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# 2008 Title 24 Nonresidential CASE Envelope Tradeoff Proposal

## PG&E Codes & Standards Program

## CEC Staff Workshop July 12, 2006

Pacific Gas and Electric Company

Codes & Standards Enhancement Project

# Overview of proposal

- Update 2008 envelope tradeoff equation
- Base the tradeoff on TDV energy rather than source energy
- Combine heat loss and heat gain equations into one equation
- Introduce a new term VT for glazing
- Simplify the cool roof term

# Energy Benefits

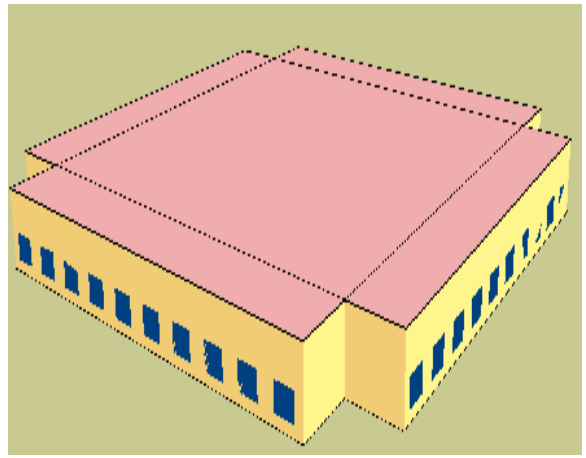
- A tradeoff equation is energy neutral, but:
- Visible light transmittance (VT) will allow for improved fenestration modeling
  - The current method underestimates negative energy impacts of replacing double low-e glass with single glazed low transmittance glass
- Coefficients by orientation provide for more accurate modeling
- Use of TDV factors will recognize demand reductions

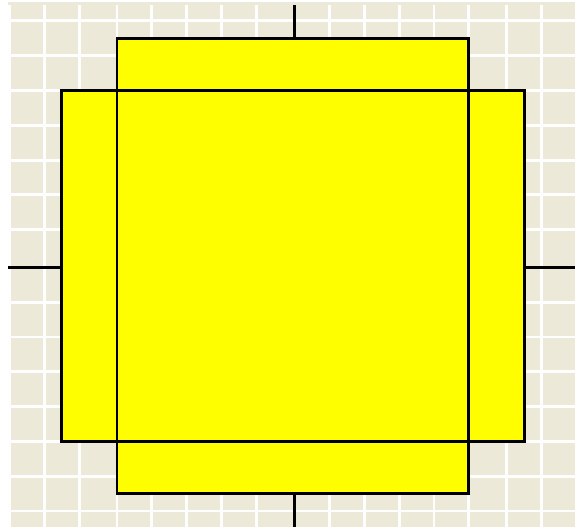
# Methodology

- Regression analysis to determine a set of coefficients for each envelope type, class of construction, occupancy type, and climate zone

# Description of simulation model

- Geometry
  - A 5-zone model
  - Four exterior zones (100 ft X 15 ft)
  - One interior zone (100 ft X 100 ft) Space height 13 ft
- Fenestration: The fenestration is set to 30% for daytime and 24-hour occupancy and 10% for retail occupancy.
- HVAC systems
  - One packaged single zone (PSZ) system for each zone. Ducted return.
  - Cooling EER 9.5 (COOLING-EIR = 0.2846), fan power at 0.35 W/cfm
  - Integrated air-side economizer
  - Outside air 0.15 cfm/ft²
  - Gas heating





# 2005 Tradeoff Heat Loss Equation

- Proposed Building

$$HL_{std} = \sum_{i=1}^{nW}\left(A_{Wi} \times U_{Wi_{std}}\right) + \sum_{i=1}^{nF}\left(A_{Fi} \times U_{Fi_{std}}\right) + \sum_{i=1}^{nR}\left(A_{Ri} \times U_{Ri_{std}}\right) + \sum_{i=1}^{nG}\left(A_{Gi} \times U_{Gi_{std}}\right) + \sum_{i=1}^{nS}\left(A_{Si} \times U_{Si_{std}}\right)$$

- Standard Building

$$HL_{prop} = \sum_{j=1}^{nW}\left(A_{Wj} \times U_{Wj_{prop}}\right) + \sum_{j=1}^{nF}\left(A_{Fj} \times U_{Fj_{prop}}\right) + \sum_{j=1}^{nR}\left(A_{Rj} \times U_{Rj_{prop}}\right) + \sum_{j=1}^{nG}\left(A_{Gj} \times U_{Gj_{prop}}\right) + \sum_{j=1}^{nS}\left(A_{Sj} \times U_{Sj_{prop}}\right)$$

