Synergistic Water and Energy Demand Modeling and Management

1960

1977

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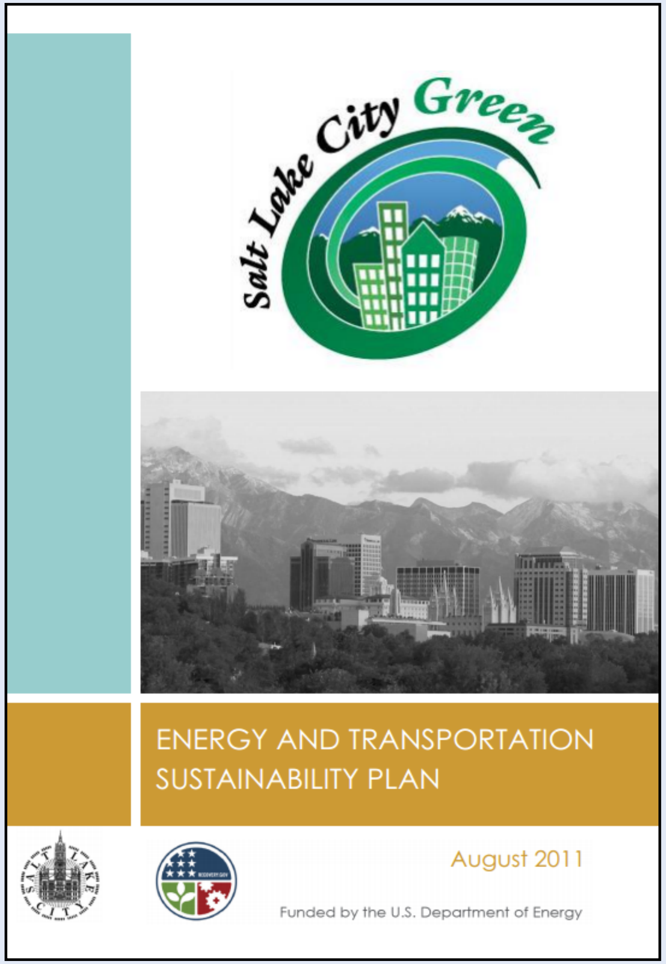
Smart Systems for Water Management
Monte Verita, Switzerland

UtahStateUniversity
Utah Water Research Laboratory
UWRL

Utah's Conservation Targets

Reduce 2000 water use by 25% by 2025

Reduce 2005 emissions by 80% by 2050



Motivating Questions

1) What home-owner actions **jointly** conserve **water** and **energy**?

2) Which **cost effective** actions should cities synergistically promote?

3) How to **target** households to adopt actions?

4) What is next?

Data-Driven Simulation-Optimization
(PhD research of Adel Abdallah)

1. Collect high-freq. behavior data
2. Identify key parameters & distributions
3. Monte Carlo simulate
4. City-scale optimization
5. Mine results to target

High-Frequency Behavioral Data

Water (Aquacraft, 2005, 2009)

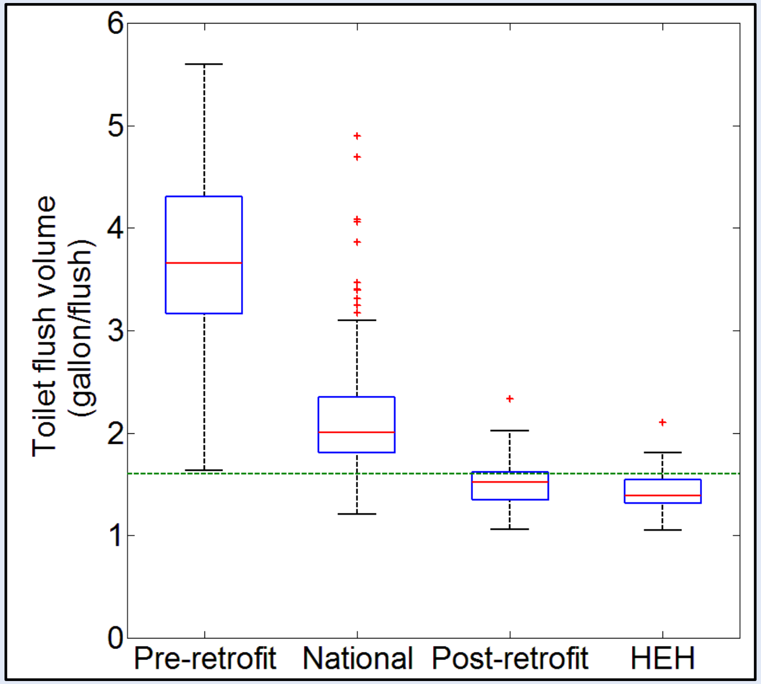
Energy (DOE, 2009)

- Water heater market shipments (709 models)
- Plumbing/heating contractor firms (343)
- Average annual potable water temperatures (74 cities across the U.S.)

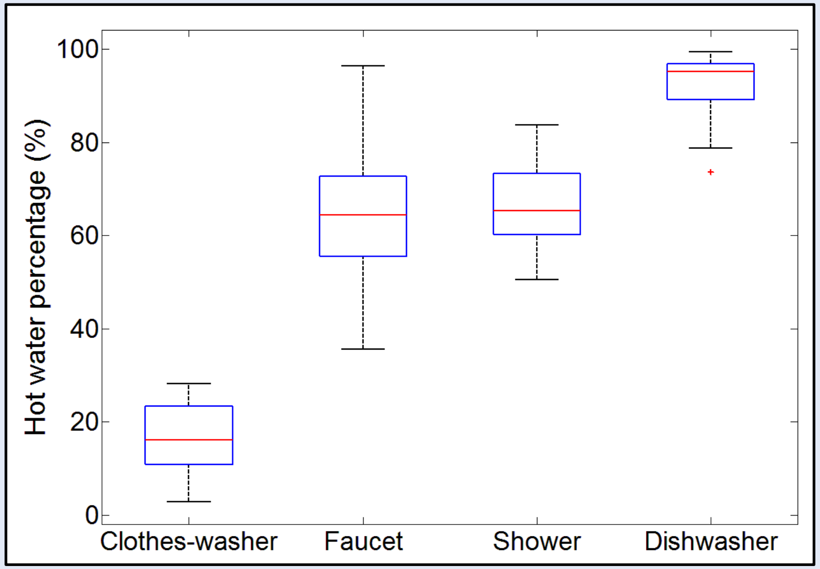
Dataset	Number of Cities	Data collection period	Number of houses	Monitoring days	Water use events
USEPA Retrofit	3	2000-03	88	4,036	753,076
New Single Family Homes	9	2005-09	305	3,885	648,719

