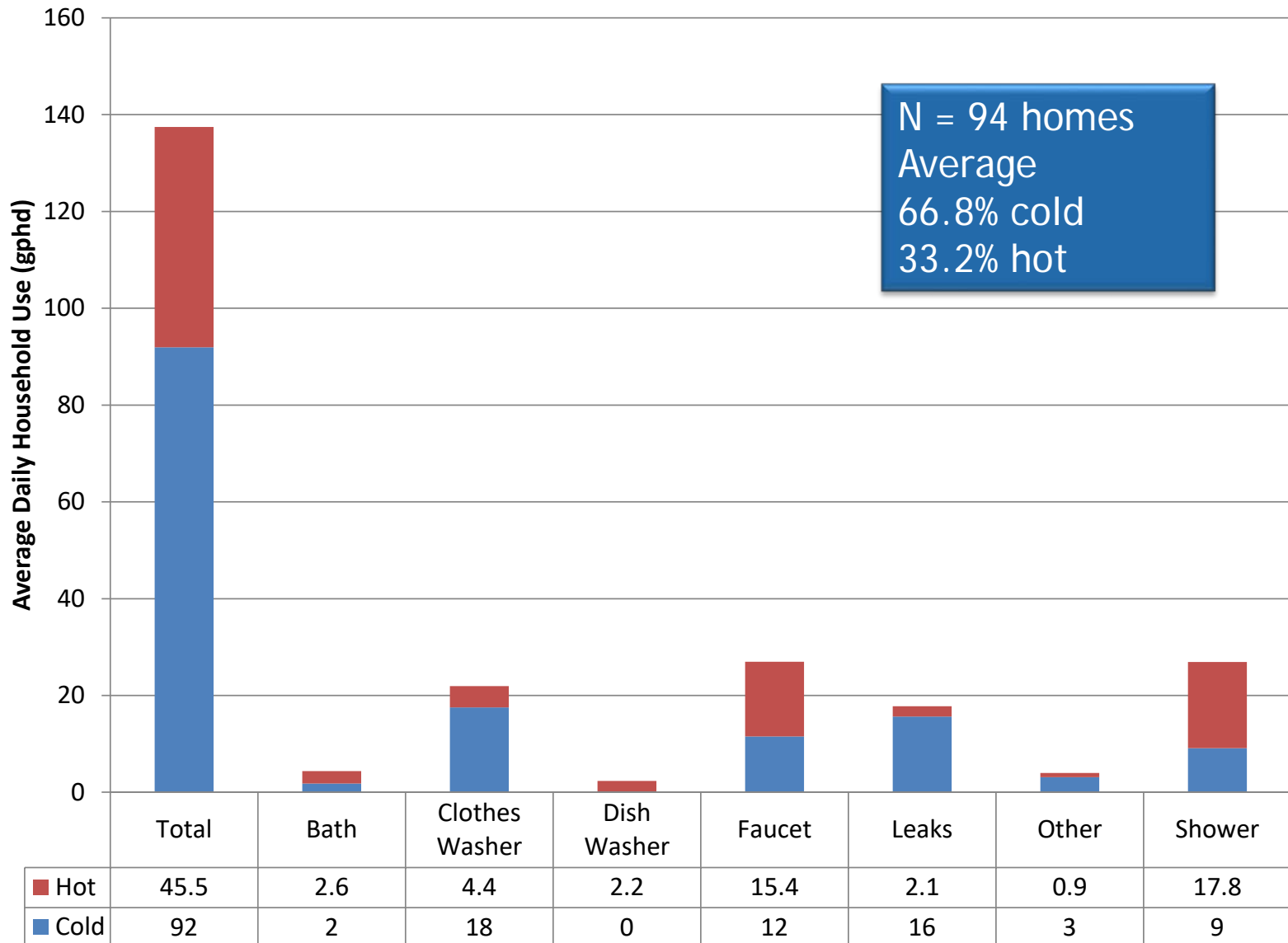
- Clothes washer
- Toilet
- Dishwasher



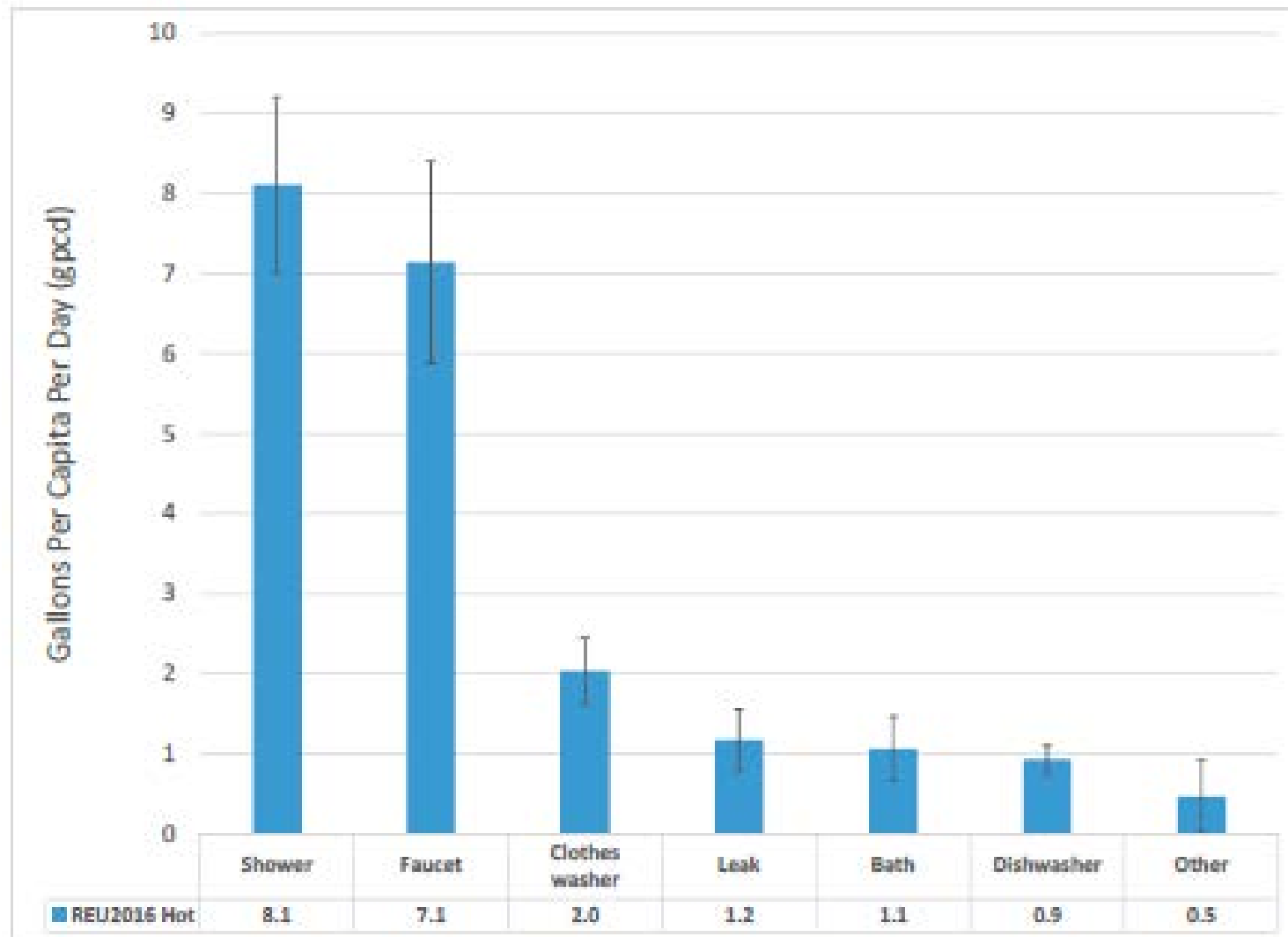
Indoor GPCD



Hot and Cold Water Household Use

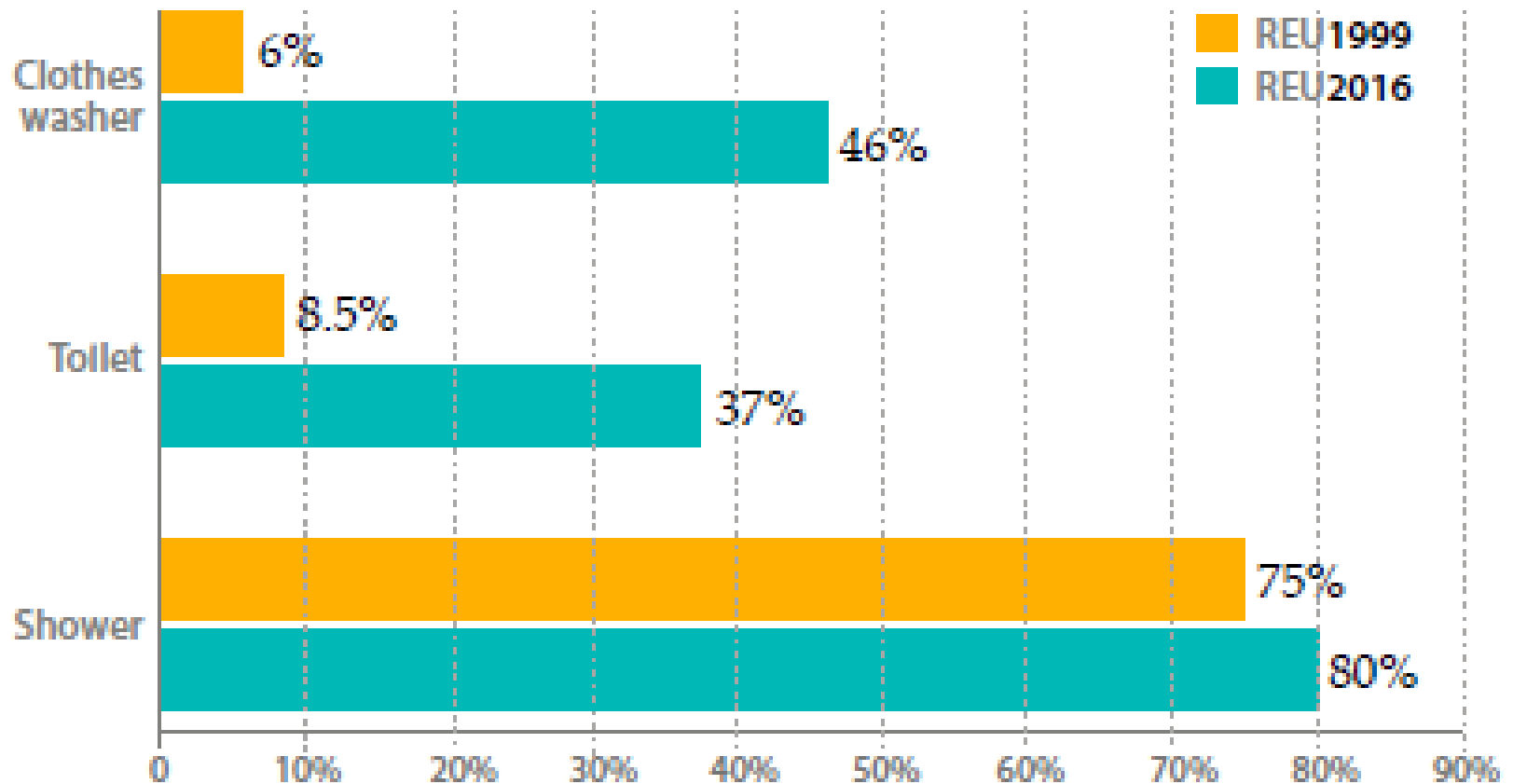


Hot Water Per Capita Use

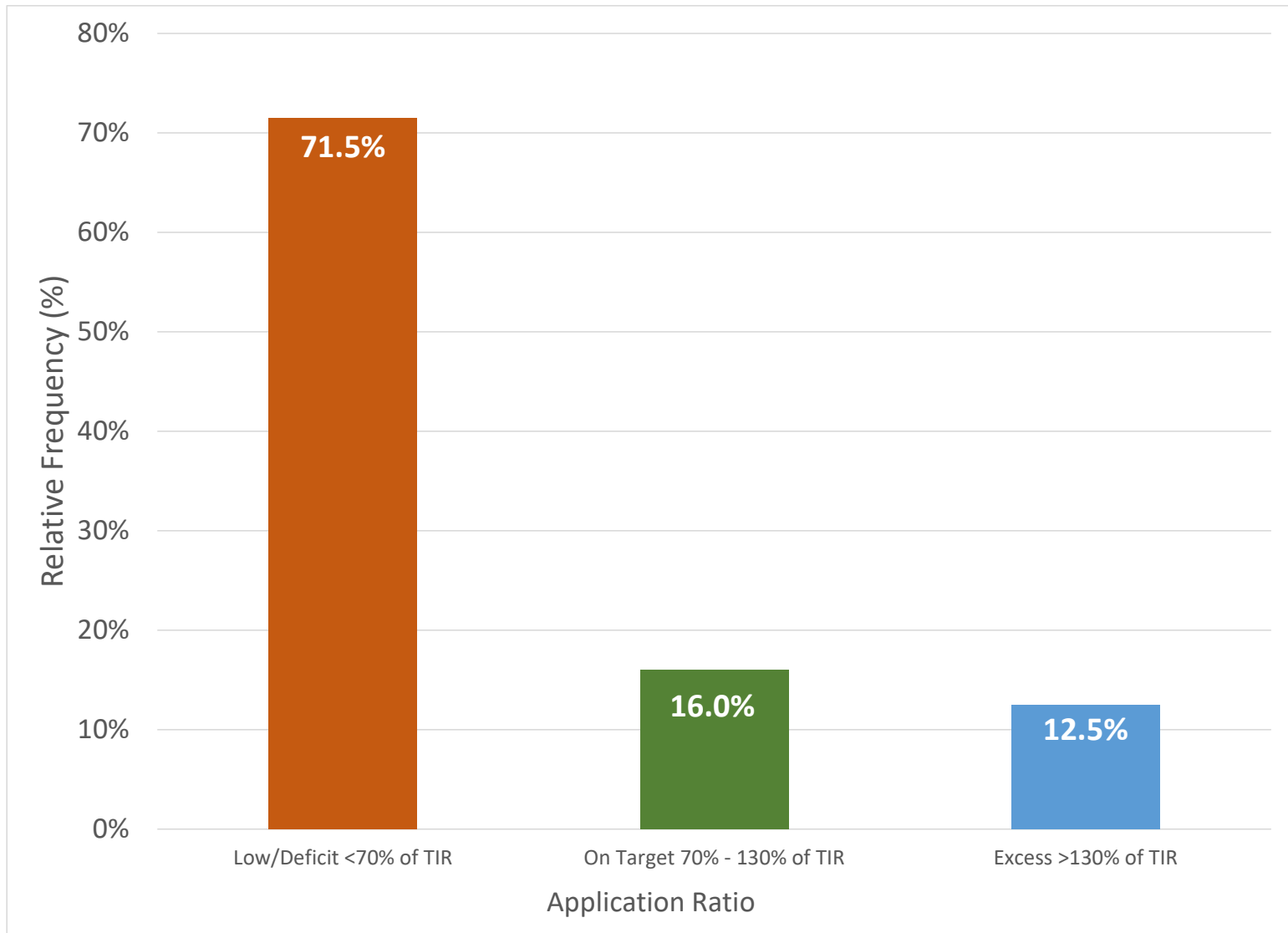


Efficiency Improvements

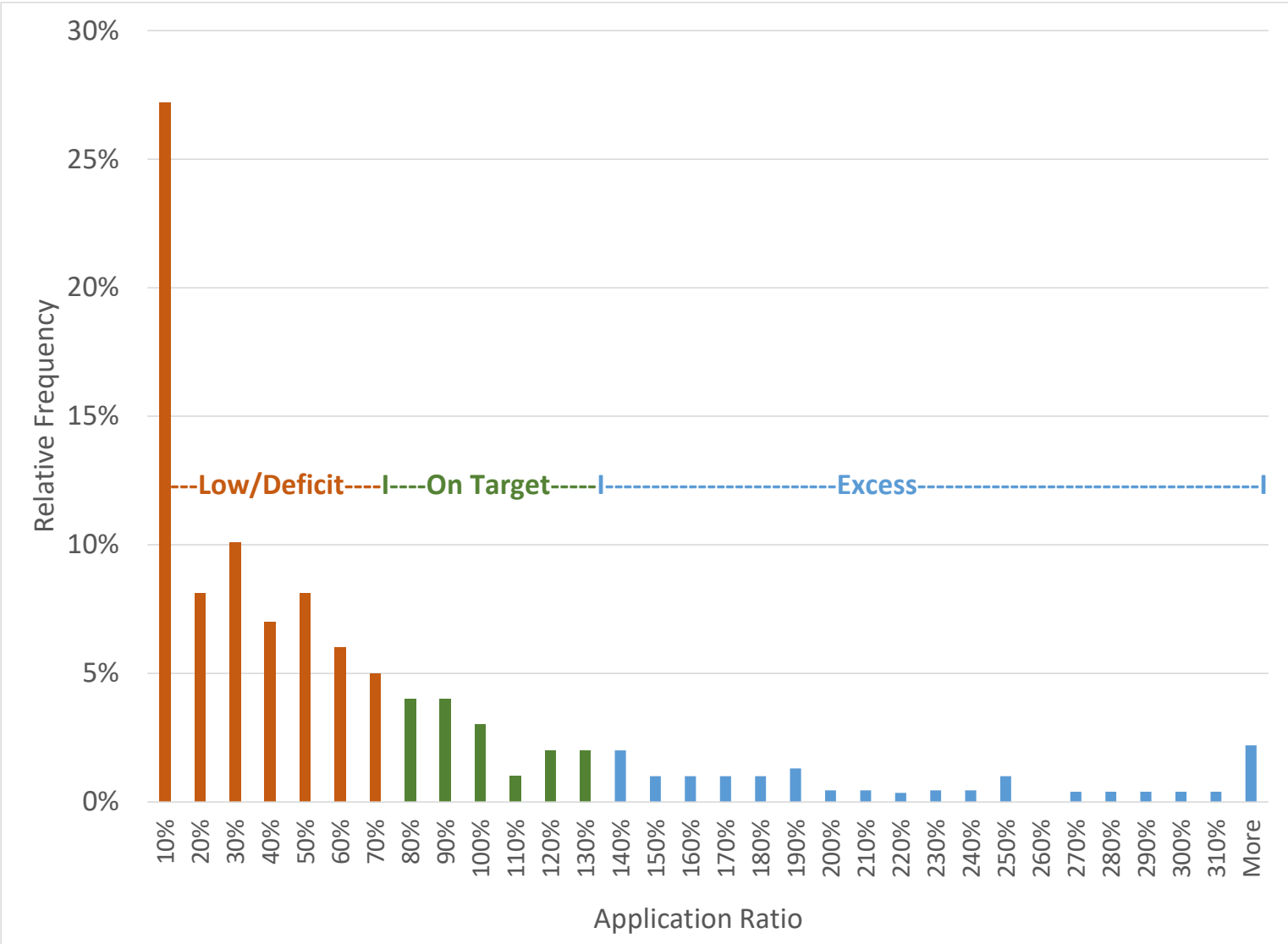
Efficiency criteria include: clothes washers <30 gal/load, toilets <2.0 gal/flush, showers <2.5 gal/minute.