# 2005 Tradeoff Heat Gain Equation

- Proposed Building

$$HG_{std} = \sum_{i=1}^{nW}\left(A_{Wi} \times U_{Wi_{std}} \times TF_i\right) + \sum_{i=1}^{nF}\left(A_{Fi} \times U_{Fi_{std}} \times TF_i\right) + \sum_{i=1}^{nR}\left(A_{Ri} \times U_{Ri_{std}} \times TF_i\right)$$
$$+ \sum_{i=1}^{nG}\left(A_{Gi} \times U_{Gi_{std}} \times TF_i\right) + \sum_{i=1}^{nS}\left(A_{Si} \times U_{Si_{std}} \times TF_i\right) + \sum_{i=1}^{nG}\left(WF_{Gi} \times A_{Gi} \times RSHG_{Gi_{std}}\right) \times SF$$
$$+ \sum_{i=1}^{nS}\left(\mathrm{WF_{Si}} \times A_{Si} \times SHGC_{Si_{std}}\right) \times SF + \sum_{i=1}^{nR}\left(\mathrm{WF_{Ri}} \times A_{Ri} \times U_{Ri_{std}} \times \left[1 - \left(0.2 + 0.7\left[\rho_{Ri_{std}} - 0.2\right]\right)\right]\right) \times SF$$

- Standard Building

$$HG_{prop} = \sum_{j=1}^{nW}\left(A_{Wj} \times U_{Wj_{prop}} \times TF_j\right) + \sum_{j=1}^{nF}\left(A_{Fj} \times U_{Fj_{prop}} \times TF_j\right) + \sum_{j=1}^{nR}\left(A_{Rj} \times U_{Rj_{prop}} \times TF_j\right)$$
$$+ \sum_{j=1}^{nG}\left(\mathrm{A_{Gj}} \times U_{Gj_{prop}} \times TF_j\right) + \sum_{j=1}^{nS}\left(A_{Sj} \times U_{Sj_{prop}} \times TF_j\right) + \sum_{j=1}^{nG}\left(WF_{Gj} \times A_{Gj} \times SHGC_{Gj_{prop}} \times OHF_j\right) \times SF$$
$$+ \sum_{j=1}^{nS}\left(WF_{Sj} \times A_{Sj} \times SHGC_{Sj_{prop}}\right) \times SF + \sum_{j=1}^{nR}\left(WF_{Rj} \times A_{Rj} \times U_{Rj_{prop}} \times \left[1 - \left(0.2 + 0.7\left[\rho_{Ri_{prop}} - 0.2\right]\right)\right]\right) \times SF$$

# 2008 Tradeoff Equation

$$TDV = \sum_{i=1}^{nW} c_W \left(A_W \times U_W\right) + \sum_{i=1}^{nF} c_F \left(A_F \times U_F\right) + \sum_{i=1}^{nR} c_R \left(A_R \times U_R \times M_{CR}\right)$$
$$+ \sum_{i=1}^{nG} A_G \left[\left(c_{Gu} \times U\right) + \left(c_{Gs} \times SHGC \times M_{OH}\right) + \left(c_{Gt} \times VT\right)\right]$$

C coefficients

$C_W$ (wall), $C_F$ (floor), $C_R$ (roof), $C_G$ (glazing)

A area

U U-factor

$M_{CR}$ multiplication factor for cool roof

$M_{OH}$ multiplication factor for overhangs

# 2008 Tradeoff Equation

$$M_{CR} = 1 + c_{Rfl}\left(Rfl - 0.70\right) + c_{Emt}\left(Emt - 0.75\right)$$

- $c_{Rfl}$ Coefficient for the reflectance of the roof.
- Rfl Reflectance of the roof.
- $c_{Emt}$ Coefficient for the emittance of the roof.
- Emt Emittance of the roof.

$$M_{OH} = 1 + \left(a \times PF\right) + \left(b \times PF^{2}\right)$$

- a First coefficient for the projection factor
- b Second coefficient for the projection factor
- PF Projection Factor, (distance/height), by orientation

