ESTIMATING WATER END-USE DEVICES IN THE COMMERCIAL AND INSTITUTIONAL SECTORS

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Introduction

- A true benefit-cost analysis of water conservation best management practices (BMPs) requires:
  - End use inventory of water using devices
  - Their water use efficiency
  - Their frequency of use
Literature Review

- Past studies regarding commercial and institutional (CI) water use have focused on:
  - Aggregate subsector water use
  - General “percentage” end-use break downs
  - Macro “utility-wide” methodologies for estimating conservation potential
  - Pre-selected subsectors
Scope of this Study

- Study presents a methodology to estimate:
  - CI Restroom water use
    - Estimates on number of restroom fixtures,
    - Their water use efficiency, and
    - Frequency of use at the parcel level
  - CI water use attributable to sprinkler systems
    - Subsector-specific water use coefficients
  - Allows cost and water saving data to be incorporated into the BMP optimization model that is part of EZ Guide
Data-driven Approach

- Florida Department of Revenue (FDOR) provides:
  - Land use code,
  - Effective year built, and
  - Building and parcel area for all 9 million parcels in Florida

- FDOR serves as the foundation database for EZ Guide
  - Relationships for residential indoor and outdoor, and CI aggregate water use have already been developed
Restroom End Uses – Fixture Count

- Based on Florida plumbing and building code
- FL plumbing code
  - Provides minimum toilet, faucet, and shower fixture requirements for 24 building types
  - Coefficients in terms of building occupancy
- FL building code
  - Provides conversion from occupancy to square footage for 42 building types
Restroom End Uses – Fixture Count

• By linking the FDOR land use codes to FL plumbing and building code categories
  • Fixture count estimates per square foot of heated building area were developed
  • Allows for fixture estimates at the parcel level
  • Minimum of two toilets and faucets per building
  • For urinals: FL plumbing code states that a maximum of 50-67% of male toilets are replaceable by urinals
Restroom frequency of use driven by people

- By estimating how many, and for how long, people are in a building, one can estimate frequency of use
- Estimate is complicated since CI facilities have arrival and departure rates that vary widely

Solution: use functional population

- Defined as a building’s population normalized to 24 hours per day, and 7 days per week
- Derived from transportation modeling statistics on employment, visitor trips, and length of stay
- Coefficients from impact fee studies specific to Florida
- Can be mapped to FDOR
Restroom End Uses – Frequency of Use

- Functional population allows for the application of generic human frequency of restroom use estimates
- Mayer et al. (1999) gathered data indicating that the average person in a single family residence flushes a toilet 5.1 times per day
  - 24-hour equivalent = 7.65 flushes per person per day

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet (flushes/person/day)</td>
<td>2.52</td>
<td>7.56</td>
</tr>
<tr>
<td>Urinal (flushes/person/day)</td>
<td>5.04</td>
<td>0</td>
</tr>
<tr>
<td>Faucet (minutes/person/day)</td>
<td>12.15</td>
<td>12.15</td>
</tr>
<tr>
<td>Shower (minutes/person/day)</td>
<td>5.6</td>
<td>5.6</td>
</tr>
</tbody>
</table>
Restroom End Uses – Fixture Efficiency

- Florida’s plumbing code mandates water use efficiencies, provides historical information
- A fixture’s efficiency is thus a function of a building’s year built and a fixture’s replacement rate
- Replacement rate based on 20 year service life for toilets and urinals; 5 year service life for faucets and showerheads (Santa Clara Valley Water District 2008)

<table>
<thead>
<tr>
<th>Fixture Efficiency Group</th>
<th>Toilets (gal/flush)</th>
<th>Urinals (gal/flush)</th>
<th>Faucets (gal/min)</th>
<th>Showerheads (gal/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre 1983</td>
<td>5.0</td>
<td>3.0</td>
<td>3.3</td>
<td>4.3</td>
</tr>
<tr>
<td>1983-1994</td>
<td>3.5</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>1995-2008</td>
<td>1.6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Estimating Restroom Fixture Water Use

- Functional population
- Frequency of fixture use
- Fixture efficiency
- Fixture count

\[
\left( \frac{\text{functional population}}{\text{ft}^2} \right) \times \left( \frac{\text{uses}}{\text{person} \times \text{day}} \right) \times \left( \frac{\text{gallons}}{\text{use}} \right) \times \left( \frac{\text{ft}^2}{\text{fixtures}} \right) = \frac{\text{gallons}}{\text{fixture} \times \text{day}}
\]

From FL-specific impact fee studies
From national studies on residential frequency of use
From FL plumbing and building codes
Sprinkler System Water Use

- Gainesville Regional Utilities (GRU) provided water billing data for 738 parcels, representing the ten largest commercial subsectors of water use.
- Alachua County Property Appraiser (ACPA) data, which identifies accounts with sprinkler systems.
- Water billing time series information for the top ten commercial subsectors can thus be split into parcels with and without sprinkler systems.
Sprinkler System Water Use

