Residential Swimming Pools

PG&E Codes And Standards Enhancement (CASE) Study

Pacific Gas and Electric Company
DAVIS ENERGY GROUP INCORPORATED
Codes & Standards Enhancement Project

Proposed Measures & Findings

1. MOTOR EFFICIENCY REFERENCE
2. MINIMUM TURNOVER TIME
3. EFFICIENT PIPE & FITTING DESIGN
4. FILTER SIZING AND SELECTION
5. DEMAND RESPONSE
6. POOL COVERS

1. Motor Efficiency Reference

- Require that pump is listed with the CEC
  - Energy efficient type motor
  - Cross reference Title 20

ENERGY SAVINGS

10% or 260 kWh/pool annually.

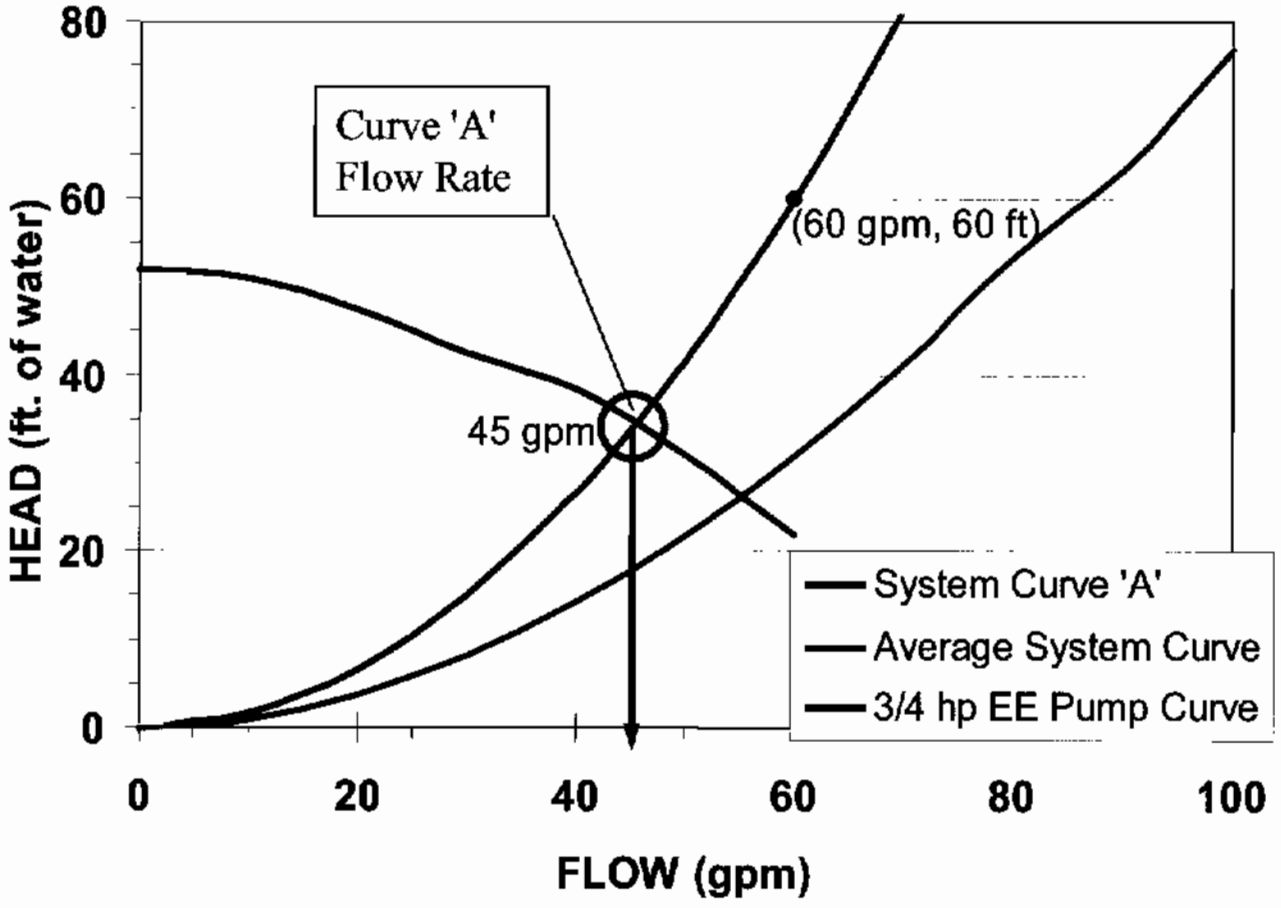
2. Minimum Turnover Time

- Filtration flow rate set for a minimum 6-hour turnover time.
  - Max Filtration Rate (gpm) = Volume of Pool (gallons) ÷ 360 min
- The selected pump shall have a Curve 'A' Flow Rate less than the Filtration Flow Rate
  - with Multi-speed pumps, use the low Curve 'A' Flow Rate

