TDV Lighting Controls
2008 Title 24 Codes and Standards Enhancements
October 25, 2005 Workshop

Analysis conducted by:
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For:
Pacific Gas & Electric Company
Background

- 2005 Title 24 allows Power Adjustment Factors (PAF) for various lighting controls
  - Bi-level enabled occupancy sensors
  - Manual Dimming and Multi-scene Programmable
  - Daylighting Controls
- PAFs listed in table 146-A
- PAF taken as a fixed reduction in wattage for all hours of occupancy in space
  - No accounting for timing of energy savings
  - Important with Time Dependent Valuation (TDV)
CASE Scope and Workplan

- Account for the effect of TDV on lighting controls
  - TDV used to calculate prescriptive PAF’s
    - Determine the need to change PAF’s based on TDV effects

- Propose Hourly control credits for performance method
  - Based on best available monitoring data
  - Hourly credits to be implemented through reduction in hours of lighting system operation
  - Placeholders for controls without reliable data
Data Collection

- Data collected from literature review and researchers
  - Good data for occupancy sensors in small areas from published studies
    - Small Private Offices
    - Classrooms
  - Manufacturer data on Warehouses, Libraries
  - No data on hallway occupancy sensor, manual dimming, multi-scene programmable controls
  - Daylighting controls not included in this CASE
- TDV spreadsheet model created
  - Compare savings from controls to prescriptive PAF’s
## Analysis Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbrev.</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw hourly adjustment factor</td>
<td>$r_{HAF_{h,d}}$</td>
<td>From the raw research data, savings as a proportion of baseline consumption for each hour and each day type (note, this value is the same whether TDV-weighted or not)</td>
</tr>
<tr>
<td>Raw daily adjustment factor</td>
<td>$r_{DAF_{TDV,d}}$</td>
<td>From the raw research data, average savings as a proportion of baseline for each day type (Saturday, Sunday, weekday), weighted by the varying TDV value of each hour</td>
</tr>
<tr>
<td>Raw power adjustment factor (kWh)</td>
<td>$r_{PAF_{kWh}}$</td>
<td>From the raw research data, average savings as a proportion of baseline for the whole week (note, this is not TDV-weighted)</td>
</tr>
<tr>
<td>Raw power adjustment factor (TDV-weighted kWh)</td>
<td>$r_{PAF_{TDV_{kWh}}}$</td>
<td>From the raw research data, average savings as a proportion of baseline for the whole week, weighted by the varying TDV value of each hour</td>
</tr>
<tr>
<td>Hourly adjustment factor</td>
<td>$HAF_{h,d}$</td>
<td>Final, smoothed and adjusted hourly adjustment factors for each hour and each day type, proposed for use in Title 24 2008</td>
</tr>
<tr>
<td>Power adjustment factor (kWh)</td>
<td>$PAF_{kWh}$</td>
<td>Power adjustment factor based on total energy consumption.</td>
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<tr>
<td>Power adjustment factor (TDV-weighted kWh)</td>
<td>$PAF_{TDV_{kWh}}$</td>
<td>Power adjustment factor based on TDV-weighted energy consumption; can be compared with PAFs in table 146-A of Title 24 2005</td>
</tr>
</tbody>
</table>
### PAF Comparison

<table>
<thead>
<tr>
<th>Space Type</th>
<th>rDAF&lt;sub&gt;Saturday&lt;/sub&gt;</th>
<th>rDAF&lt;sub&gt;Sunday&lt;/sub&gt;</th>
<th>rDAF&lt;sub&gt;Weekday&lt;/sub&gt;</th>
<th>PAF</th>
<th>Raw Data from Research</th>
<th>TDV-weighted kWh</th>
<th>PAFs from T24 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spaces &lt;250 sq ft</strong></td>
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<tr>
<td></td>
<td>no data</td>
<td>no data</td>
<td>0.37</td>
<td>0.27</td>
<td></td>
<td>0.27</td>
<td>0.20</td>
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<tr>
<td><strong>Hallways of hotels/motels</strong></td>
<td></td>
<td></td>
<td>insufficient data</td>
<td></td>
<td></td>
<td>insufficient data</td>
<td>0.25</td>
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<td></td>
<td></td>
<td></td>
<td>insufficient data</td>
<td></td>
<td></td>
<td>insufficient data</td>
<td>0.25</td>
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<td></td>
<td></td>
<td></td>
<td>insufficient data</td>
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<td>insufficient data</td>
<td>0.25</td>
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<tr>
<td><strong>Commercial and industrial storage rack areas</strong></td>
<td></td>
<td></td>
<td>0.26</td>
<td>0.28</td>
<td></td>
<td>0.28</td>
<td>0.15</td>
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<tr>
<td><strong>Library stacks</strong></td>
<td></td>
<td></td>
<td>0.30</td>
<td>0.31</td>
<td></td>
<td>0.30</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Results Summary

- Current PAF values adequate and appropriate
  - Spaces with good data, PAF’s are 60% of raw savings
  - Insufficient data on most controls to justify change in PAF
  - Less longevity/reliability than electric lighting
    - DEER database: occupancy sensor life 8 – 10 years

- Prescriptive Compliance: TDV weighted PAF’s to have same value as current PAF’s

- Performance Method: Hourly Adjustment Factors for lighting schedule
  - Annual savings from HAF’s same as Prescriptive PAF
ACM Changes

- Add Controlled Lighting Schedules
  - Table N2-5: Nonresidential Occupancy Schedules (Other than Retail)
  - Controlled lighting schedule calculated as
    - Hourly uncontrolled lighting schedule x (1- HAF)

- Add 24-Hour lighting schedule for Hallways
  - Controlled lighting schedule for hallways based on this 24-hour schedule

- Method also applied to controls with no research data on savings
  - HAF’s are constant for all hours of day
Multiple controls in single space

- DOE-2.1E (reference program) allows only two schedules per space
  - Lighting
  - Task-Lighting (cannot use daylighting command)
- More than two controls – divide up into two spaces with separate lighting schedules
  - Divide spaces relative to wattage on each control
    - Floor area, wall area, fenestration area
- In daylit areas, create wattage weighted schedules
  - Non-daylit areas – Task-Lighting
  - Daylit area - Lighting
Combined Occupancy and Daylighting Controls

- When occupancy based controls used in conjunction with photocontrols
  - Occupancy control results in change in schedule
  - Daylighting control modeled using DAYLIGHTING command in reference program (DOE-2.1E)
  - Savings a function of daylight availability

- Methods of modeling daylighting in PG&E Sidelighting and Skylighting CASE studies
Summary of Changes

- Has no effect on prescriptive method
  - PAF’s are the same as in 2005
- Little change in the performance method
  - Savings balanced across peak and off-peak periods
- Sets the framework in place to credit controls that primarily reduce peak consumption
- Compatible with TDV
  - Lighting savings vary with respect to time of day
Acknowledgements

- PG&E Codes and Standards Program
  - Pat Eilert & Steve Blanc

- Heschong Mahone Group
  - Doug Mahone, Jon McHugh, Abhijeet Pande & Owen Howlett