Identifying Collaborative Residential Water and Energy Conservation Programs

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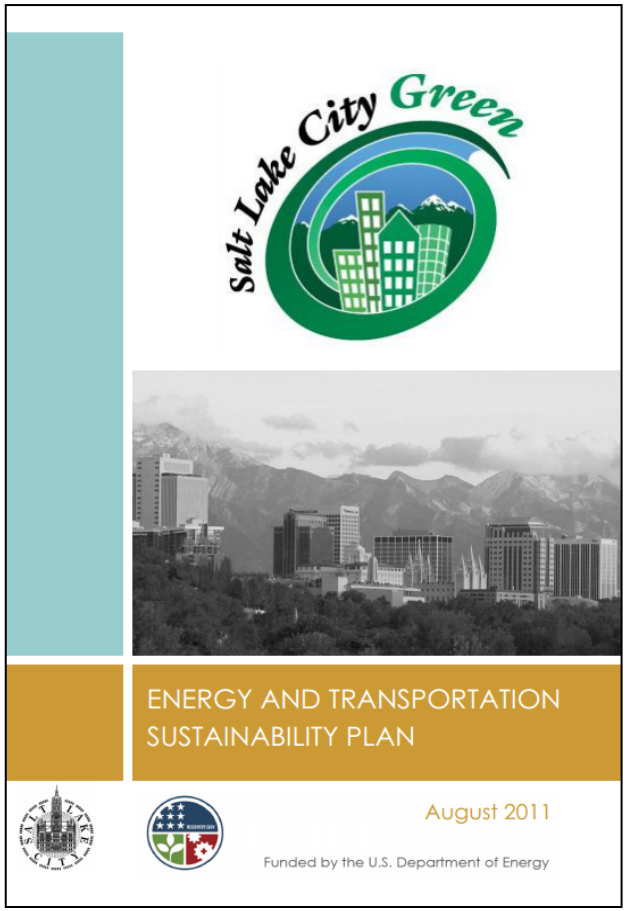
Utah's Conservation Target

