Plug Loads: Challenges and Opportunities

Michael J. Klopfer, PhD
California Plug Load Research Center
California Institute for Telecommunications and Information Technology
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www.calplug.org
Why investigate plug loads?

What are the contributors to this “other” category, and how can this issue be addressed?

What are the challenges in accurately modeling residential plug loads?

What are plug loads becoming ‘more’ of a problem?

Source: Graph created by Ecova with data from EIA 2008 Annual Energy Outlook
Factors in plug load increase

- Home medical care and mobility
- Rise of overlooked devices
- Overhead associated with automation control?
- Changing habits/lifestyles
Energy and respiratory disease

<table>
<thead>
<tr>
<th></th>
<th>Rate (hrs/day)</th>
<th>Energy/day (kWh)</th>
<th>Energy/yr (kWh)</th>
<th>Pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPAP</strong></td>
<td>8</td>
<td>0.4-0.8</td>
<td>146 - 292 kWh</td>
<td>25M</td>
</tr>
<tr>
<td><strong>O₂ Concentrator</strong></td>
<td>24</td>
<td>8.64 - 16.56</td>
<td>3153.6 - 6044.4 kWh</td>
<td>1,425,431 CA</td>
</tr>
</tbody>
</table>

Chronic respiratory disease is one of numerous diseases on the rise, specially with an aging population.
Smart devices for energy savings

Classic IoT Installation:
- Increased vampire load
- New Infrastructure load
- Potentially very large savings potential

Occupancy Sensor Installation:
- Low vampire load (potentially under 1mW)
- Simple configuration, low intelligence
Case Study: Connected LED Light Bulb

Smart bulb vampire (standby) power usage
Average = 0.38 W

Smart bulb ON power usage
Average = 7.86 W
Motion sensors for control

[Diagram of motion sensor and electrical connections]

[Graph showing standby power and power factor samples]
Vampire load considerations

<table>
<thead>
<tr>
<th></th>
<th>Standby Power</th>
<th>On Power</th>
<th>Usage</th>
<th>kWh Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular LED Lightbulb</td>
<td>0 W</td>
<td>9.62 W</td>
<td>4 Hours/Day in ON state (normal)</td>
<td>14.0 kWh/yr</td>
</tr>
<tr>
<td>IOT Smart LED Lightbulb</td>
<td>0.38 W</td>
<td>10 W (9.62W+0.38W)</td>
<td>2.8 Hours/Day in ON State (~30% reduction)</td>
<td>13.1 kWh/yr</td>
</tr>
</tbody>
</table>

Equivalent Bulb (or plug load luminary) without IoT Technology

Smart Bulb (or plug load luminary) with IoT Technology resulting in 30% usage reduction

Only 6.4% decrease in energy usage with 30% reduction in ON time state due to IoT energy overhead at device level only
Behavior Based Savings Opportunities

**Electricity Usage Context**
- Environment
- Network
- Behavior

**Sensing**
- Optical
- Acoustic
- Tactile
- Electronic

**PEF Management**
- User Inputs
- Sensor Inputs
- Pattern record

**Plug Load Devices and Functional States**

CalPlug 5W5S Demo

Energy savings in the classroom

Proper HVAC and lighting controls?

Using natural light?

Task lighting?

Under Desk heater?

The overlooked teacher’s computer


Projector and document camera on during breaks?

Proper PC power management?

Printers and small network equipment?

Student Plug Loads?

Classroom pets?
Projector Buddy: A Tool for Classroom Energy Management

![Diagram of Projector Buddy System Block Diagram]

- **Image:**
  - Classroom setting with a projector and desks.

- **Diagram:**
  - Projector
  - IR Emitter
  - Mod. Light Sensor
  - Sound/IR Recvr.
  - Motion Sensor
  - Projected Indicator (Laser)
  - Logic
  - 5V Communication
  - 120V Power Source
  - Power Supply, Relay, and Current Sensor

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California Plug Load Research Center
Commitment to training the leaders of tomorrow

- **Projector Buddy: Classroom Energy Management**
- **Smart EV Charger**
- **Secure WiFi controller for large residential loads (dual speed pool pumps)**
- **PLSim – rapid plug load simulation**
- **SparkyStrip – load desegregation**
Thank You!