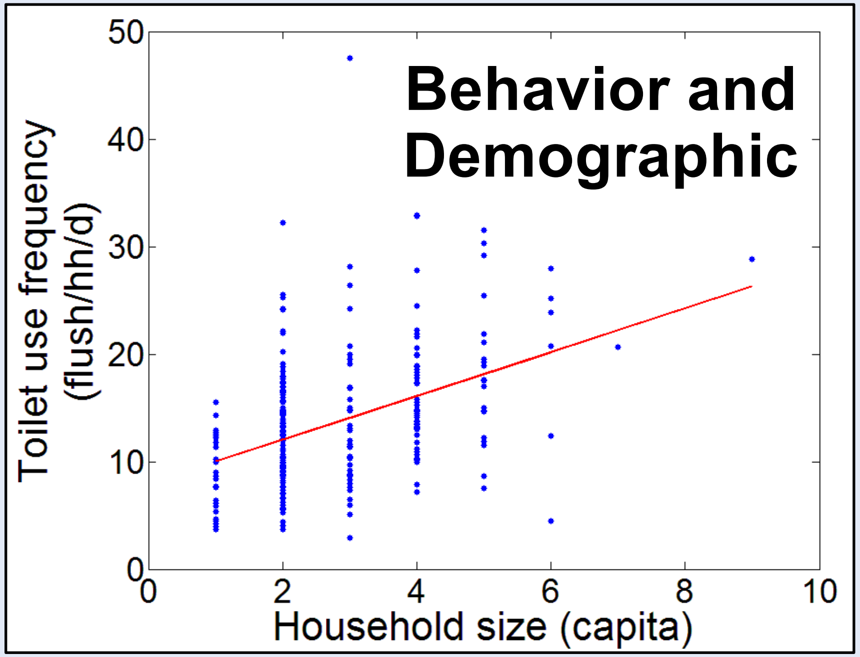
Key Parameters

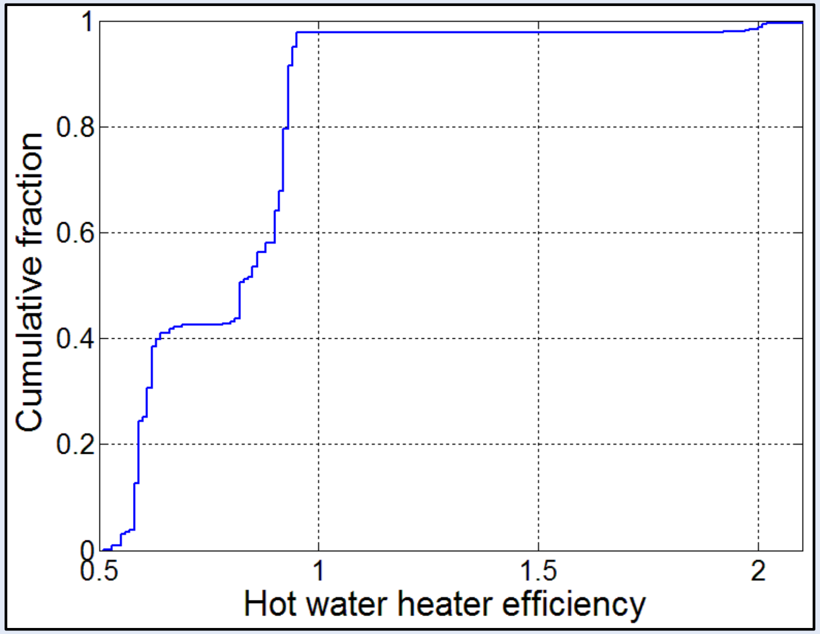
Technology



Energy Factors

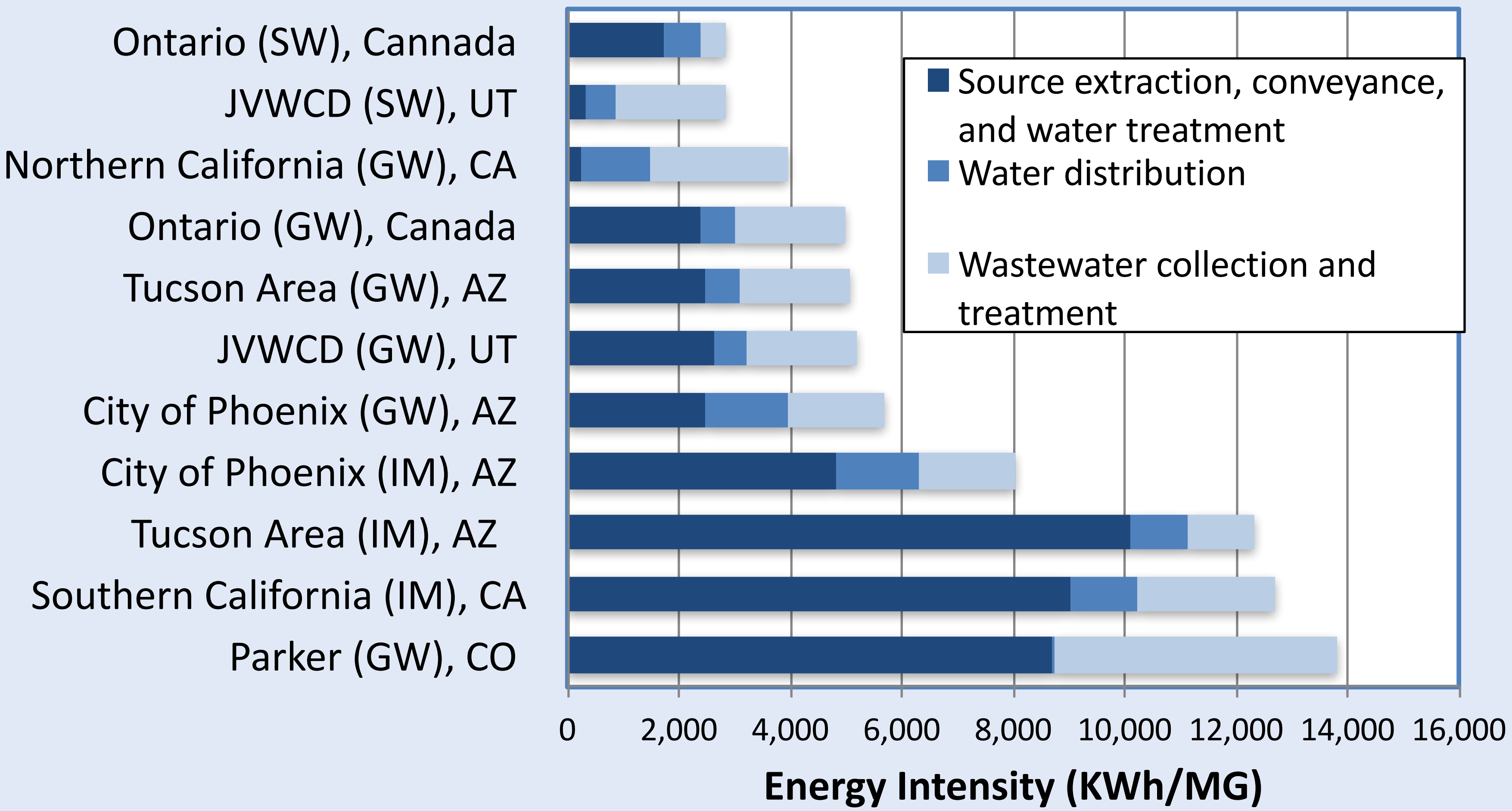






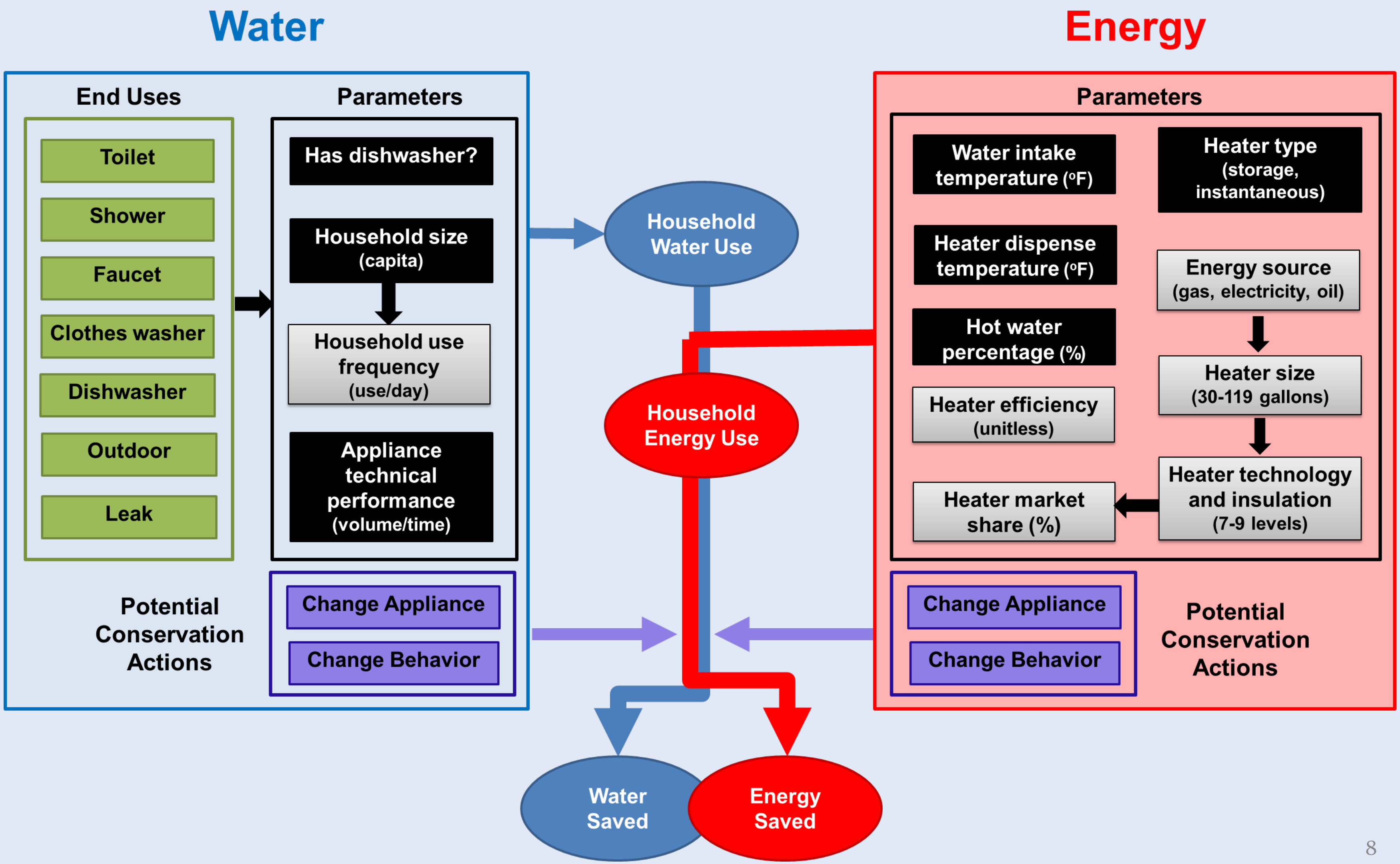