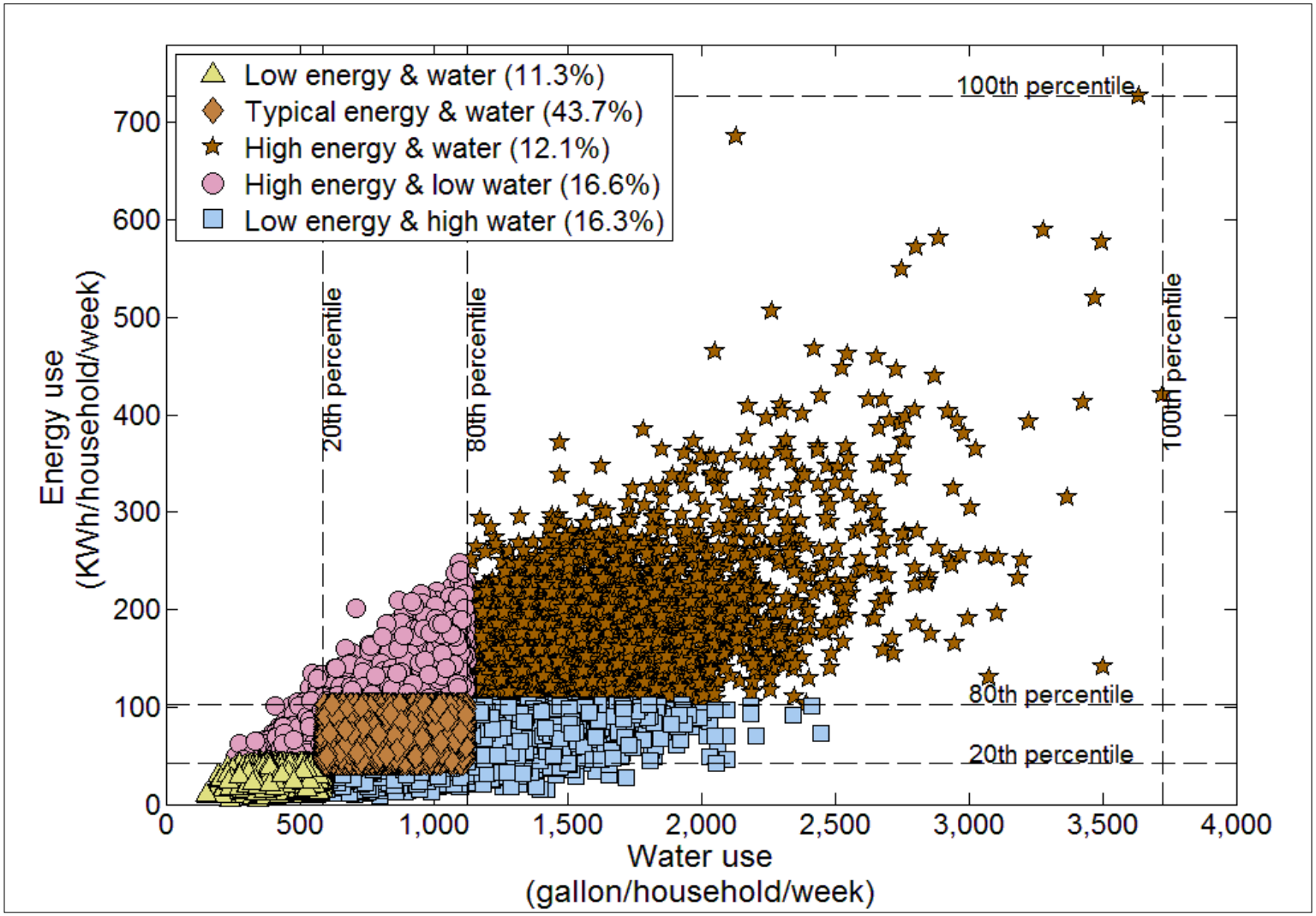
Reduce water use by 25% from 1995 to 2025

Reduce emissions by 80% from 2005 to 2050



Heterogeneous water and energy and uses

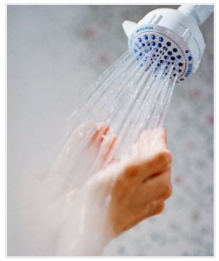
(largest 12% of users use 21% and 24% of water and energy)



How can we exploit urban water-energy uses to collaboratively conserve both resources?