Residential Outdoor Water Use



Residential Outdoor Water Use



Some Factors that Influence Indoor Water Use

- Number of people residing in the home (large + impact)
- Presence of a home water treatment system (+)
- Parcel size as a proxy for income (+)
- Presence of a swimming pool (+)
- Presence of efficient toilets (large - impact)
- Increased sewer rates (-)
- Presence of a hot water recirculating system (-)
- Presence of efficient clothes washer (-)

Some Factors that Influence Outdoor Water Use

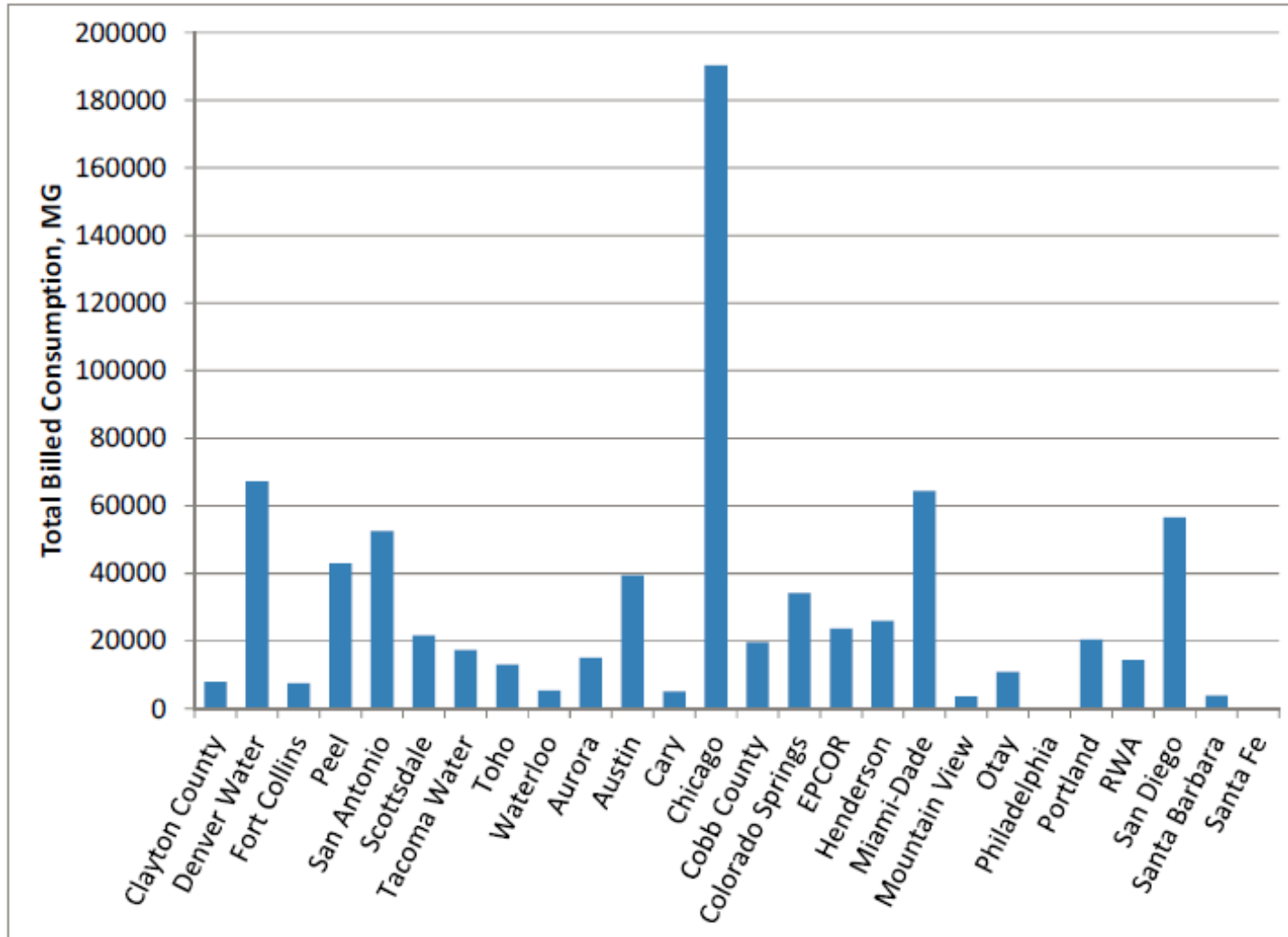
- Application of excess irrigation (large + impact)
- Net ET (large + impact)
- Presence of an in-ground sprinkler system (large + impact)
- Irrigated area (+)
- Presence of a swimming pool (+)
- Cost of water (-)