Energy Embedded for Utility Operations

(~1/15 energy needed to heat water inside the home 92,000 KWh to heat one million gallon of water)

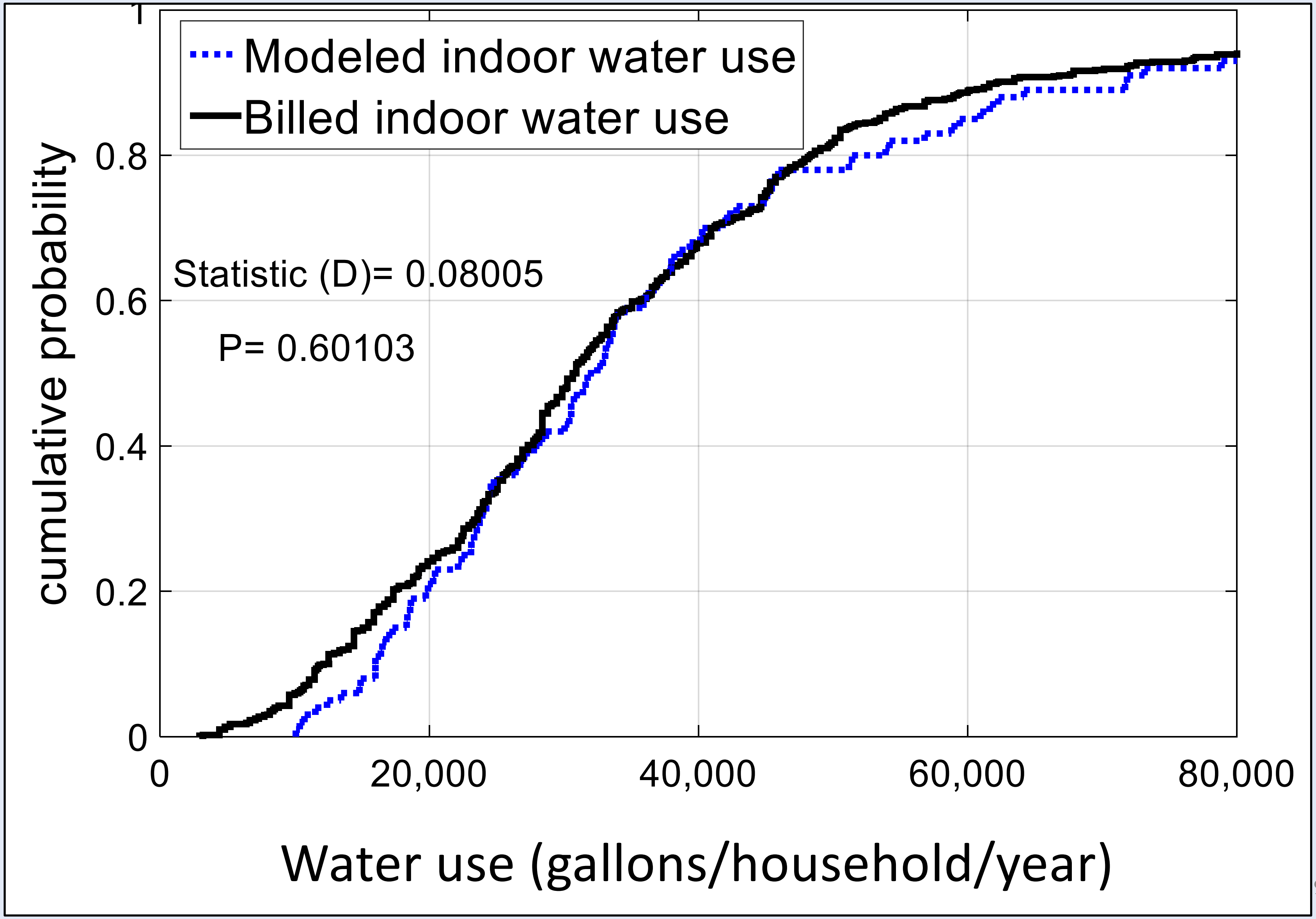


Monte Carlo Simulation

(1,000 households)