- Objectives
- Simulation/ Optimization
- Results
- Follow up work
- Conclusions

Direct Energy

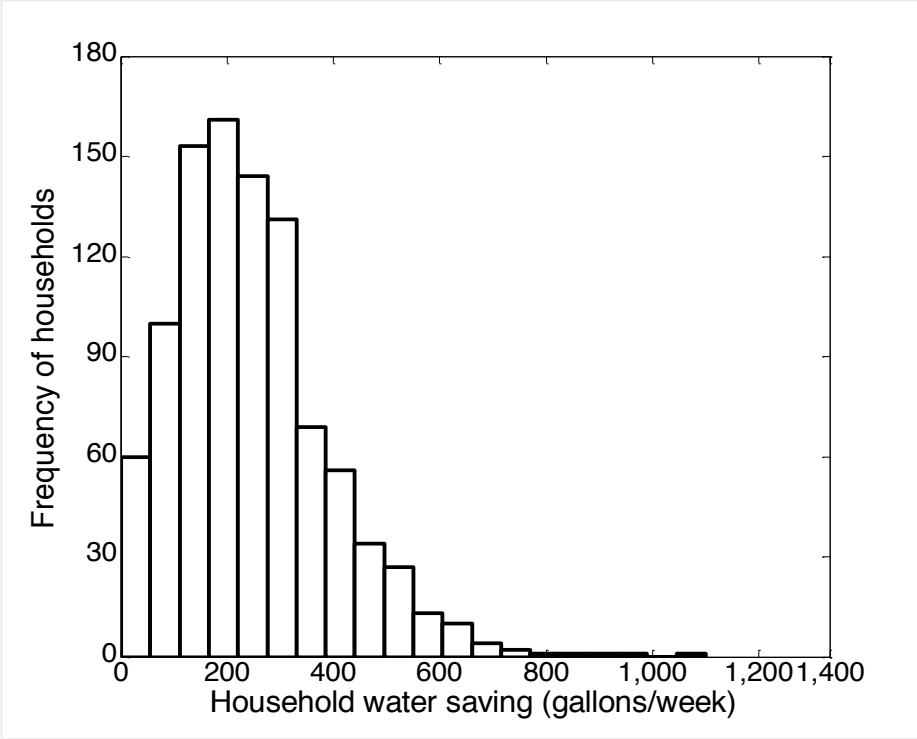


Embedded Energy

Objectives

- Identify feasible city-wide collaborative water and energy conservation targets
- Select and size water and energy conservation programs
- Identify synergies and tradeoffs between water and energy
- Consider payback periods of actions