# 2008 Opaque Envelope Coefficients

| | Floors | | Roofs | | | Walls | | |
|---|---|---|---|---|---|---|---|---|
| C | $C_F$ (light) | $C_F$ (mass) | $C_R$ (attic) | $C_R$ (light) | $C_R$ (mass) | $C_W$ (light) | $C_W$ (HC>7) | $C_W$ (HC>15) |
| 1 | 73.39429 | 54.09392 | 116.4931 | 100.031 | 82.85337 | 72.48759 | 58.26854 | 46.27456 |
| 2 | 98.24113 | 50.22727 | 181.5417 | 172.0796 | 82.19169 | 135.264 | 58.05326 | 33.04017 |
| 3 | 43.40928 | 10.68002 | 115.8483 | 101.5243 | 56.83775 | 79.88986 | 35.09661 | 18.59709 |
| 4 | 55.58278 | 10.90104 | 140.758 | 134.5547 | 58.33815 | 105.2931 | 35.11207 | 15.06453 |
| 5 | 47.25045 | -4.04018 | 114.8051 | 105.4027 | 45.12801 | 87.01309 | 18.38963 | -3.06332 |
| 6 | 4.442216 | -31.6618 | 90.70553 | 83.89788 | 24.17653 | 69.49416 | 8.102436 | -7.57518 |
| 7 | 13.88764 | -13.6195 | 94.63668 | 94.39895 | 32.66666 | 75.52403 | 11.96484 | 12.06304 |
| 8 | 25.68847 | -18.4392 | 117.9913 | 113.6732 | 40.20578 | 104.2996 | 25.05023 | 5.543649 |
| 9 | 45.15959 | -13.0944 | 130.9946 | 127.7971 | 37.33069 | 119.1338 | 29.00373 | 4.30014 |
| 10 | 65.72214 | 8.073223 | 156.4211 | 155.2971 | 56.14438 | 142.743 | 44.35157 | 18.43627 |
| 11 | 104.7054 | 57.41605 | 180.3576 | 163.5056 | 100.0306 | 153.4598 | 92.08146 | 68.88897 |
| 12 | 90.65458 | 40.40881 | 173.6884 | 159.3801 | 89.76127 | 137.8381 | 74.85078 | 51.09223 |
| 13 | 89.40161 | 44.73477 | 171.4726 | 158.4751 | 91.74804 | 148.5212 | 81.1973 | 58.6926 |
| 14 | 120.3708 | 69.0801 | 207.3574 | 191.3552 | 113.7622 | 169.934 | 97.67529 | 66.67344 |
| 15 | 118.0298 | 65.80799 | 191.5255 | 187.1658 | 96.05978 | 201.1271 | 105.3068 | 76.14727 |
| 16 | 161.7221 | 125.7804 | 224.1798 | 198.4682 | 142.0036 | 164.1553 | 122.0838 | 98.42786 |

# 2008 Fenestration Coefficients
## (similar for other orientations)

| | North Windows | | | North Overhangs | |
|---|---|---|---|---|---|
| CZ | $C_{GU}$ (U-factor) | $C_{GS}$ (SHGC) | $C_{GT}$ (VLT) | a | b |
| 1 | 42.87148 | 502.13977 | -485.23943 | 0.18259 | -0.08240 |
| 2 | 36.49900 | 457.83688 | -337.99338 | -0.01808 | 0.01152 |
| 3 | 30.00591 | 462.37038 | -393.83223 | 0.07145 | -0.03222 |
| 4 | 25.27835 | 441.31426 | -304.58994 | -0.03744 | 0.01859 |
| 5 | 28.38473 | 433.88861 | -363.78604 | 0.02813 | -0.00984 |
| 6 | 15.88926 | 291.70460 | -218.71869 | -0.04446 | 0.02327 |
| 7 | 9.00809 | 302.97790 | -182.63926 | -0.12058 | 0.05983 |
| 8 | 13.90724 | 367.92780 | -217.86795 | -0.11884 | 0.05809 |
| 9 | 13.54925 | 428.96755 | -250.37360 | -0.12024 | 0.05783 |
| 10 | 26.25122 | 455.45599 | -259.54773 | -0.12987 | 0.06179 |
| 11 | 31.17000 | 708.43006 | -474.72856 | -0.03393 | 0.01757 |
| 12 | 29.91404 | 625.05946 | -427.88298 | -0.03376 | 0.01830 |
| 13 | 26.37053 | 609.38664 | -390.30484 | -0.05129 | 0.02618 |
| 14 | 37.07516 | 679.76301 | -448.94637 | -0.05770 | 0.03087 |
| 15 | 12.95919 | 796.38926 | -445.31226 | -0.11679 | 0.05475 |
| 16 | 59.52705 | 878.02567 | -668.83975 | 0.01465 | -0.00384 |