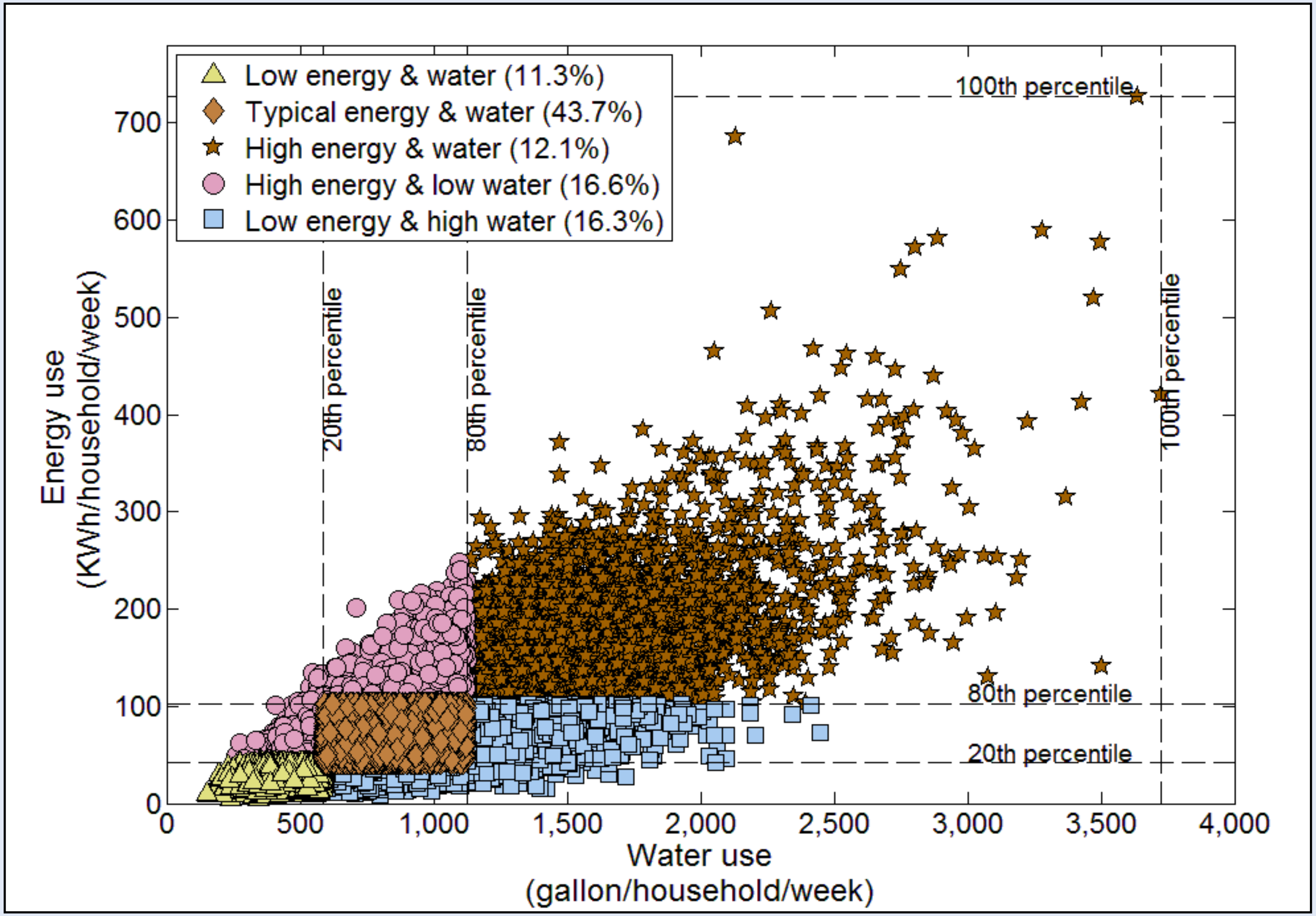


Model Calibration – Salt Lake City



Simulated indoor water and energy uses

(largest 12% of users use 21% and 24% of water and energy)



City-Scale Optimization

Decisions

Conservation actions implemented (binary) by:

- Household (1,000)
- End use/Appliance (8)
- Method (4)

Objective function ($)

Minimize total cost to implement conservation actions

Subject to:

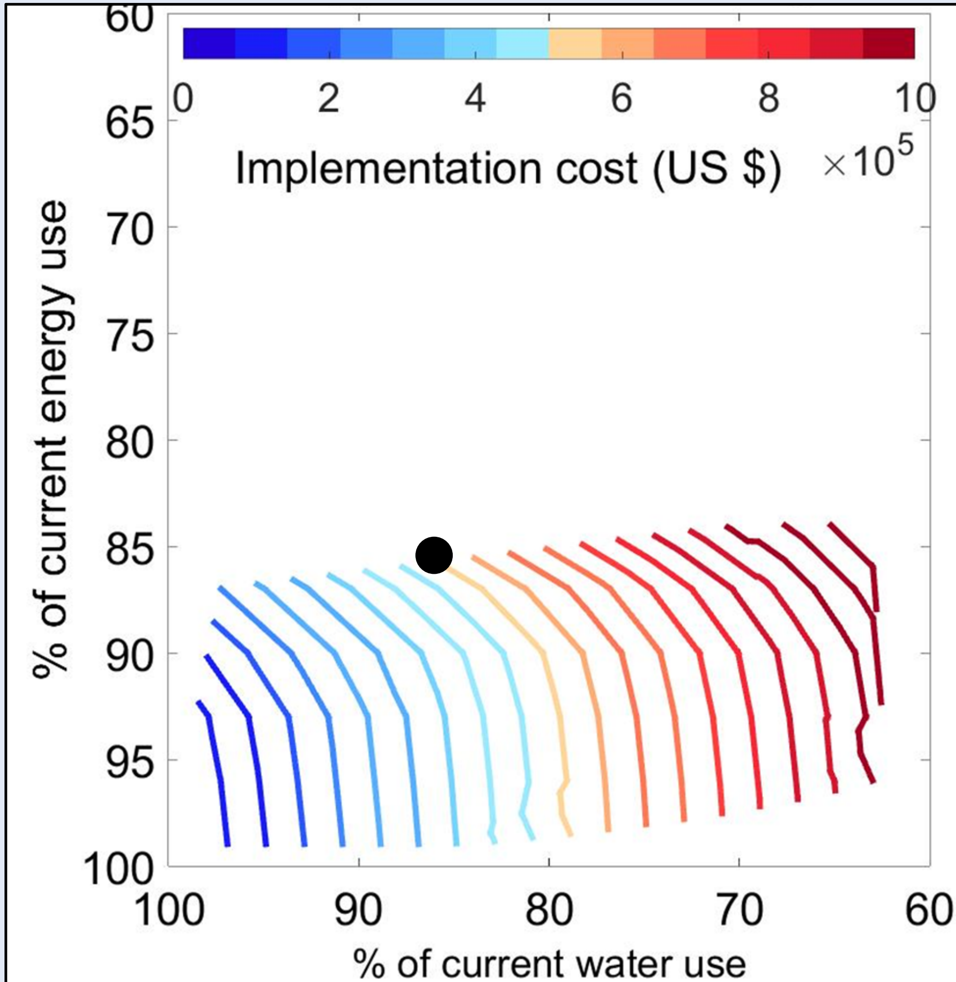
- Meet city water reduction target
- Meet city direct energy reduction target
- Lower and upper bounds on number of actions
- Mutually exclusive actions
- Upper bound on payback period for actions