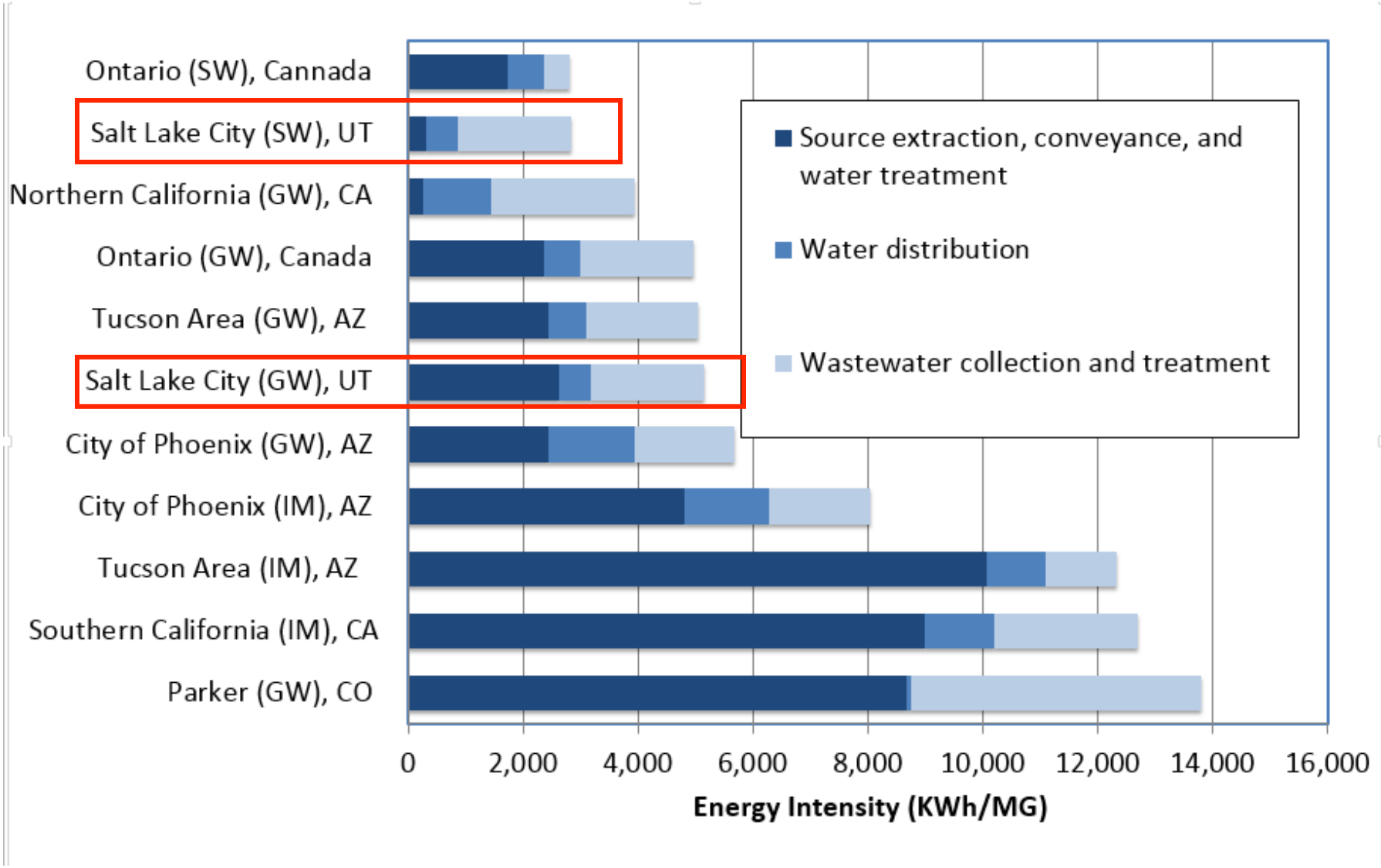
Targeted approach



Action	Cost ($US)
Retrofit toilet to stand.	342
Retrofit Shower to stand.	30
Retrofit faucet to stand.	50
Retrofit clotheswasher to stand.	819
Reduce outdoor by 10%	200
Lower heater set point temp to 120 F	200

$$City\ Water\ Savings = \sum_{hh} (Savings_{hh})$$

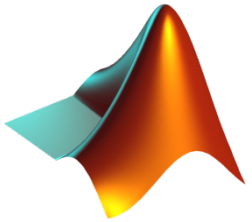
Energy embedded to treat, pump, distribute water plus treat wastewater



Modeling Methods

Simulation (Monte Carlo Simulations)

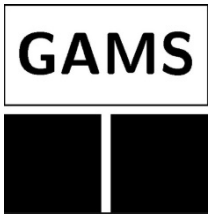
- Sample 1,000 households in Salt Lake City
  - 50% of households have old appliances
  - Water heater type
  - Demographic, technologic, behavior factors



- Estimate HH water and energy
  - Use
  - Savings by adopting conservation actions

Optimization (Mixed integer linear program)

- Find feasible city-wide water and energy savings
- Identify actions that minimize cost to meet targets



Optimization model formulation

Decision variables

Conservation actions implemented

- Binary by appliance and household (e.g., retrofit all toilets in a house or not)