ENERGY SAVINGS

53% or 1450 kWh/pool annually

2. Minimum Turnover Time (cont.)

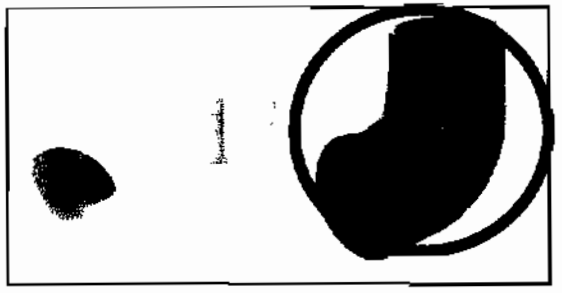


3. Pipe Design & Efficient Fittings

3. Pipe Design & Efficient Fittings (cont.)

Pipe sizing according to maximum velocities of 8 and 6 fps in the return and suction lines, respectively.

Flow rate (high speed if multi-speed pump)	*Pipe Diameter*	
	Return	*Suction*
up to 23 gpm	1	1.25
24 to 33 gpm	1.25	1.5
34 to 59 gpm	1.5	2
60 to 92 gpm	2	2.5
93 to 132 gpm	2.5	3
133 to 235 gpm	3	4
236 to 367 gpm	4	5



Efficient Pipe Fittings (short radius 90° on the left and hard 90° elbow on the right.)

3. Pipe Design & Efficient Fittings (cont.)

ENERGY SAVINGS

Description	*Annual Energy Savings (kWh/pool)*	*%*
4D of straight pipe on suction side of pump	104	4%
Maximum velocity of 8 fps return and 6 fps suction	403	15%
Sweep elbows	31	1%

4. Filter Sizing and Selection

- The filter shall be sized according to flow rate
- Similar to commercial pool recommendations

Filter Type	Max Flow Per Area (gpm/sqft)
Cartridge	0.375
Sand	20
Diatomaceous Earth (DE)	2

4. Filter Sizing and Selection (cont.)

ENERGY SAVINGS

Description	*Annual Energy Savings*	
	(kWh/pool)	*%*
Correctly sized filters	13	0.5%
Correctly sized MPV valves	159	5.9%

5. Demand Response Findings

First Year Savings in 2008 TDV$ (per pool)

	Base Case	*Proposed Design Measures*
No Demand Response	$6,215	$3,056
With Demand Response	$5,910	$2,912
Savings	$305	$144

6. Pool & Spa Covers

- Current Title 24 mandates outdoor pool & spa covers if more than 40% is heated without solar heaters.
- Based on industry feedback regarding current practice and enforcement:
  - Proposing to remove requirement for pools.
  - Proposing to keep requirement for spas.

All Design Measures Applied

ENERGY SAVINGS

- Annual Energy Savings:
  1,600 kWh per pool

- First Year Statewide Energy Savings:
  57 GWh
  (35,000 new construction pools)

All Design Measures Applied

DEMAND SAVINGS

- Annual Demand Savings:
  970 W per pool

- First Year Statewide Demand Savings:
  34 MW
  (35,000 new construction pools)

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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 P

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

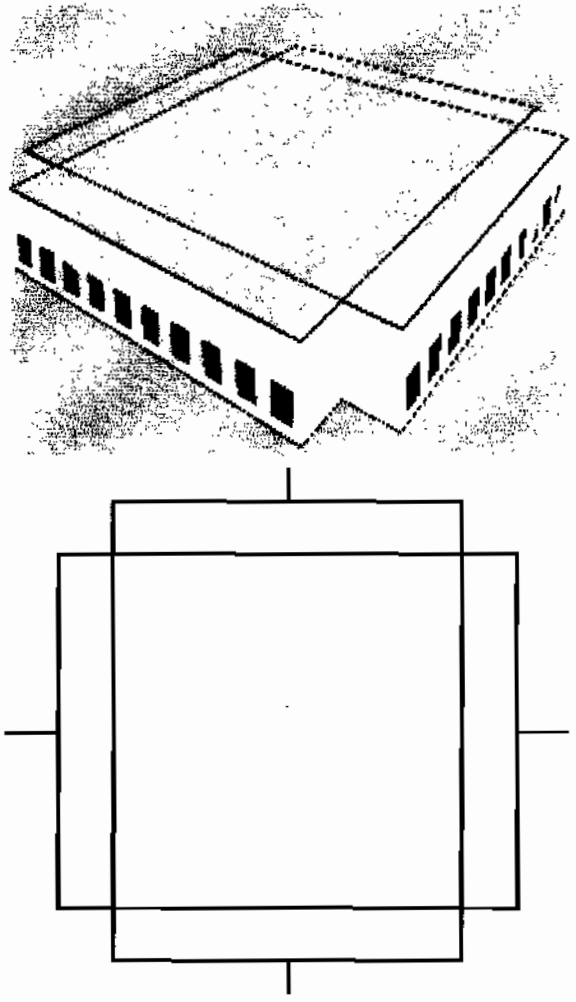
- A tradeoff equation is energy neutral, but:
- Visible light transmittance (VT) will allow for improved fenestration modeling
  - The current method underestimates negative energy impacts of replacing double low-e glass with single glazed low transmittance glass
- Coefficients by orientation provide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

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

- 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.

