Energy Usage and Waste Study Estimation Approach

Summary for DOE
Behavior Potential Workshop

June 13, 2016
Traditional Potential Studies Provide a Forecast of DSM Savings

- Behavior, other than consumer purchase behavior, “gets lost”
- Produces results that are too blunt for strategic program planning and program gap analysis
  - Often rely heavily on secondary data and rules of thumb for important analytic assumptions
  - Results do not adequately reflect potential associated with behavior change or O&M measures
Study Incorporates Behavior Into Energy Use and Waste Estimation

- Usage and Waste study had three goals:
  1. **Baseline study, first and foremost (equipment and behavioral)**
  2. Support utility program planning and gap analysis
  3. Provide a comprehensive assessment of energy usage and waste at the end-use level

- Method estimates energy “waste”, not a forecast of savings potential
- Estimates most closely align with **technical potential**, did not include estimates of economic or program achievable potential
- Characterized and quantified waste from both technological (equipment) and behavioral waste categories
Characterized Waste for Residential and Commercial Sectors

- Selected measurable / quantifiable behaviors with potential for high impact
  - Quantified waste from 11 residential behaviors and 16 commercial behaviors
  - Looked at behaviors with interaction between end-users and end-use equipment

- Turn off lights in unoccupied spaces
- Decrease temperature set-point on electric water heating
- Adopt efficient CAC control strategies
- Reduce industrial ventilation when not needed based on facility operations
Required Data Inputs & Estimation Method
Study Incorporated Primary Data with Engineering Approach

- Effort included:
  - Extensive primary data collection and metering to define equipment and behavioral baseline
  - Building, circuit and equipment level metering to disaggregate load by end-use
  - Define efficient technologies and behaviors for each end-use
  - Enhanced engineering analysis to assess energy usage and waste
Data Sources

- Extensive primary data collection (nested design)

  Mail/Phone Survey:
  4,414 completes (Res)
  1,519 completes (C&I)
  • Penetration/saturation
  • Behavioral/operational practices

  On-Site Audits:
  297 completes (Res)
  347 completes (C&I)
  • Penetration/saturation
  • Equipment technical specifications

  Monitoring:
  140 completes (Res)
  70 completes (C&I)
  • Log current on all circuits (Res)
  • Lighting/occupancy
  • Temperature and humidity (Res)
Conceptualizing Usage and Waste

Technological Waste = A+B

Shared Waste = B

Behavioral Waste = B+C

Efficient Use
Enhanced, bottom up engineering approach

- Began by estimating baseline annual energy usage by end use with TRM algorithms using heterogenous, site-specific data

**Example: Electric Usage for Residential Central AC**

\[
\Delta kWh = \frac{EFLH_{\text{cool}} \cdot \frac{Btu}{Hr} \cdot SEER}{1000}
\]

- Traditional approach would be to use TRM default values, plus, in some cases, slightly more granular data (e.g., regionally-defined EFLH)
- We used actual parameters measured from site visits

Assessed waste by varying parameters to reflect efficient behavior/technology and calculating differential
## Estimation Method – Incorporating Site-Specific Data

### Home A

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<thead>
<tr>
<th>Time</th>
<th>Set Point</th>
<th>Actual CDD</th>
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<tbody>
<tr>
<td>6am-9am</td>
<td>78.5</td>
<td>16.7</td>
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<tr>
<td>9am-12pm</td>
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<td>12pm-4pm</td>
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<tr>
<td>4pm-7pm</td>
<td>76.5</td>
<td>135.8</td>
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<tr>
<td>7pm-10pm</td>
<td>76.5</td>
<td>59.1</td>
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<tr>
<td>10pm-6am</td>
<td>78.5</td>
<td>30.0</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>400.4</strong></td>
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\[\text{EFLH} = 320.3\]

### Home B

<table>
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<th>Actual CDD</th>
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<td>9am-12pm</td>
<td>67</td>
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<td>12pm-4pm</td>
<td>67</td>
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<td>7pm-10pm</td>
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<td><strong>Total</strong></td>
<td><strong>1176.8</strong></td>
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</tbody>
</table>

\[\text{EFLH} = 941.5\]
Estimation Method – Quantifying Waste

 Defined Current Usage Case

\[ \Delta kW_{\text{actual}} = \frac{EFLH_{\text{actual}} \times \frac{Btu}{Hr} \times SEER}{1000} \]

1000 kWh/year

 Defined Efficient Usage Case

\[ \Delta kW_{\text{eff}} = \frac{EFLH_{\text{eff}} \times \frac{Btu}{Hr} \times SEER}{1000} \]

700 kWh/year

 Differential is Behavioral Waste:
Set-points Below Efficient Level

300 kWh/year

(30% of current usage)
Select Results
Example Results – Overall Residential Usage & Waste

Energy Use Classified in Baseline Study

- Efficient Usage: 53%
- Technology Waste: 30-37%
- Shared Waste*: 7%
- Behavioral Waste: 10-17%
- Other: 35%

Waste Estimated: 65%
Penetration: 100%
Current Usage: 5,528 GWh
Current Waste: 4,208 GWh

Technology Waste: 42-65%
- Upgrade incandescent and halogen bulbs to CFLs

Shared Waste*
* Either technology or behavioral waste, depending on which is addressed first

Behavioral Waste: 11-30%
- Turn off lights when room not in use (15-minute time-out)
Application of Approach
Who Can Use This Method?

- No proprietary model required
- Relies on comprehensive, accurate primary data collection, TRM algorithms, and secondary sources
- Requires accurate definition of equipment and behavioral baseline
- Requires significant expertise in primary research design and engineering
- Method will need to be customized to each service territory/area it will be applied to
Additional Inputs Required to Forecast Behavioral Potential

- Effort is a starting point, but does not provide a comprehensive forecast of savings over a specified time horizon
  - Doesn’t reflect all behaviors
  - Reflects behaviors for one year only (no estimated useful life/persistence of action)
  - Does not reflect market, economic, or program spending contraints
  - No program spending (cost-effectiveness)
- Could be incorporated into traditional potential model – would need to develop a comprehensive list of “behavioral” measures and fully define/characterize each measure (e.g. EUL, adoption rates, savings, etc)
# Behavioral Waste Quantified

## Residential
- Turning off lights when room is not occupied (15 minute time-out period)
- Performing annual system maintenance on CAC
- CAC temperature setback
- Electric space heating temperature setback
- Electric water heating set-point decrease
- Unplug empty/nearly empty secondary fridge
- Unplug empty/nearly empty secondary freezer
- Eliminate excessive hot water usage for clothes washers
- Use “no heat dry” function for dishwashers
- Eliminate partial loads for dishwashers
- Turn off TV when not watching

## Commercial & Industrial
- Turn off lights when not in use for given task
- Implement multiple methods of lighting controls
- Maintain split.packaged systems on a regular schedule
- Cooling temperature setback
- Reduce ventilation when not needed based on facility operations
- Perform regular maintenance of motors
- Decrease rewinding of motors
- Refrigeration temperature setbacks
- Office equipment power management
  - e.g. turn off computers, copiers, retail registers when not in use