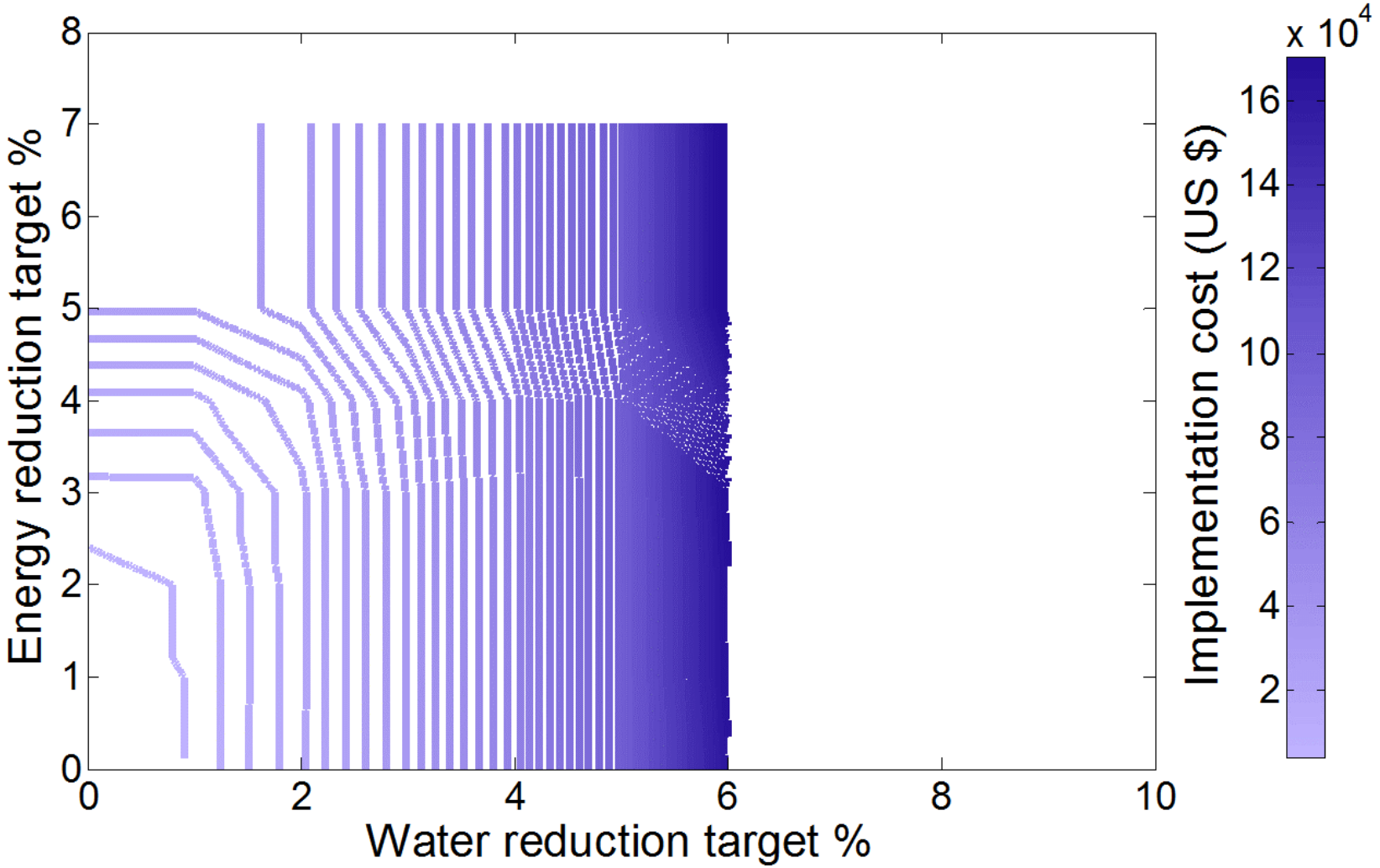
Objective function ($)