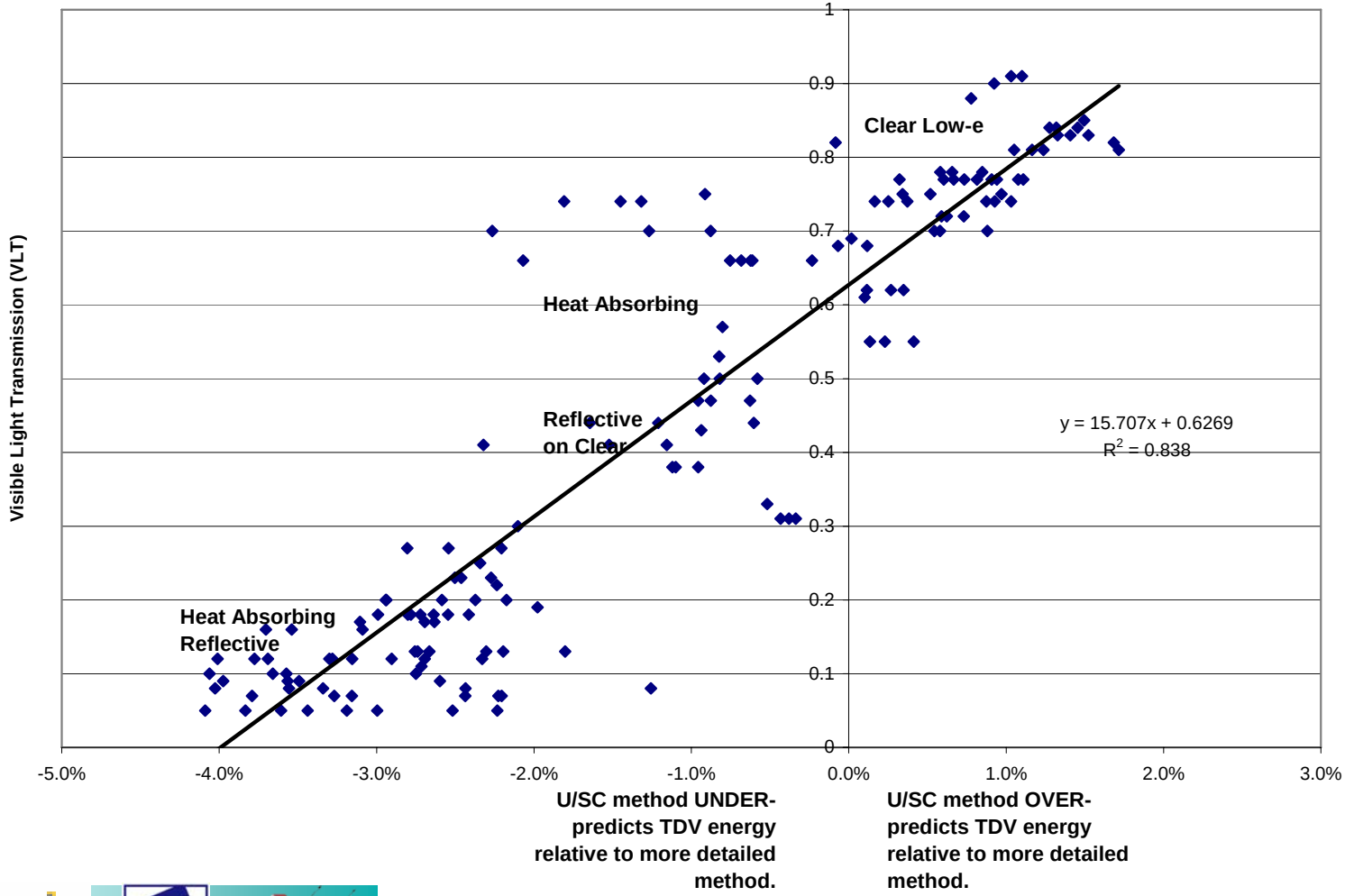
# 2008 Skylight Coefficients

| | Skylight | | |
|---|---|---|---|
| CZ | $C_{GU}$ (U-factor) | $C_{GS}$ (SHGC) | $C_{GT}$ (VLT) |
| 1 | 23.15580 | 298.93504 | -118.20991 |
| 2 | 20.60519 | 572.83657 | -50.54849 |
| 3 | 9.20939 | 381.39417 | 54.94562 |
| 4 | 7.08055 | 663.39274 | -18.56346 |
| 5 | 42.38104 | 165.36127 | 207.71687 |
| 6 | -19.17266 | 477.33733 | 145.43181 |
| 7 | -132.36510 | 1341.04636 | -297.34861 |
| 8 | -61.58000 | 989.92391 | -84.53467 |
| 9 | -2.49718 | 606.34803 | 104.67280 |
| 10 | -1.55230 | 698.86690 | 23.86485 |
| 11 | 22.93900 | 803.21519 | -42.69423 |
| 12 | 25.58718 | 688.92186 | 23.31673 |
| 13 | 14.24253 | 774.38320 | 1.77955 |
| 14 | 30.42767 | 827.82014 | -22.65048 |
| 15 | -0.07893 | 991.61703 | 67.34638 |
| 16 | 62.19712 | 672.51965 | -162.67138 |

# 2008 Cool Roof Coefficients

| | Cool Roofs | |
|---|---|---|
| CZ | $C_{Ref}$ (Reflectance) | $C_{Emit}$ (Emittance) |
| 1 | -0.59289 | 0.02481 |
| 2 | -1.37476 | -0.34681 |
| 3 | -1.48627 | -0.27481 |
| 4 | -1.79223 | -0.42444 |
| 5 | -1.72360 | -0.37094 |
| 6 | -2.26883 | 0.19853 |
| 7 | -3.25175 | -0.92403 |
| 8 | -2.86776 | -0.94669 |
| 9 | -2.49811 | -0.83096 |
| 10 | -2.38293 | -0.80943 |
| 11 | -1.68425 | -0.45618 |
| 12 | -1.66513 | -0.41352 |
| 13 | -1.64300 | -0.55147 |
| 14 | -1.74952 | -0.50026 |
| 15 | -2.52452 | -0.88823 |
| 16 | -0.94938 | -0.18083 |

# Visible Light Transmittance (VT)






**TDV Shading Coefficient Method - TDV Layers Method**

**TDV Layers Method**

# Visual Light Transmittance

- Negative % means U/SHGC method under predicts TDV for the entire building when compared to Layers method