GAMS

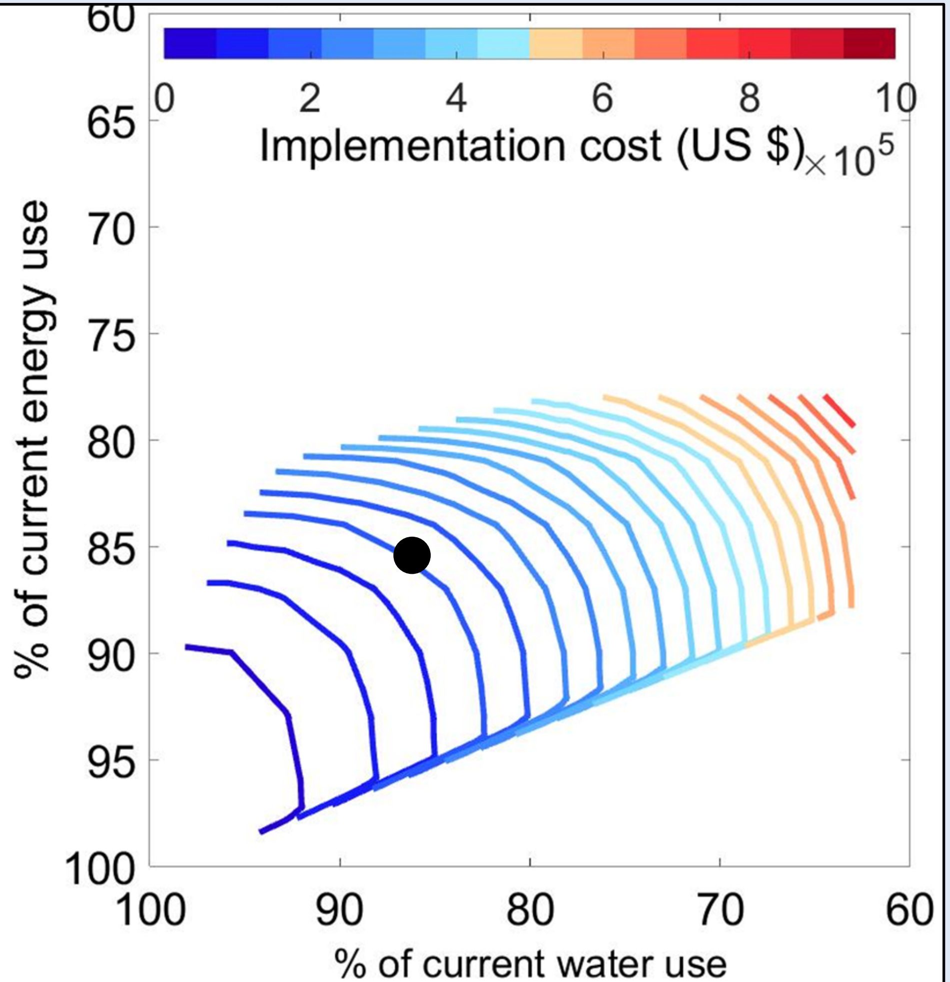
Action	Cost
Retrofit toilet	$150
Retrofit shower	$40
Retrofit faucet	$40
Retrofit clothes washer	$500
Reduce outdoor 10%	$200
Lower heater to 120ºF	$100