- Water billing time series information normalized by heated square footage for the 186 one-story office buildings in GRU:
Sprinkler System Water Use - Coefficient Calculation

- Average water use coefficients normalized by heated area are determined for FDOR parcels with sprinkler systems and those without via GRU billing, and associated ACPA data:

\[
AWU = \left[ \frac{\sum_{i=1} Q_i}{\sum_{i=1} HA_i} \right]
\]

Where:
- \( AWU \) = average weighted water use coefficient (monthly gallons/heated ft\(^2\))
- \( Q_i \) = average monthly water use of parcel \( i \) (gallons/month)
- \( HA_i \) = heated square footage of all buildings on parcel \( i \) (ft\(^2\))
Sprinkler System Water Use - Coefficient Calculation

- Similar to AWU, the base weighted water use coefficients (BWU) can be calculated using the total sector minimum water use month.
- The seasonal water use (SWU) coefficient is then obtained by subtracting the base water use (BWU) coefficient from the average water use (AWU).
- The difference between the sprinkler and non-sprinkler seasonal water use coefficients is taken to be water use attributable to sprinkler systems.

\[ WU_{sprk} = SWU_{ws} - SWU_{wos} \]
Sprinkler System Water Use

- Methodology is directly dependent on the hydrograph signature of sprinkler and non-sprinkler parcels in each subsector analyzed.
- Unlike the residential sector, the CI subsectors are often prone to other seasonal drivers besides irrigation.
- By taking into account the seasonality associated with the non-sprinkler parcels, this better ensures that other seasonal components are not included.
## Sprinkler System Water Use Coefficients

<table>
<thead>
<tr>
<th>FDOR</th>
<th>Description</th>
<th>Sample size</th>
<th>% of total</th>
<th>Avg. water use (gal/ft²/mo)</th>
<th>Seasonal water use (gal/ft²/mo)</th>
<th>Water use attributable to sprinkler systems (gal/ft²/mo)</th>
<th>% water use attributable to sprinkler systems</th>
<th>% of parcel area irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Stores, One-Story</td>
<td>137</td>
<td>18%</td>
<td>6.23</td>
<td>1.20</td>
<td>0.87</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>16</td>
<td>Community Shopping Centers</td>
<td>71</td>
<td>34%</td>
<td>1.62</td>
<td>0.27</td>
<td>0.00</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>17</td>
<td>Office, One-Story</td>
<td>186</td>
<td>29%</td>
<td>3.92</td>
<td>0.75</td>
<td>0.39</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>18</td>
<td>Office, Multi-Story</td>
<td>28</td>
<td>71%</td>
<td>1.82</td>
<td>0.57</td>
<td>0.39</td>
<td>21%</td>
<td>5%</td>
</tr>
<tr>
<td>19</td>
<td>Medical Office</td>
<td>115</td>
<td>50%</td>
<td>6.94</td>
<td>1.31</td>
<td>0.86</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>21</td>
<td>Restaurant</td>
<td>41</td>
<td>39%</td>
<td>23.65</td>
<td>1.70</td>
<td>0.29</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>22</td>
<td>Fast-Food Restaurants</td>
<td>41</td>
<td>59%</td>
<td>23.16</td>
<td>2.09</td>
<td>0.61</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>39</td>
<td>Hotels / Motels</td>
<td>37</td>
<td>30%</td>
<td>7.52</td>
<td>1.15</td>
<td>0.12</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Prevalence of Sprinkler Systems

- Parcels with sprinkler systems only make up a fraction of the total parcels within a given subsector.
- This percentage of parcels with sprinkler systems largely influences the relative subsector importance of this end-use device.

<table>
<thead>
<tr>
<th>FDOR</th>
<th>Sample size</th>
<th>Average heated area (ft²)</th>
<th>% with sprinkler systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>68</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>16</td>
<td>28</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>17</td>
<td>98</td>
<td>47</td>
<td>41</td>
</tr>
<tr>
<td>18</td>
<td>9</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>31</td>
<td>33</td>
<td>51</td>
</tr>
<tr>
<td>21</td>
<td>18</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>22</td>
<td>10</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>39</td>
<td>19</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>weighted avg.</td>
<td></td>
<td></td>
<td></td>
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</table>
BMP Evaluations

- Water use and end-use device estimates, along with economic data on total cost of retrofits and water, allow for evaluation of water conservation BMPs.

- Cost-effectiveness of a retrofit will increase the less water efficient an existing end-use device is, and with increased use of the device.

- With this methodology, and heated area and effective year built (from FDOR)
  - Water use per end use device can be calculated
  - BMPs evaluated for cost effectiveness.
Conclusions and Future Work

- This methodology allows for the evaluation of water conservation BMPs for cost-effectiveness for CI restroom fixtures and sprinkler systems.
- Future work in this area should:
  - Validate the use of minimum fixture requirements by using survey data.
  - Increase sample sizes across the CI subsectors.
  - Expanded to include other end uses such as cooling towers, hotel/motel clothes washers, and restaurant spray valves.
QUESTIONS?

COMMENTS?

SUGGESTIONS?