Questions on Part 1

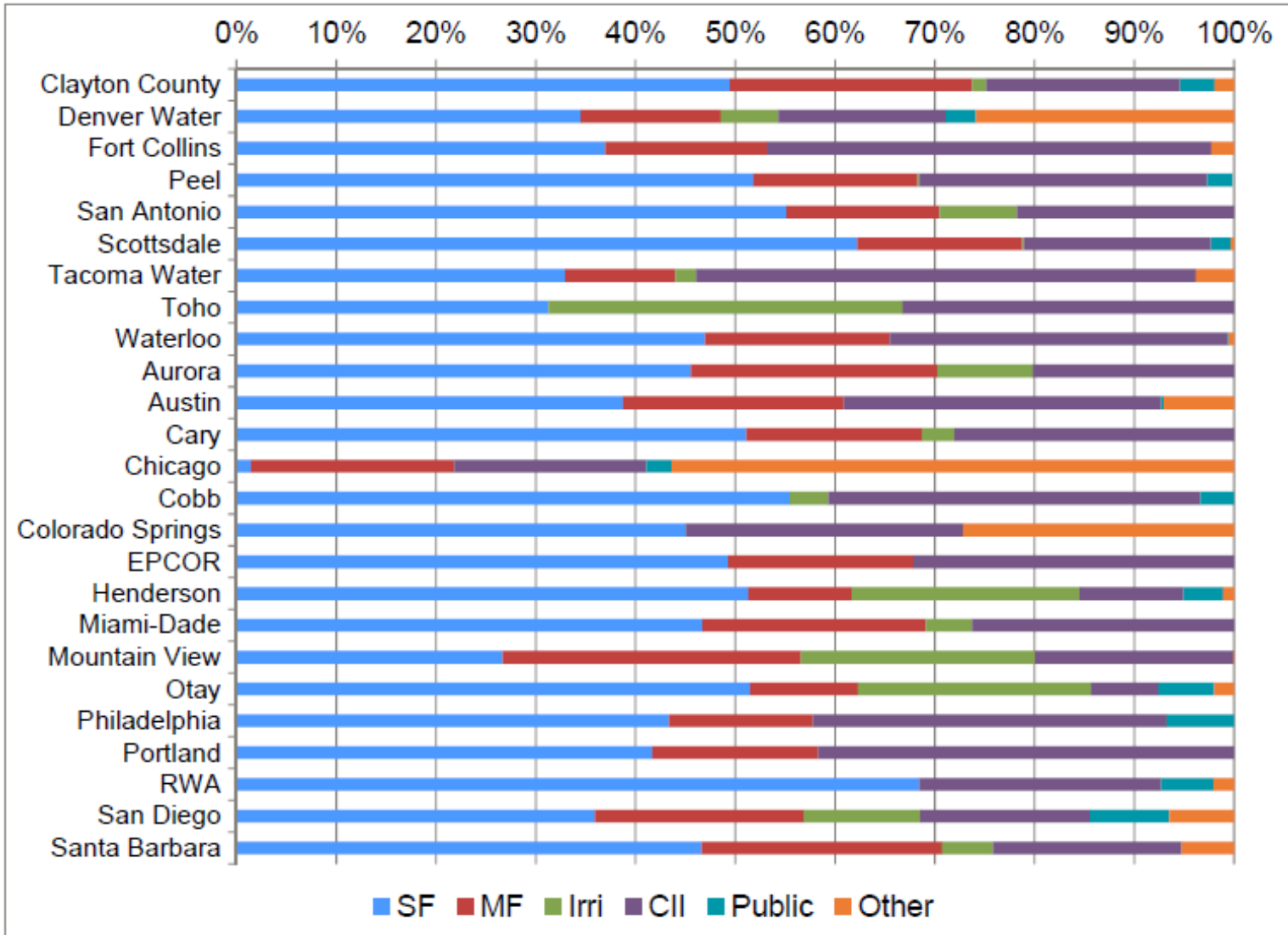
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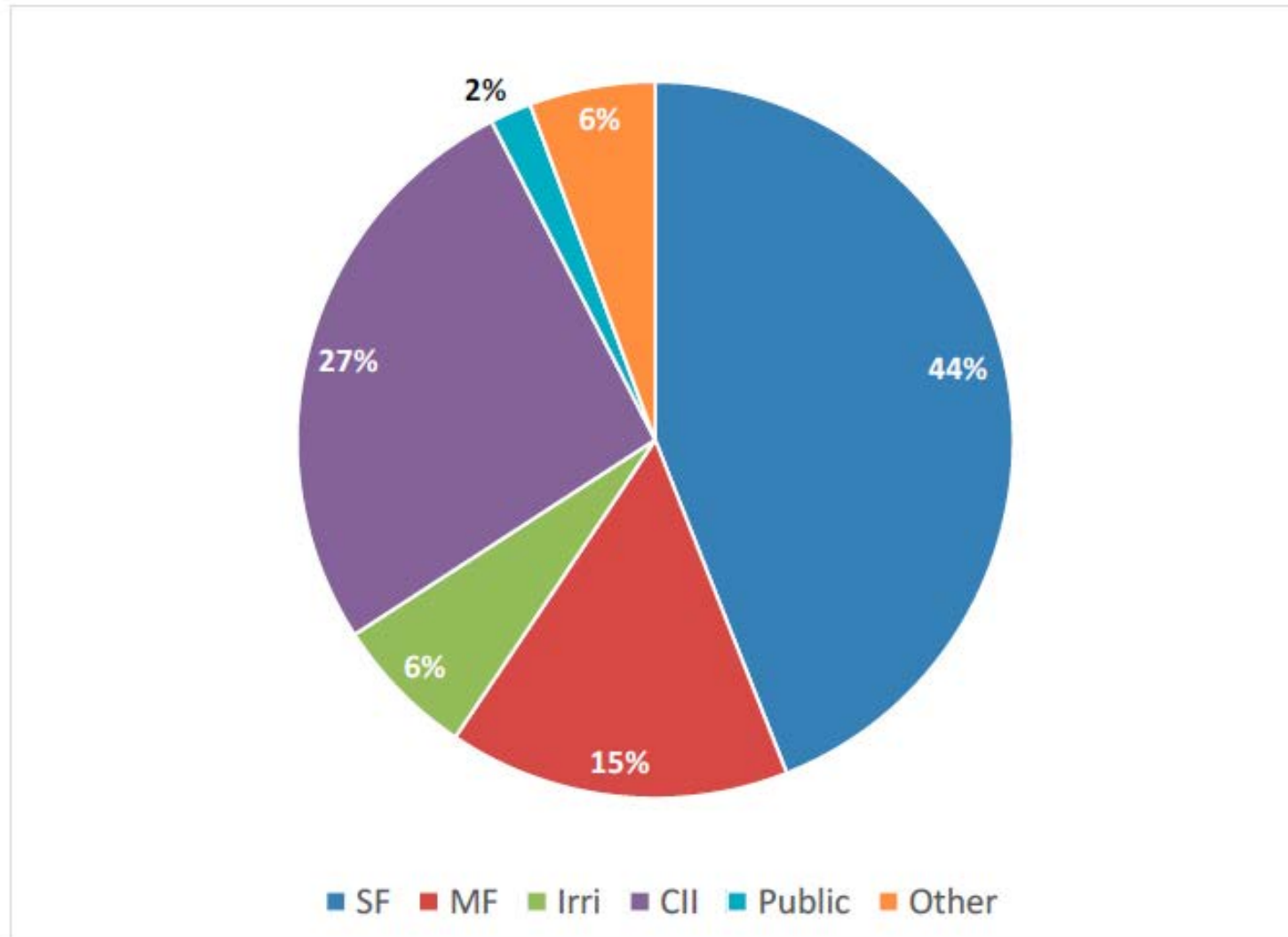
Total Billed Consumption