Costs to meet reduction targets

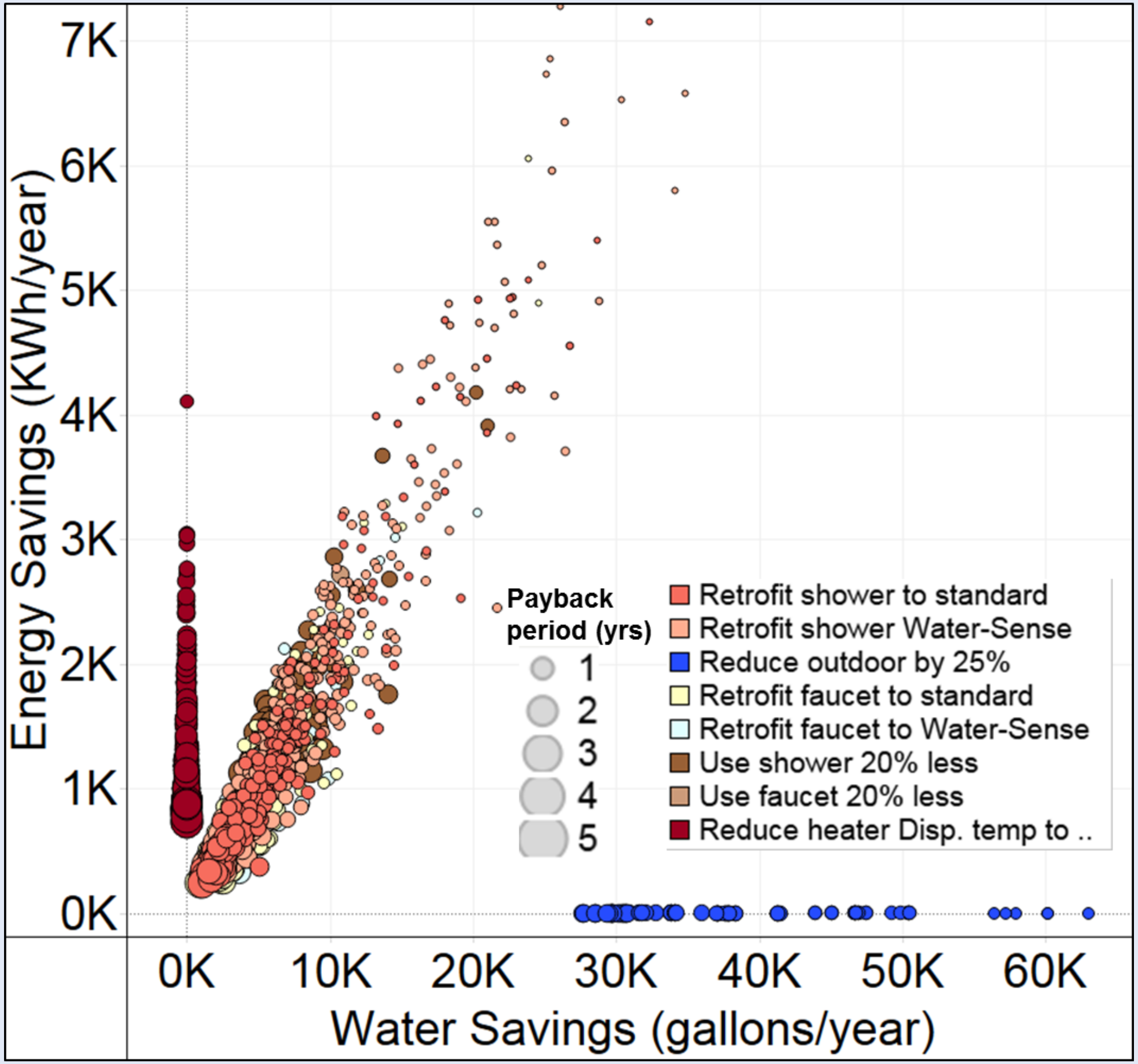
Mass-Applied



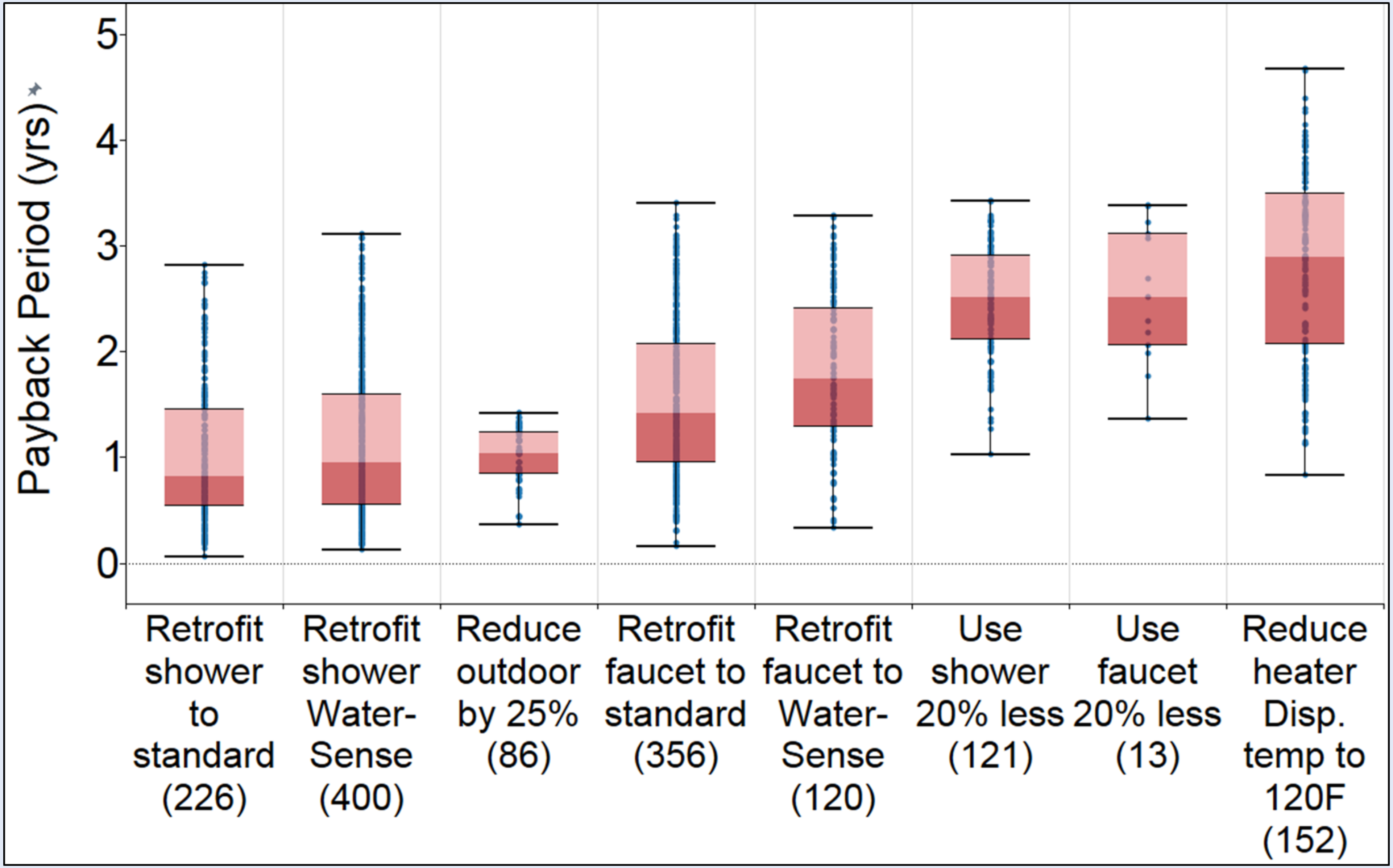
Targeted



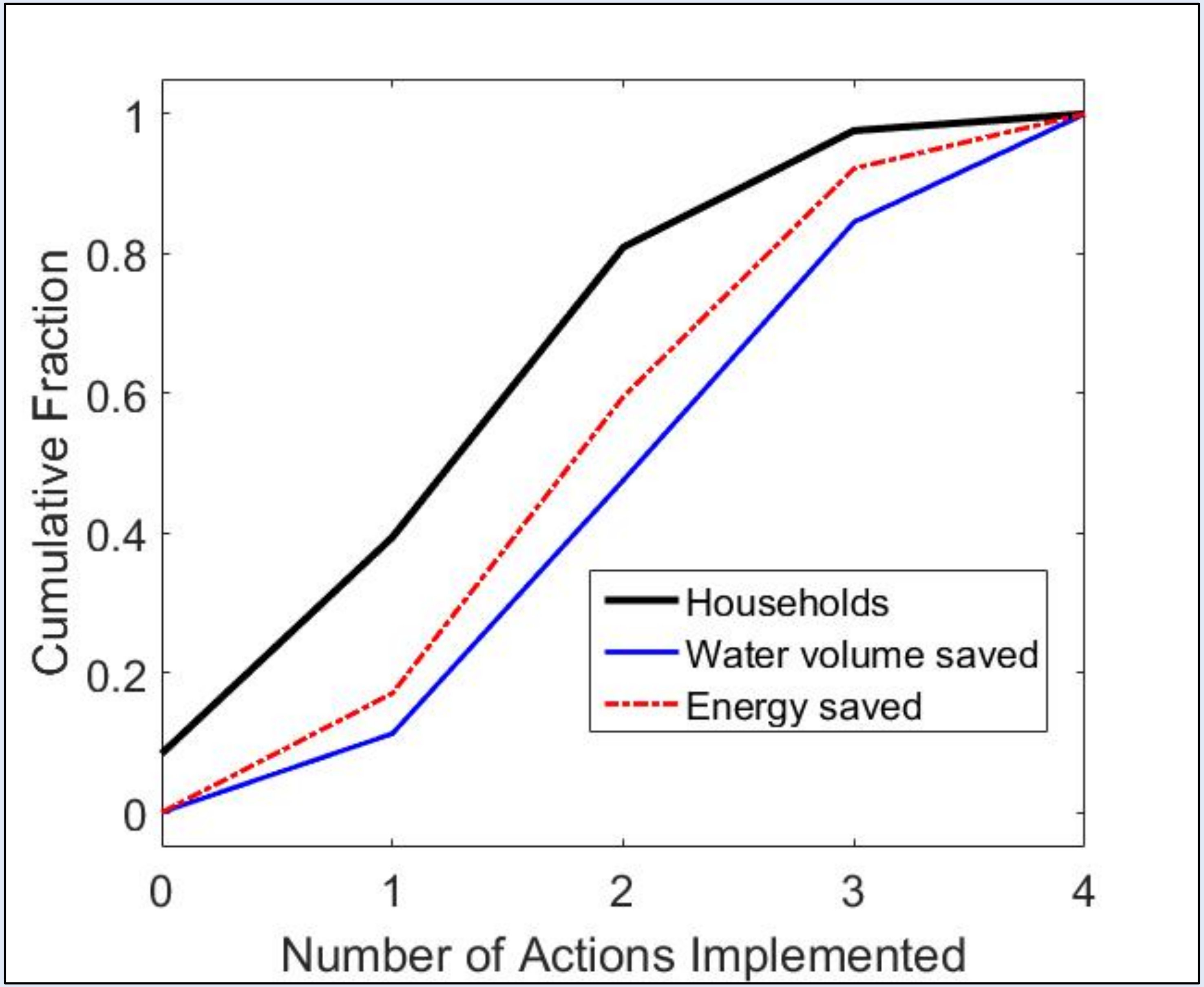
Heterogeneity of household savings and payback periods



