Identifying Collaborative Residential Water and Energy Conservation Programs

EWRI CONGRESS
June 3, 2014

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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
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

\[
\text{City Water Savings} = \sum_{hh} (\text{Savings}_{hh})
\]

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit toilet to stand.</td>
<td>342</td>
</tr>
<tr>
<td>Retrofit Shower to stand.</td>
<td>30</td>
</tr>
<tr>
<td>Retrofit faucet to stand.</td>
<td>50</td>
</tr>
<tr>
<td>Retrofit clotheswasher to stand.</td>
<td>819</td>
</tr>
<tr>
<td>Reduce outdoor by 10%</td>
<td>200</td>
</tr>
<tr>
<td>Lower heater set point temp to 120 F</td>
<td>200</td>
</tr>
</tbody>
</table>
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

![Graph showing the relationship between energy and water reduction targets and implementation costs.](image)
Heterogeneity of household savings and payback periods
Range of payback periods for actions

- Ret shower to stand. (274 actions)
- Ret faucet to stand. (212 actions)
- Reduce heater set point temp to 120 F (26 actions)
- Reduce outdoor by 10% (178 actions)
- Ret toilet to stand. (22 actions)
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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