Minimize city-wide implementation cost of conservation actions

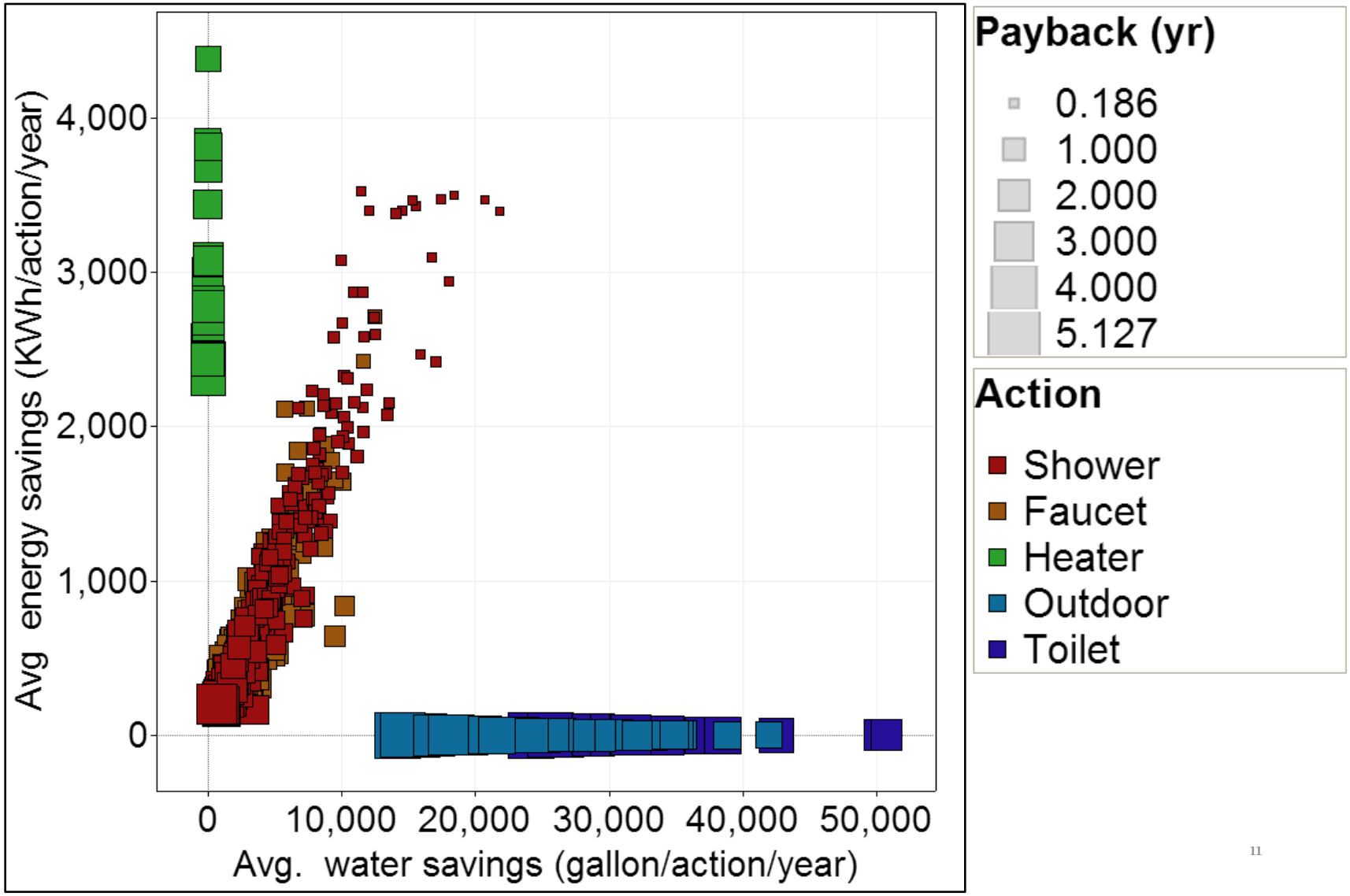
Subject to:

- Meet city water reduction target
- Meet city direct energy reduction target
- Lower and upper bounds on city conservation actions
- Upper bounds of payback period for actions (5 years)