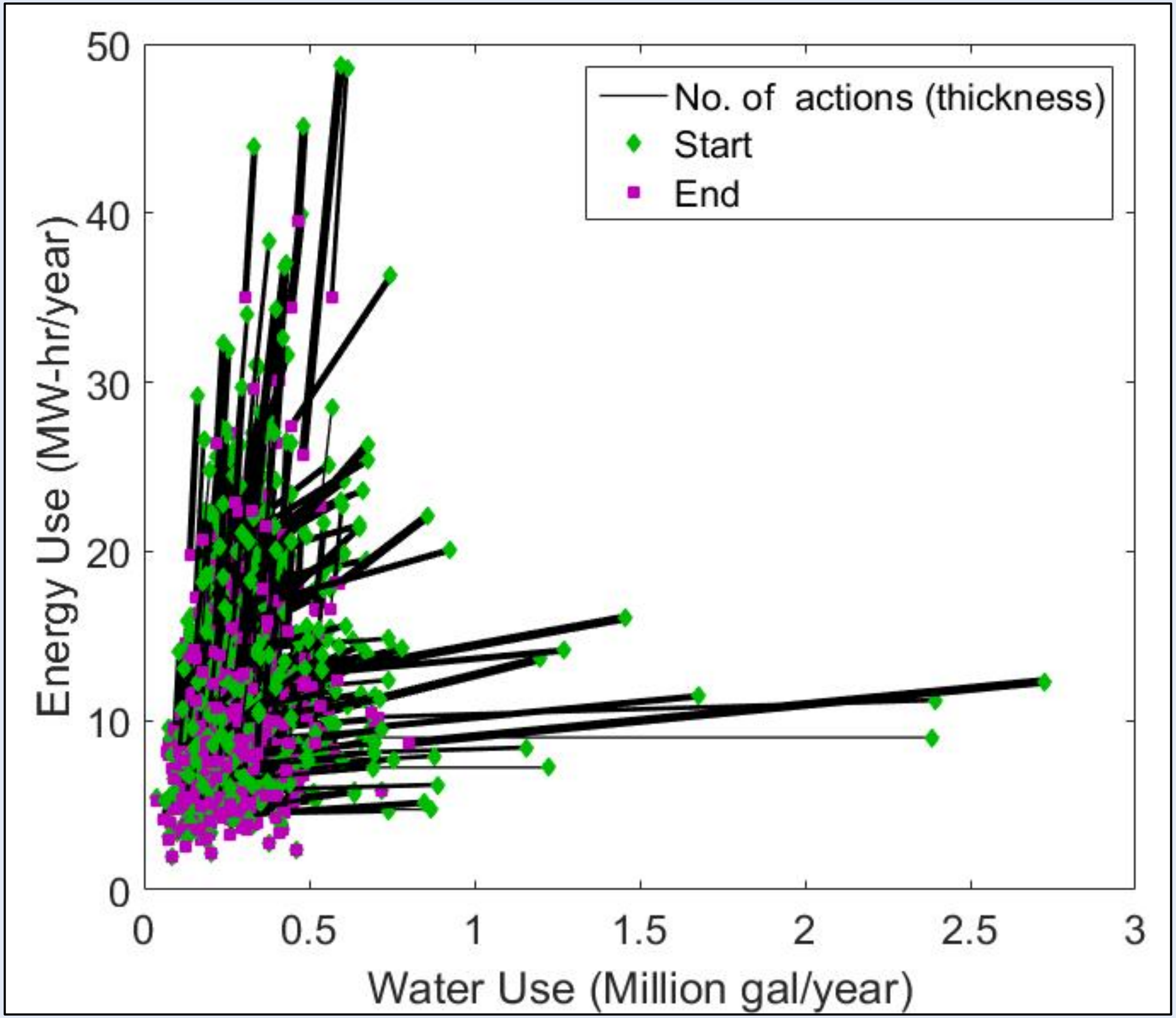
Payback periods for actions



Household share of conservation effort



Identifying who to target

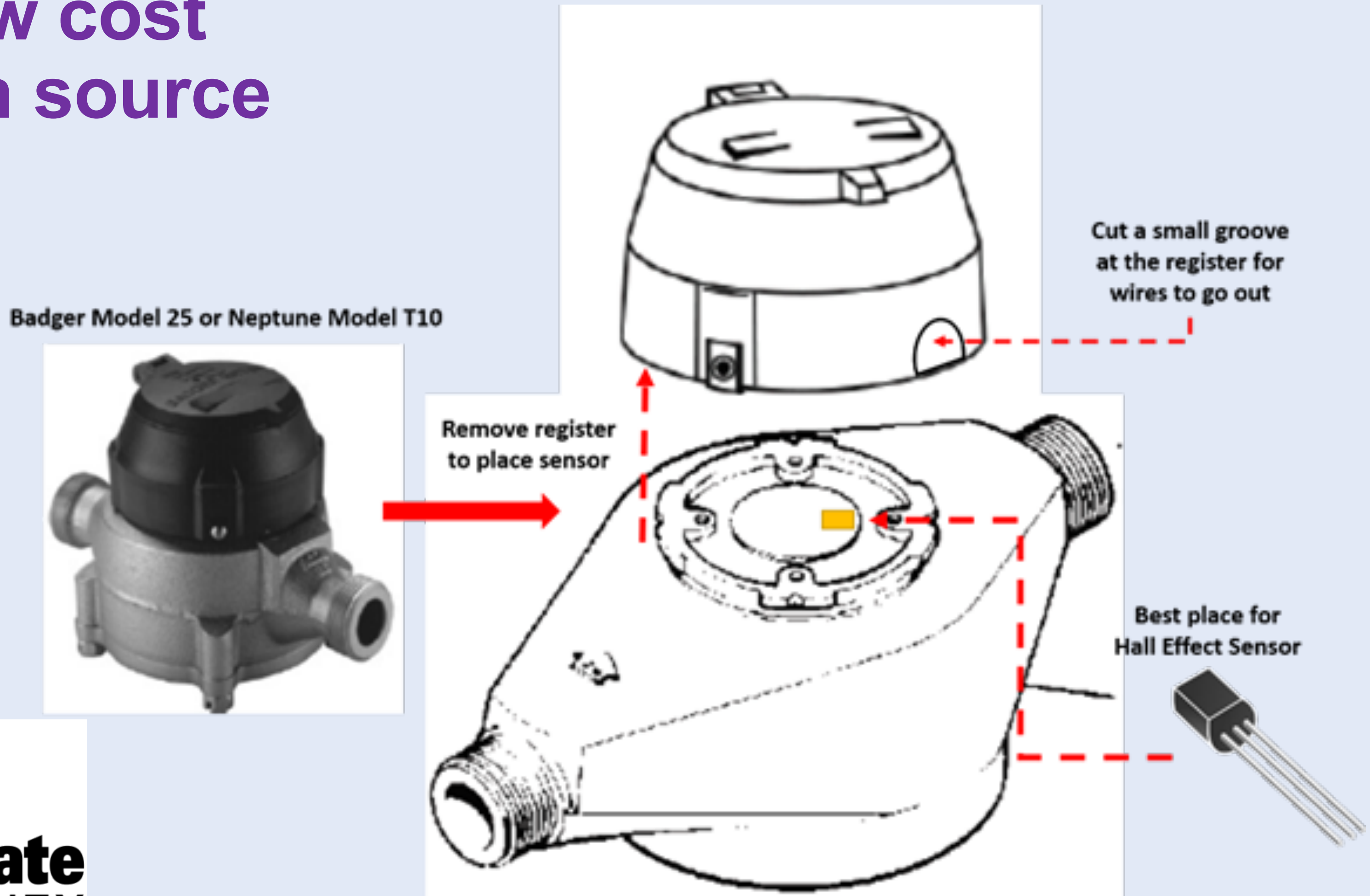


Apply the results

- **Target** customers with large water and/or energy use
- **Encourage** to implement one or more conservation actions
- Shower + faucet actions save water + energy with shorter payback periods
- **Reduce** heater temperature to save energy
- Outdoor conservation actions save water