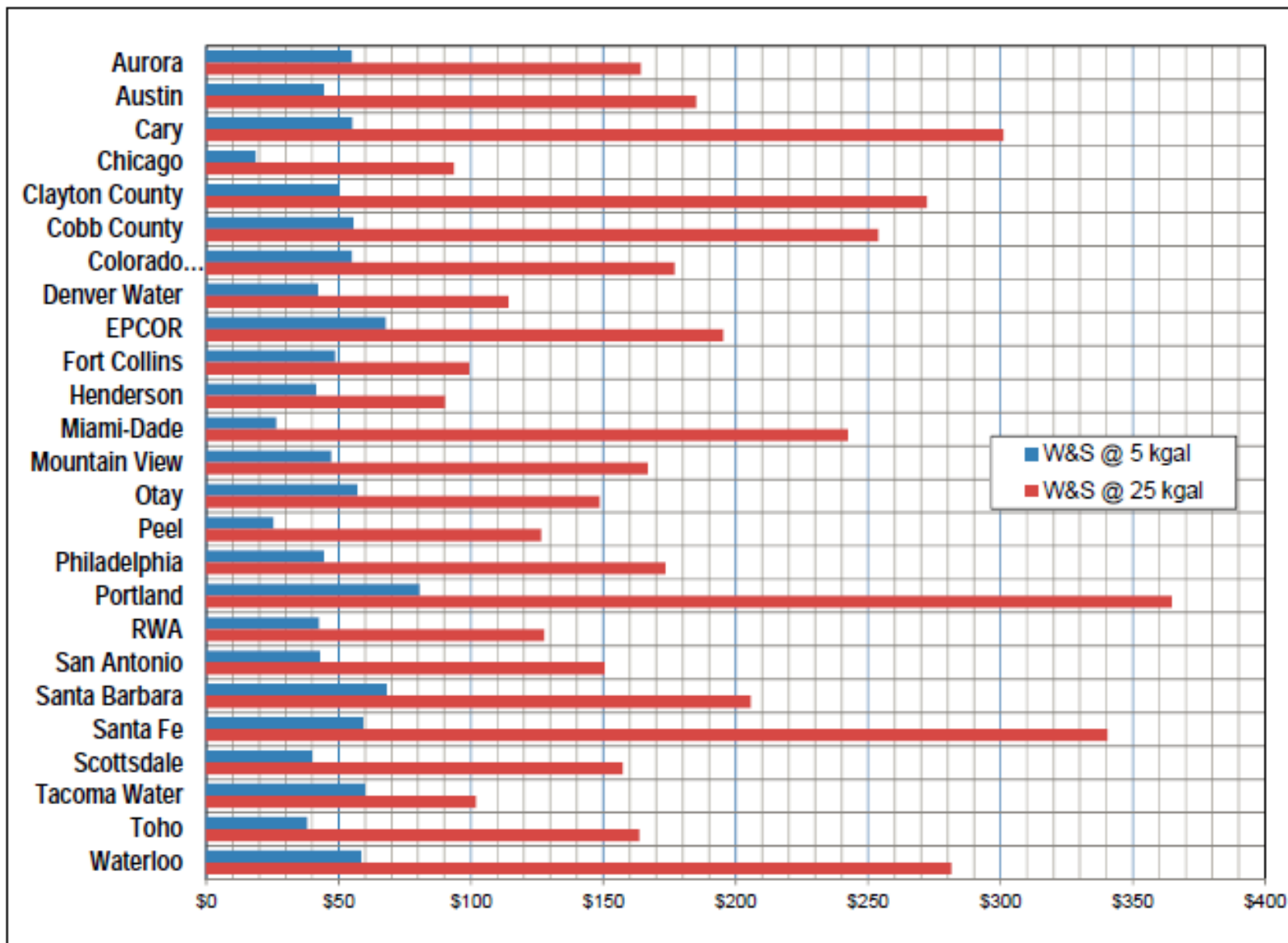
Metered Demand By Sector



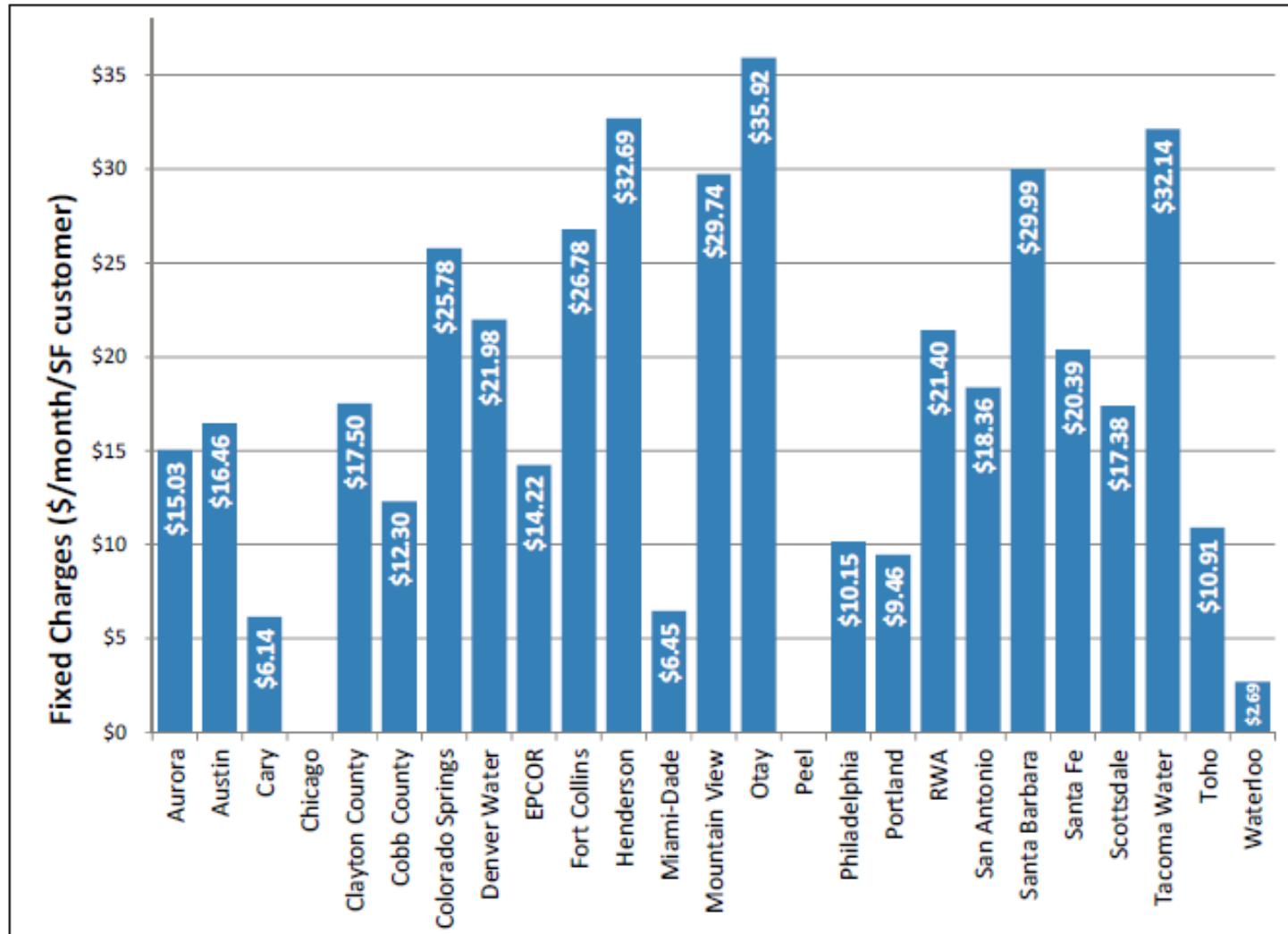
Avg. Demand by Sector



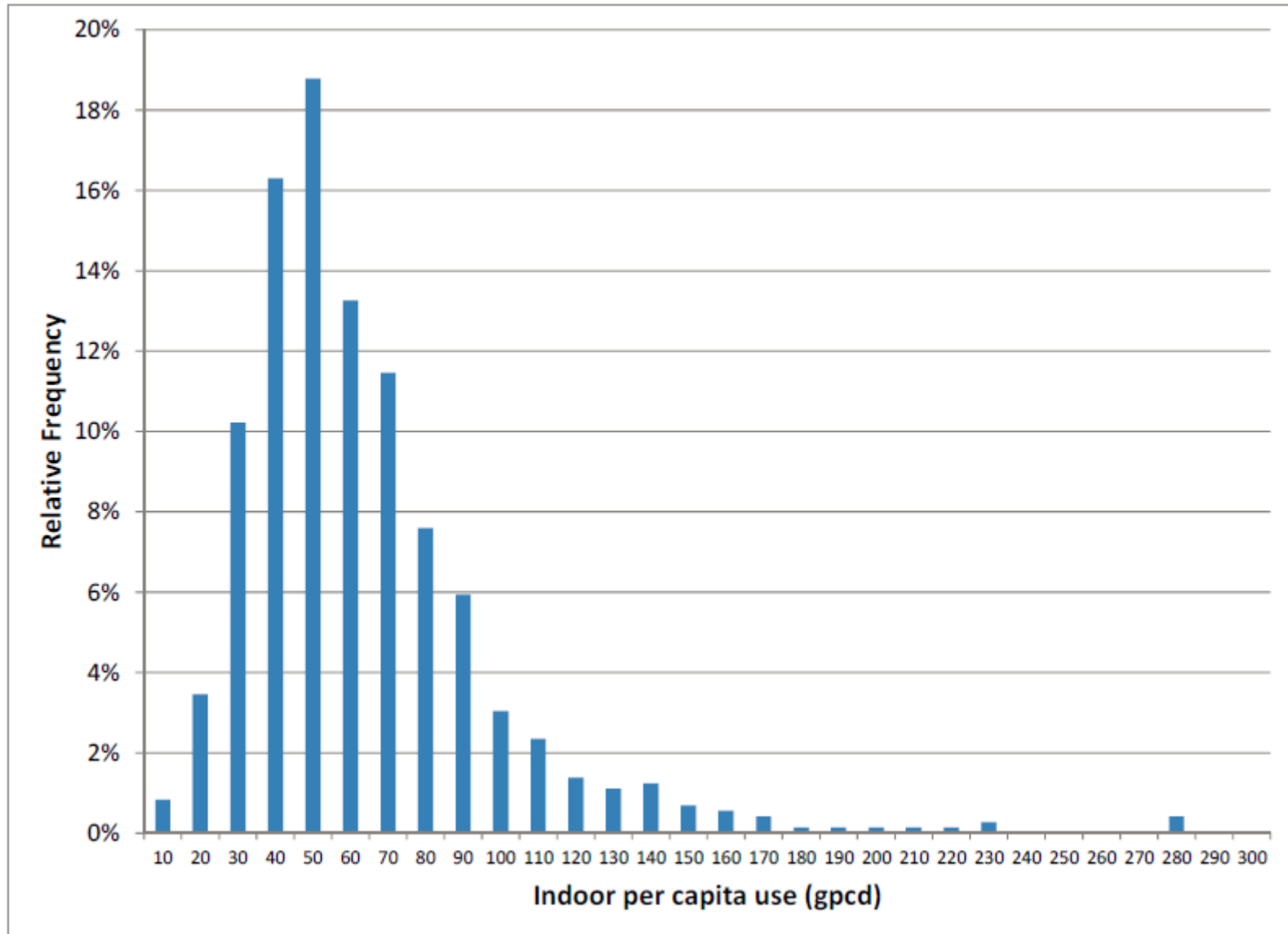
Water & Sewer Bill - 5, 25 kgal



Fixed Water and Sewer Charges



Indoor GPCD



Average # of Residents

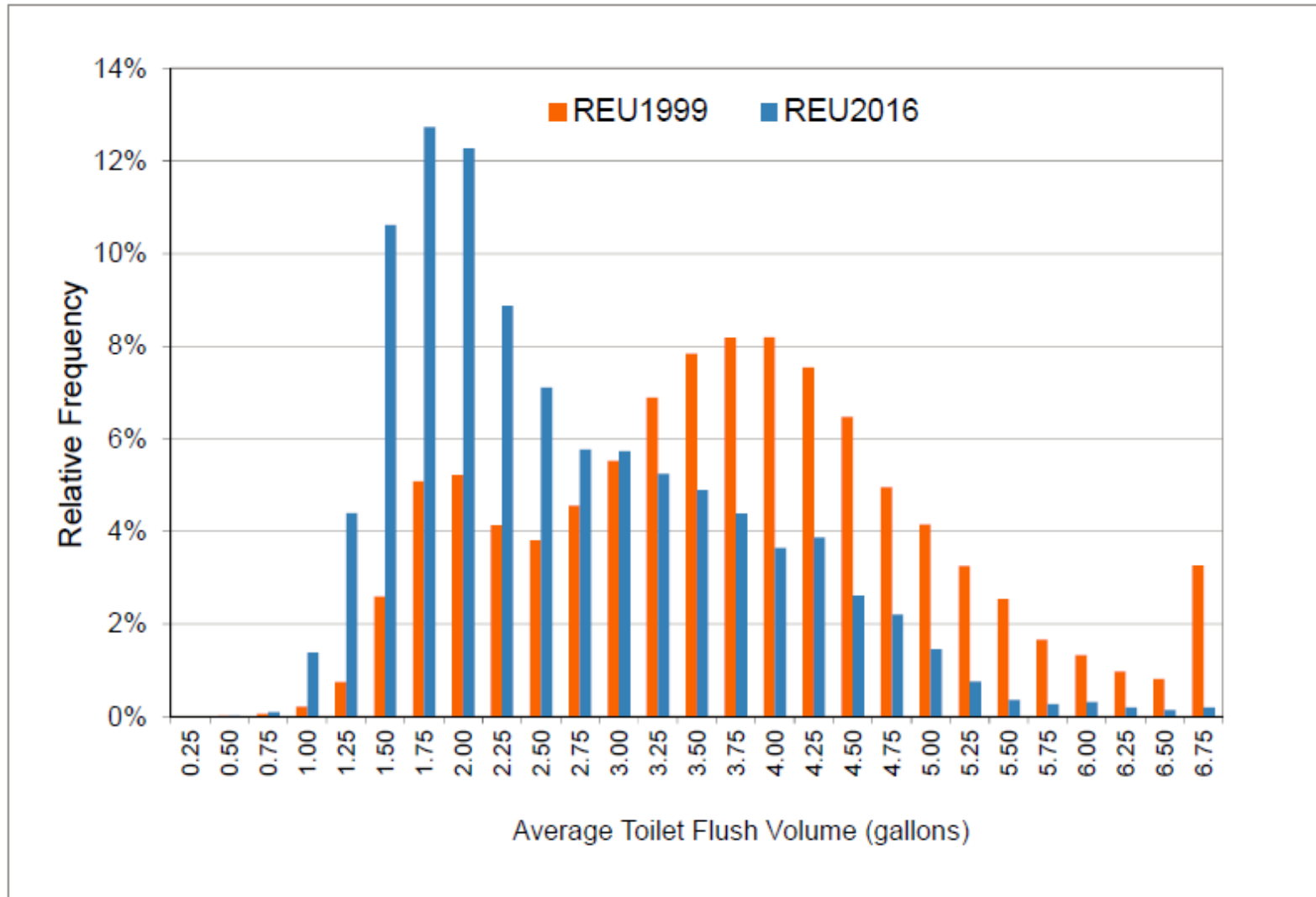
- REU1999 = 2.7
- REU2016 = 2.6

Toilets

	REU1999	REU2016
Number of houses logged	1,187	762
Average flushes/household per day	12.4	13
Average flushes per person per day	5.05	5.0