- VT is included to make fenestration modeling more accurate, helps account for layers and tint
- The VT can be taken directly off NFRC label

# Fenestration Modeling

- The coefficients for fenestration will be revised.
- The current database uses 206 fenestrations currently available in DOE-2.
- Removed some outliers and windows that are not currently on the market such as quad glazing electrochromic glass.
- We are in the process of developing a new database of 17 glazings to perform the regression analysis on using Windows 5.0 with the help of LBNL.

# 2005/2008 Tradeoff Comparison

| | | Base | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 |
|---|---|---|---|---|---|---|---|---|
| **2005 Method** | Heat Loss | 2070 | +220 | 0 | +150 | 0 | 0 | +220 |
| | Heat Gain | 176,455 | +21,377 | -27,953 | -8,168 | -5,216 | 0 | +11,964 |
| | 2005 Tradeoff | | Pass | Fail | Fail | Fail | Pass | Pass |
| **2008 Method** | TDV | 393,905 | +35,064 | -101,165 | +3,674 | -5,683 | -4,416 | +4,279 |
| | % Source | | 12% | -16% | -4% | -3% | 0% | 7% |
| | % TDV | | 9% | -26% | 1% | -1% | -1% | 1% |
| | 2008 Tradeoff | | Pass | Fail | Pass | Fail | Fail | Pass |

- Base Case (R-19 rafter roof, r-13 wall, R-11 floor, cool roof, glazing U 0.47, glazing SHGC 0.47 (north) 0.36 (non-north)
- Case 2, switch from R-30 to R-38 Rafter)
- Case 3, Non-north SHGC from 0.36 to 0.56
- Case 4, Non-north SHGC from 0.36 to 0.40, R-30 Rafter
- Case 5, Non-north SHGC from 0.36 to 0.40, add Overhang PF=2
- Case 6, Non-north VT from 0.23 to 0.20
- Case 7, switch from R-30 to R-38 Rafter, and from cool roof to no cool roof

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