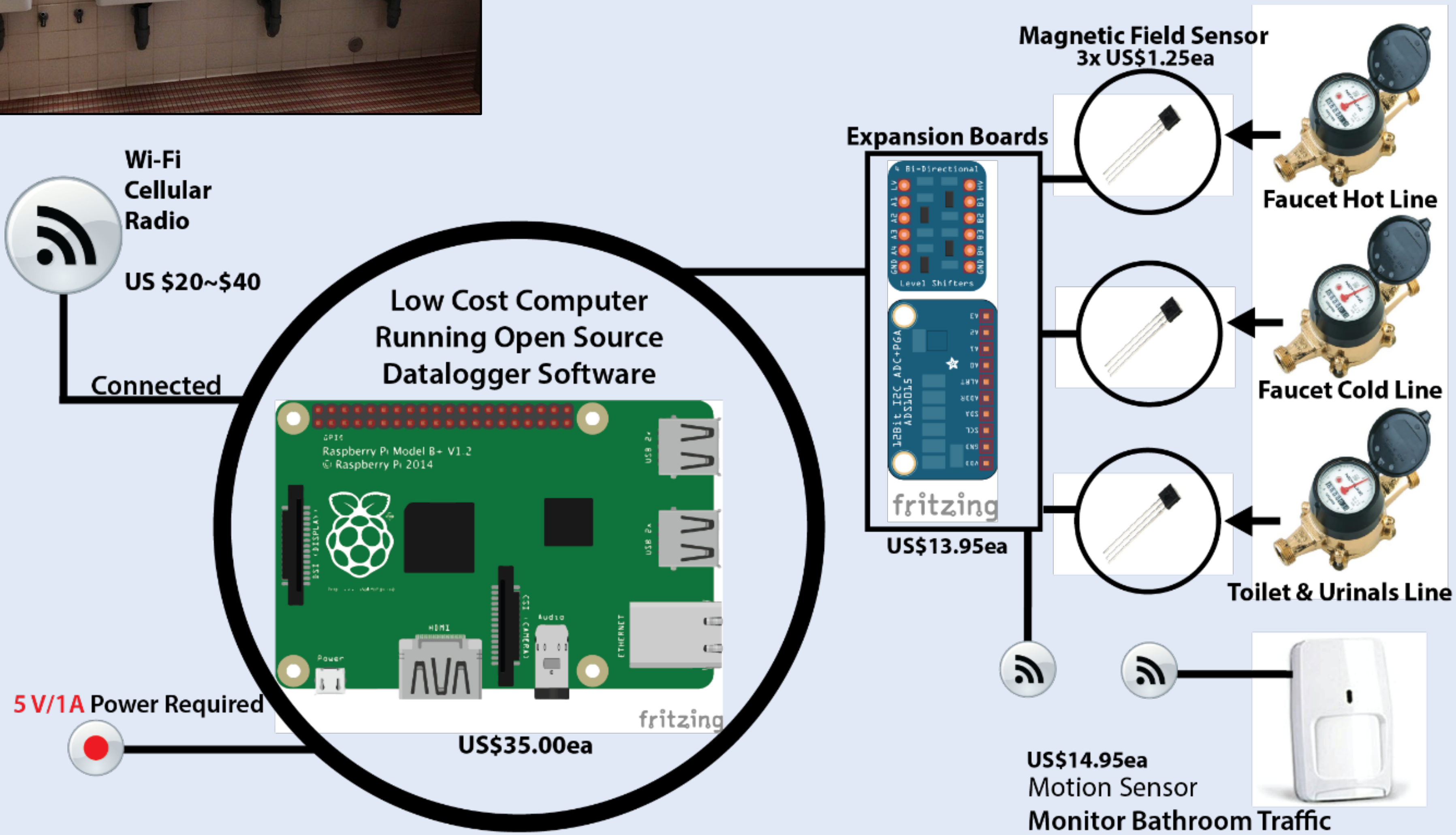
Make Dumb Meters Smarter

Low cost
Open source

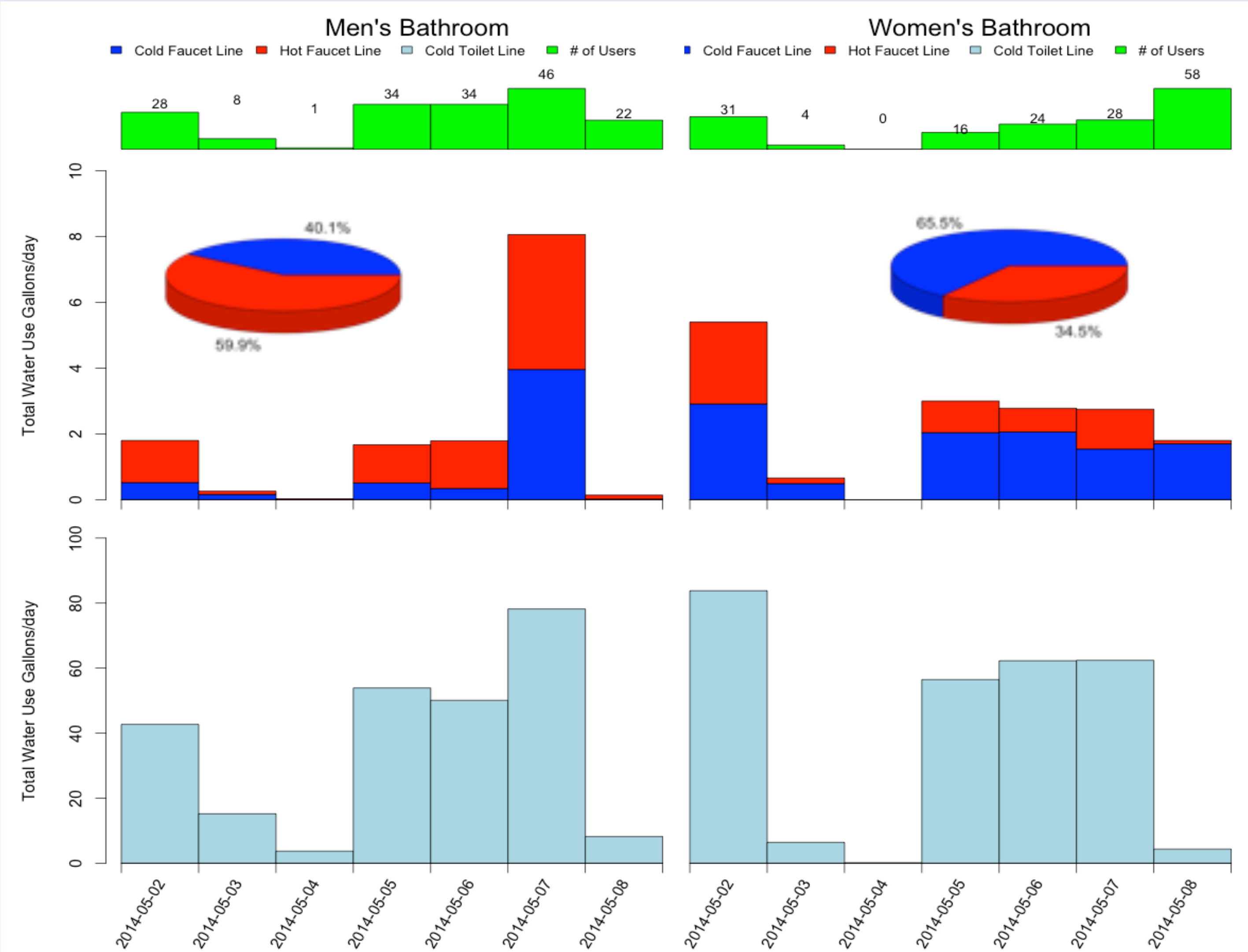


UtahState UNIVERSITY

USU Business Building Male + Female Bathrooms



Preliminary results



Other Locations

- Single-family residences
- Dormitories
- Non-residential users

Smarter Water-Energy Monitoring Activity (10 min)

Where to place low-cost, open-source computers and sensors to synchronously monitor a household's water and energy use at high frequency?

- Discuss in small groups (2-3 people)
- Enter recommendations at: http://tinyurl.com/govvlvp

Conclusions

- Couple high-frequency data collection with simulation and optimization modeling
- Salt Lake City, Utah can save substantial water and energy
- Several actions save water and energy simultaneously with short payback periods
- Profile and target to motivate savings

Further Info

- Adel Abdallah and David E. Rosenberg (2014). "Heterogeneous Residential Water and Energy Linkages and Implications for Conservation and Management." ASCE-Journal of Water Resources Planning and Management. 140(3). pp. 288-297. doi: 10.1061/(ASCE)WR.1943-5452.0000340.

- Francisco Suero, David E. Rosenberg, Peter Mayer (2012). "Estimating and Verifying United States Households' Potential to Conserve Water." *ASCE-Journal of Water Resources Planning and Management*. 138(3), pp. 209-306. doi: 10.1061/(ASCE)WR.1943-5452.0000182.

Questions?

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CI-WATER

A Utah-Wyoming water science and cyberinfrastructure collaboration

Salt Lake City, Utah Public Utilities