Average flush volume	3.65 ± 0.06 gal	2.6 ± 0.01 gal
Average per capita toilet use (gpcd)	18.5	14.3

22.7% reduction in avg. per capita toilet use.

Toilet Flush Distributions



Clothes Washers

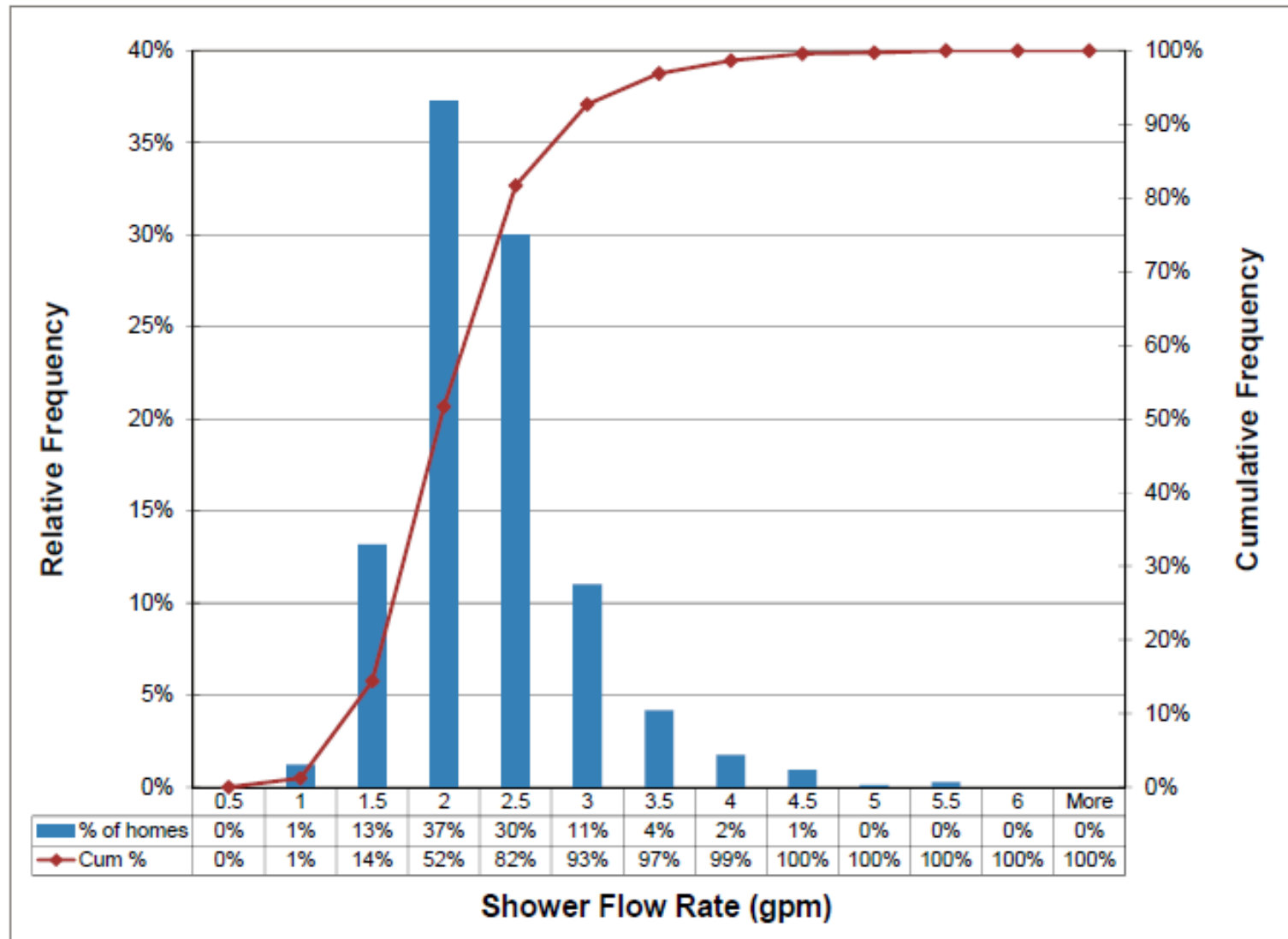
	REU1999	REU2016
Number of houses logged	1,187	762
Average loads per household per day	0.81	0.78
Average loads uses per person per day	0.3	0.3
Average gallons per load	41	31
Per capita clothes washer use	15.0	9.8

34.6% reduction in avg. per capita clothes washer use.