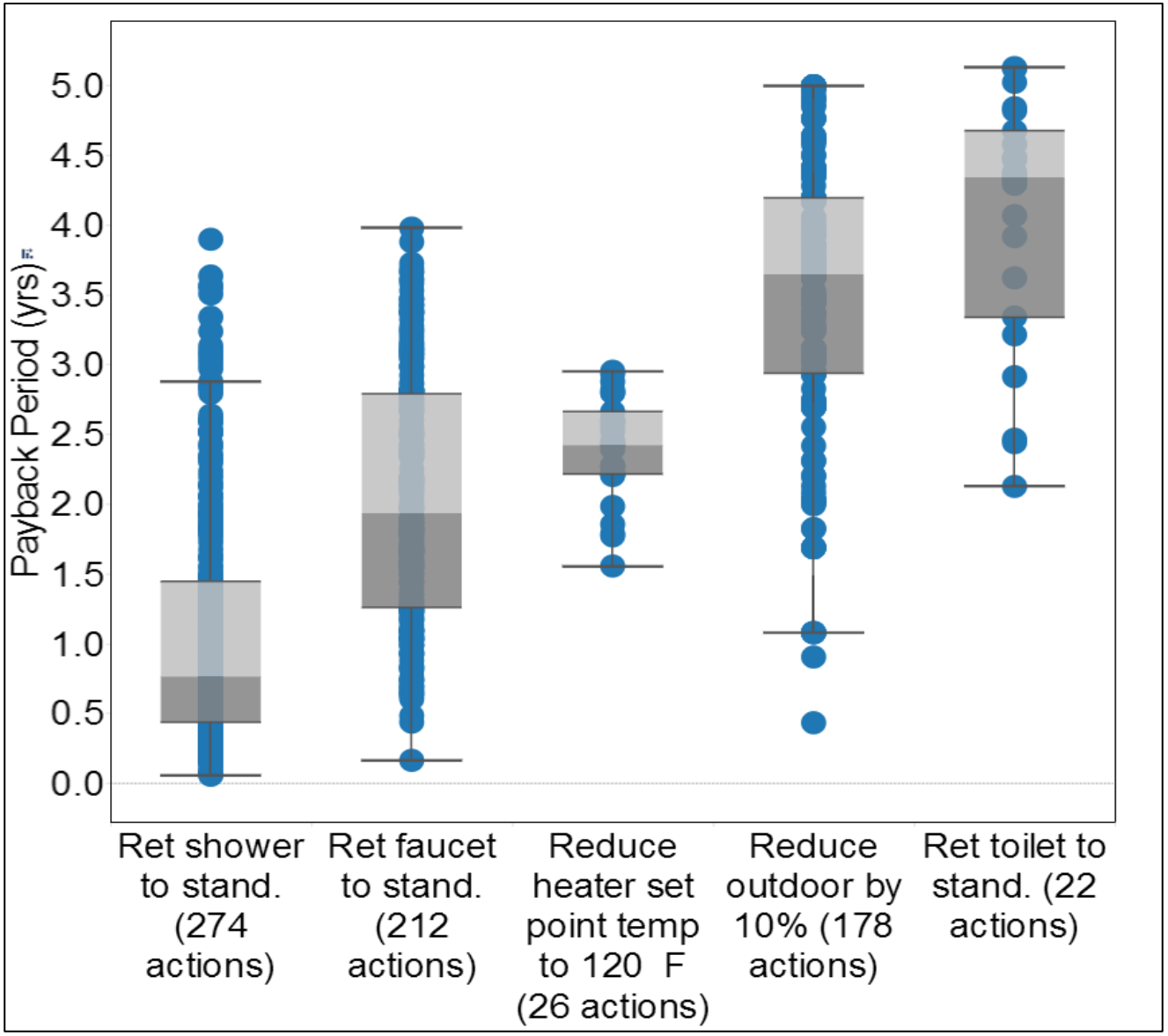
Cost to achieve reduction targets



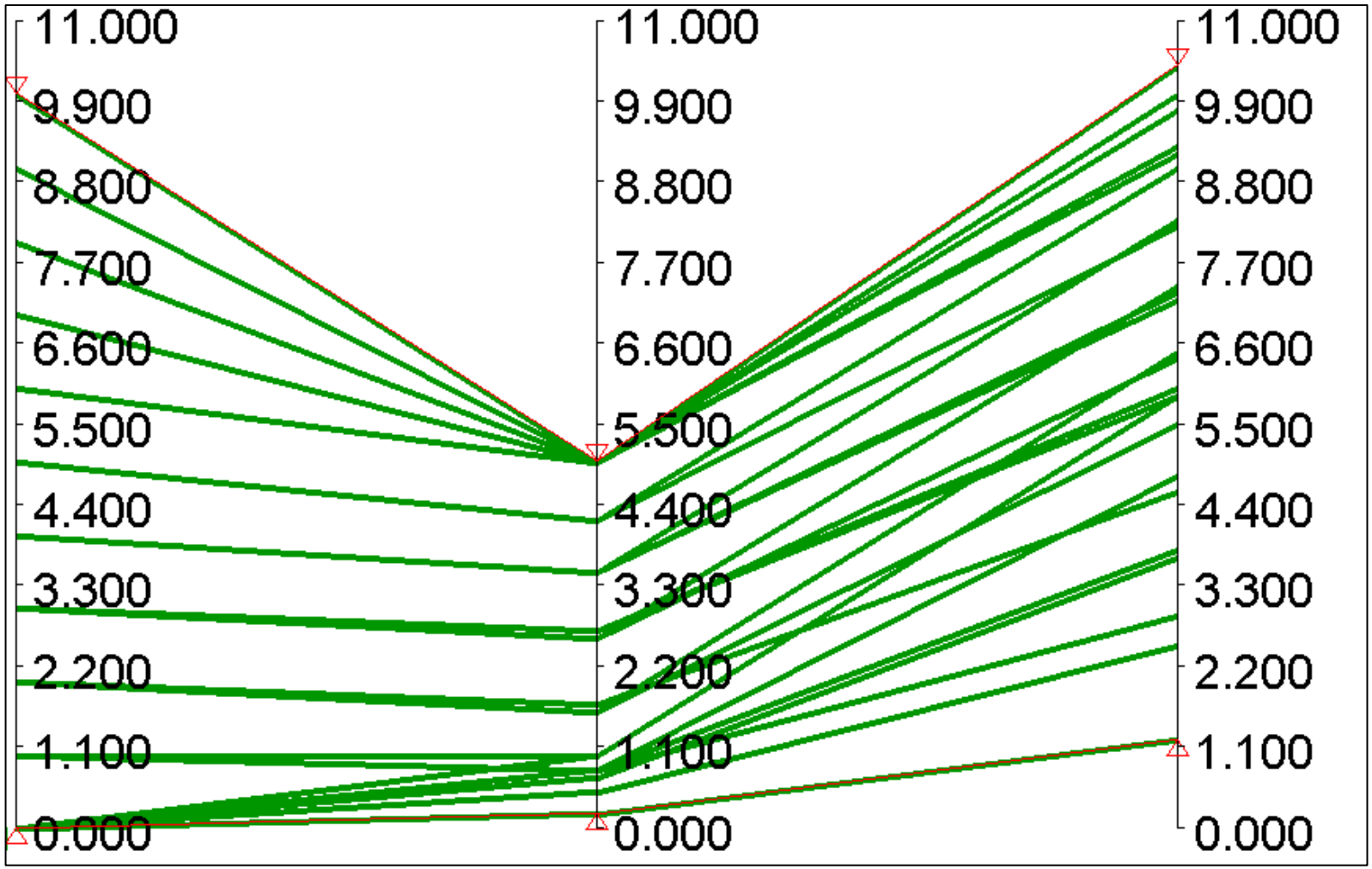
Heterogeneity of household savings and payback periods



Range of payback periods for actions



Contribution of Embedded Energy



Applying the results

- Profile customers
- Target customers with high potential to save
- Educate customers on potential for short payback period
- Motivate customers to act, e.g.
  - 712 water and energy actions for 172 households
  - Save ~7 MG/year ($1,000/MG) and ~ 2,500 KWh/ year ($26/KWh) embedded energy

Further work

Work with Salt Lake City Public Utilities:

- Represent ~40,000 single-family households
- Adjust embedded energy by topography
- Include more conservation actions and their interactions
- Leverage High Performance Computing (HPC) to compute in parallel

Conclusions

- Heterogeneous water and energy savings and payback periods
- Profile, target, educate, and motivate savings
- SLC can save 10% water and 8% energy
- Strong potential to coordinate water and energy conservation efforts

Thank you!
Questions?

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