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

- 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

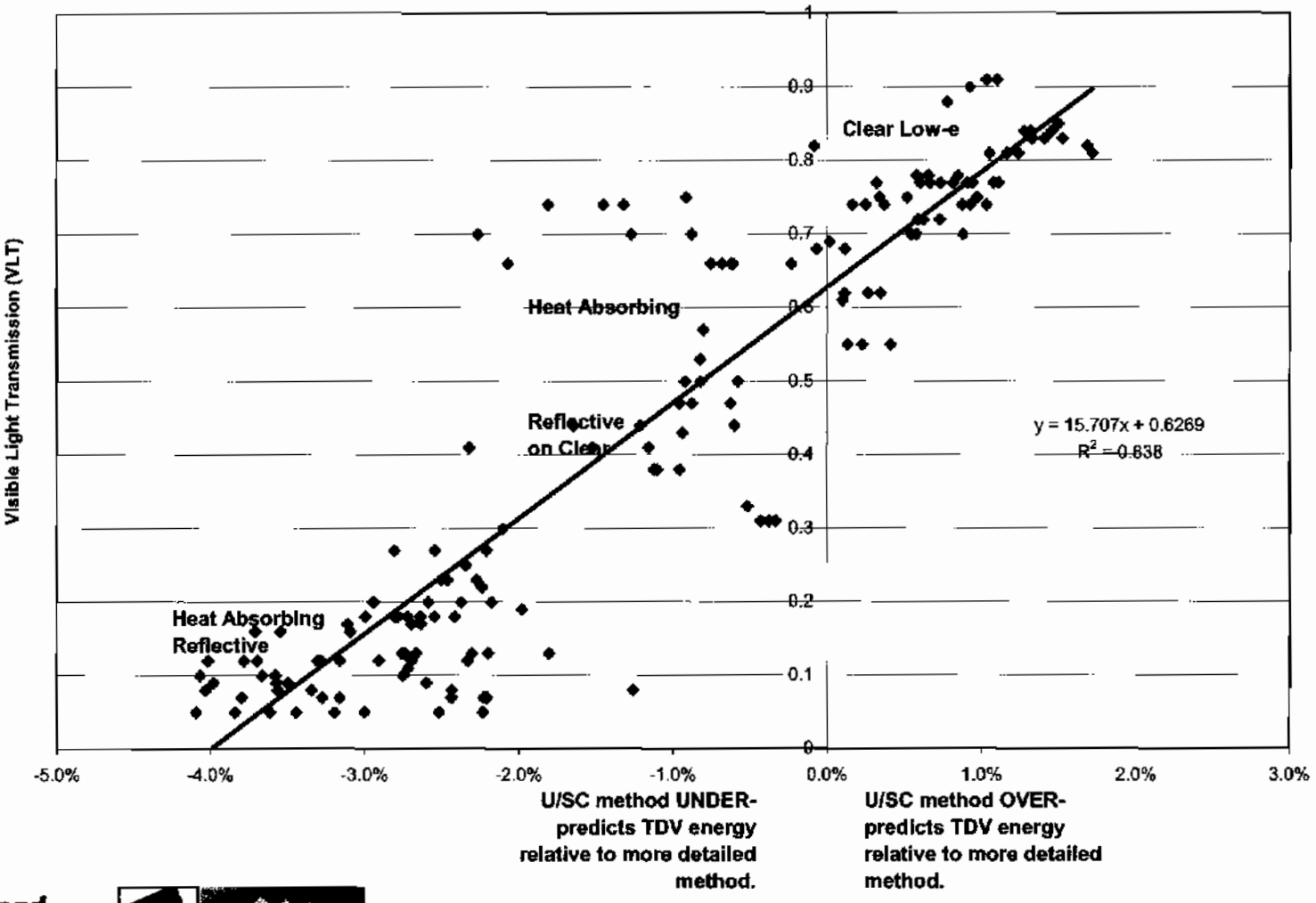
2008 Skylight Coefficients

	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			**Fail**	**Fail**	**Fail**		
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			**Fail**		**Fail**	**Fail**	

- 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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