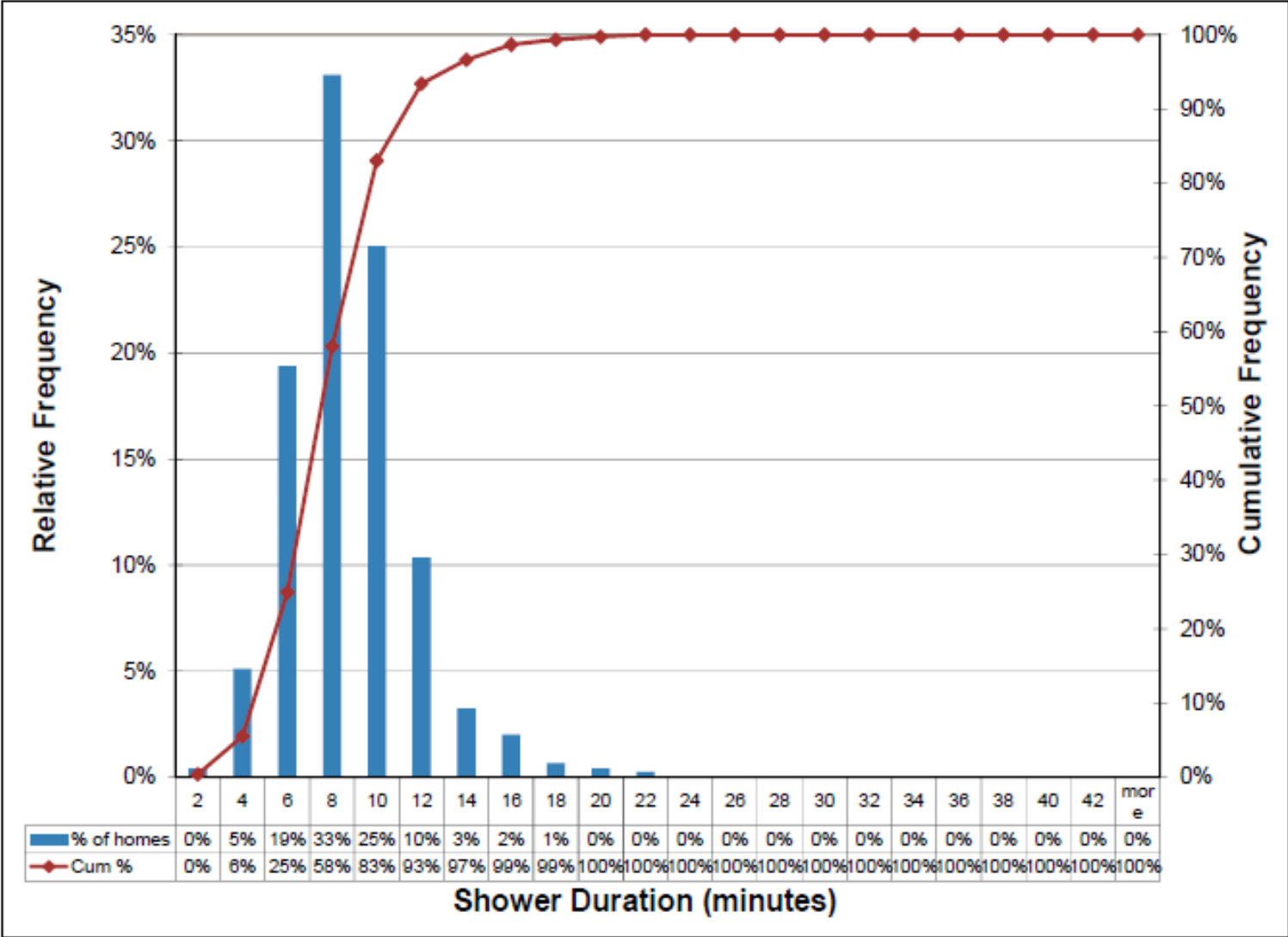
Showers

	REU1999	REU2016
Number of houses logged	1,187	762
Average showers/household per day	1.8	1.8
Average showers per person per day	0.66	0.69
Average shower volume (gal.)	16.7	15.8
Average shower duration	7.8 ± 0.14 minutes	7.8 ± 0.02 minutes
Average flow rate for showers (gpm)	2.2 ± 0.04	2.1 ± 0.04
Average per capita shower use	11.6	11.1

Shower Flow Rates



Shower Durations



Misc. Faucet Uses

	REU1999	REU2016
Number of houses logged	1,187	762
Average faucet uses/household per day	41 faucet uses	51 faucet uses
Average faucet uses per person per day	15 faucet uses	20 faucet uses
Average faucet use volume	0.7 gallons per use	0.5 gallons per use
Average faucet duration	30 seconds	30 seconds
Average per capita faucet use	10.9	11.1

Dishwashers

	REU1999	REU2016
Number of houses logged	1,187	762
Average dishwasher uses/household per day	0.24	0.26
Average dishwasher uses per person per day	0.09	0.10
Average dishwasher use volume	10.0 gallons	6.1 gallons
Average per capita dishwasher use	1	0.7

Do Dishwashers Save Water?

Dishwasher Present	Number of homes	Daily Faucet Use (Gal/HH/Day)
No	241	26.4
Yes	520	26.3

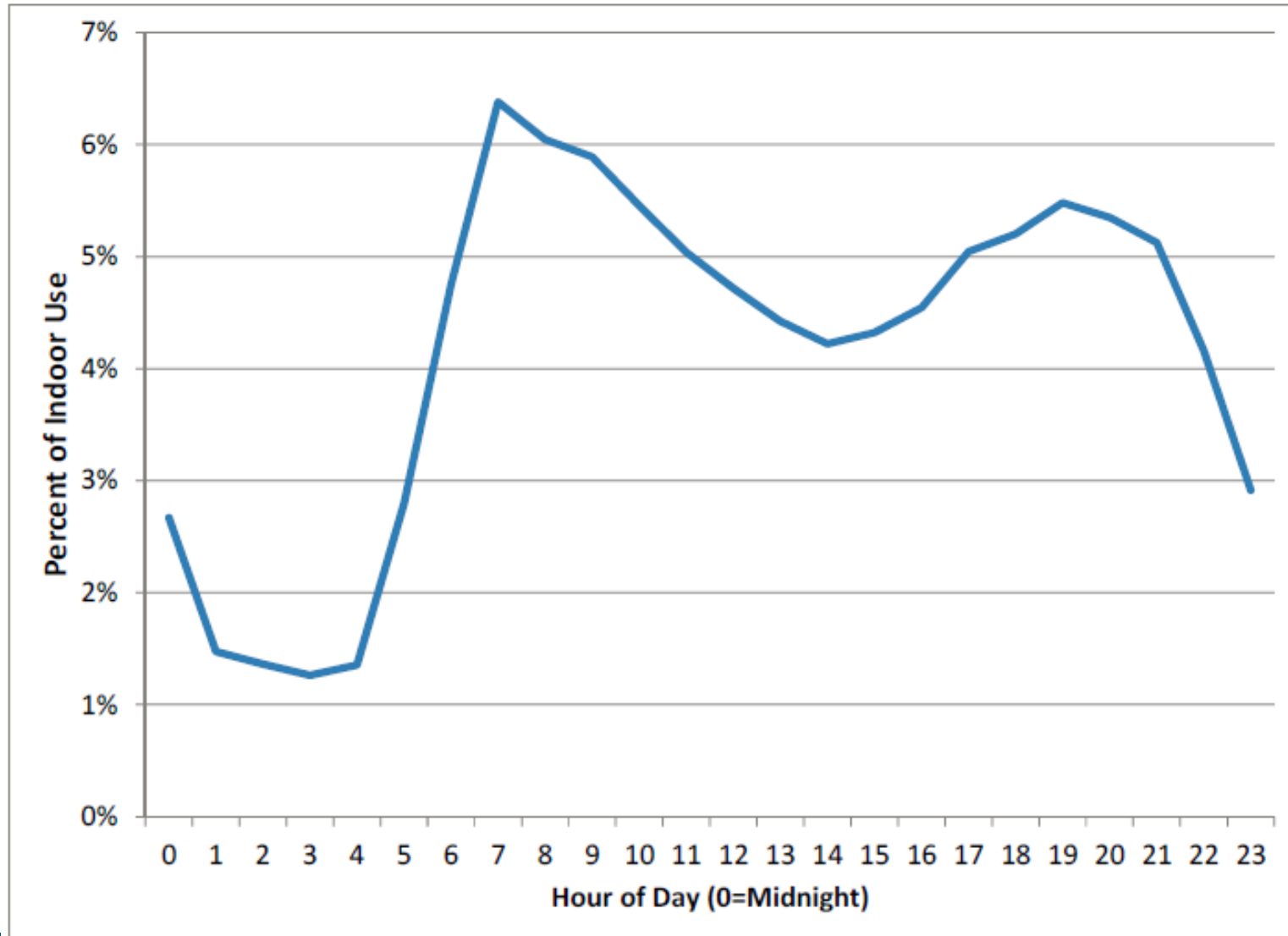
Leaks

	REU1999	REU2016
Number of houses logged	1,187	762
Average Gal/leak event	NA	0.15
Average leak events/household per day	NA	117
Average leak events per person per day	NA	43.3
Average per capita leakage	9.5	7.7

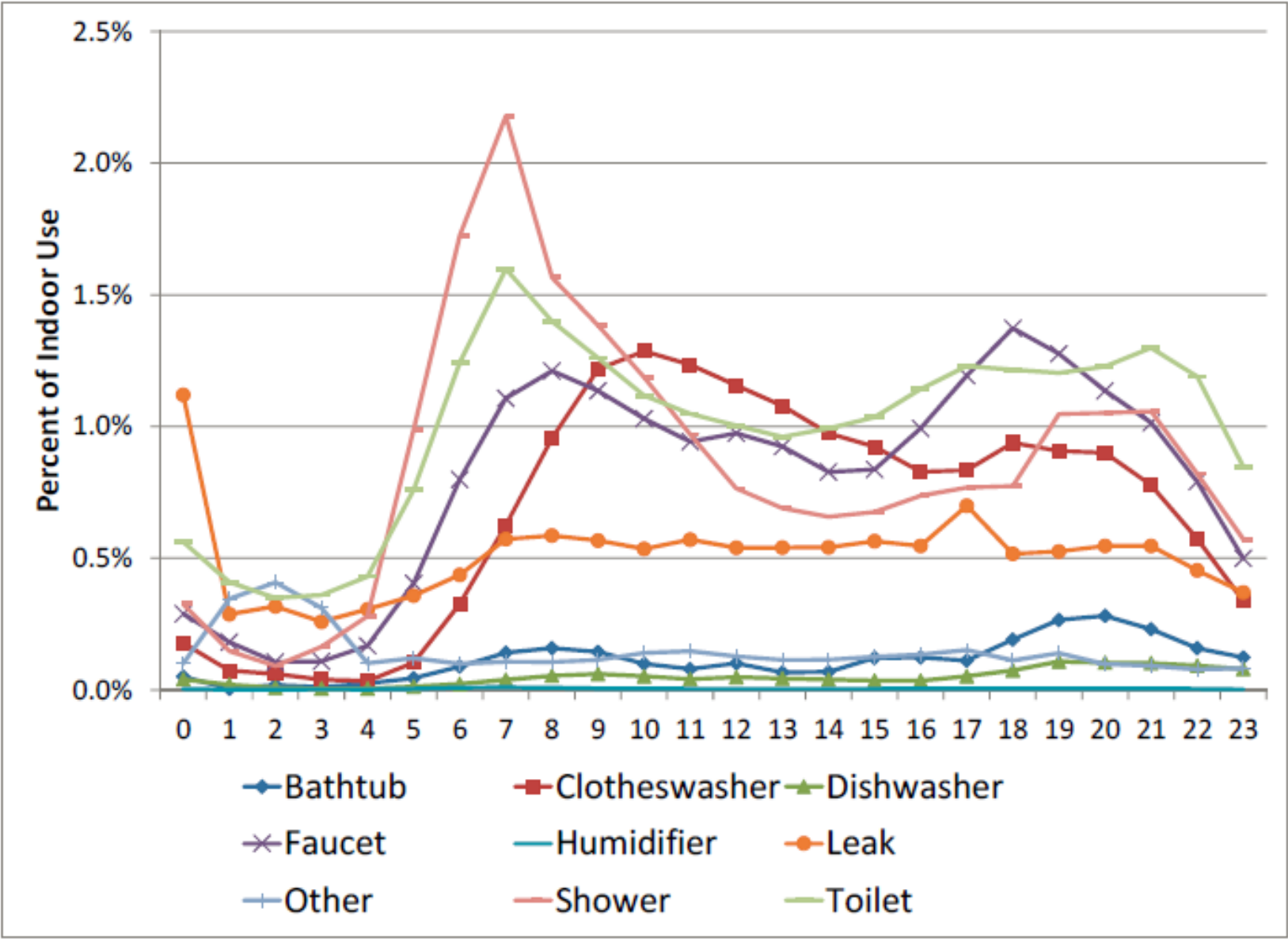
High Leakage Homes

Survey Item	Percent in group of 21 high leak homes	Percent in all survey respondents	Ratio
Water feature	14%	2%	7.14
Auto fill system on pool	29%	5%	5.71
Pool	48%	13%	3.75
Leaky pool	5%	1%	3.66
Other leak	10%	3%	3.53
Leaky irrigation	10%	3%	3.17
Hot tub	29%	9%	3.14
Treatment	29%	15%	1.90
Other fixture or appliance not listed in survey?	14%	9%	1.59
Drip Irrigation	24%	15%	1.59
Ice Maker	86%	59%	1.45
Leaky toilet	10%	8%	1.27
In-ground irrigation	67%	53%	1.25
Dripping faucet	10%	8%	1.15
Evaporative cooler	5%	6%	0.79
Humidifier	10%	20%	0.48

Indoor Use Diurnal Curve



Indoor End Use Diurnal Curve



Residential Water Use is Variable

- REU2016 average annual per household water use was 88 kgal with a standard deviation of 32 kgal
- In REU1999 it was 146 kgal, but the location of study sites was quite different.
- Local weather conditions, the size of the irrigated area, the cost of water, and the type of plant materials are major drivers of outdoor use.
- Indoor use was less variable between participating study sites than outdoor use.

Indoor Use Reductions

- Average indoor per capita water use has decreased 15.4% from 69.3 gpcd (REU1999) to 58.6 gpcd (REU2016).
- Average indoor per household water use has decreased 22% from 177 gphd (REU1999) to 138 gphd (REU2016).
- Changes are due to more efficient fixtures and appliances, not occupancy or behavior.
- Primarily a result of high efficiency clothes washers and toilets.

Expect Further Indoor Reductions

- Substantial additional indoor conservation potential exists.
- Current average daily indoor per capita use of 58.6 gpcd is expected to reduce to below 40.0 gpcd through replacement of old toilets and clothes washers.
- Reductions below these levels can be expected as future fixtures and appliances become even more efficient and customer side leakage is reduced through automated metering and leak alert programs.

Outdoor Variability

- The majority of study participants in the Landscape Group (72%) applied considerably less water to their landscapes than was theoretically required.
- Another 16% of participants applied an amount of water that was close to the theoretical requirement.
- About 13% of participants applied in excess.

Targeting

- Outdoor efficiency can be maximized by targeting efforts at customers that are over-irrigating.
- Prevent deficit irrigators from increasing their irrigation to help maintain demand reductions.
- Pricing programs and reduction in planting areas may achieve outdoor demand reductions beyond efficiency measures.
- Savings estimates for landscape conservation programs range from 20% reduction to 50% for more aggressive programs that include price increases and reductions in areas requiring irrigation.

Thank You!

Questions on Part 2

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