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EXECUTIVE SUMMARY

As part of a Home Energy Rating and Labeling Demonstration Program for the California Energy Commission (CEC), the Lawrence Berkeley Laboratory (LBL) developed a simplified energy rating tool for existing houses. Three areas of the state (Marin, Pasadena, and Roseville) were chosen by the CEC to test different delivery mechanisms. The major element of the program is the Home Energy Rating Tool, which was designed using a "slide rule" format.

All values used in the Rating Tool with the exception of those for domestic hot water are based on a series of parametric simulations using a state-of-the-art computer code (DOE-2.1). The domestic hot water values are calculated by standard CEC procedures. The Rating Tool allows adjustments for different building types (one-story or two-story), and a home's individual building characteristics including the presence or absence of thermal mass, ceiling, wall or floor insulation, infiltration levels, window measures (e.g., number of panes, window area, shaded or unshaded windows, and sash type), and different equipment types and efficiencies. The Rating Tool allows one to compute an energy rating for a house on a scale from "1" (least energy efficient) to "6" (most energy efficient).

In this report, we summarize the technical assumptions and methodology employed to develop Rating Tools for the three California climates. We describe the prototype buildings, engineering assumptions used in the computer simulations, and the calculation procedures. We also discuss the assumptions and methods for estimating domestic hot water energy usage and the contribution of various other supplementary conservation measures to the overall rating. Finally, we provide step-by-step examples on how to use the Rating Tool both for rating a typical house and for improving the rating of that house.

INTRODUCTION

To explore the benefits of a home energy rating and labeling system within California, the California Energy Commission (CEC) is sponsoring a demonstration project beginning in 1986. The goal of this project is to evaluate a variety of delivery mechanisms that might be used in conjunction with a statewide home energy rating and labeling program. Another goal of the project is to develop a single rating tool which can, with reasonable accuracy, rank the energy efficiency of any home within the state.

The CEC selected three areas of the state to test three delivery mechanisms. Roseville will implement a program in which the city, as an electric utility, will offer the home rating and labeling service. As the model for a utility-focused delivery mechanism, Roseville will conduct a certified audit of homes and deliver the appropriate rating label. The city of Pasadena will operate a program very similar to that of Roseville, but, as the model for the government-focused delivery mechanism, will use city building officials to certify home ratings and provide labels. The county of Marin, which was chosen as the third area, withdrew from the project before the demonstration period began. In Marin, the proposed delivery mechanism included participation by the local realtors.

The key component of the California Home Rating and Labeling Demonstration Project is the Home Energy Rating Tool. The Building Energy Analysis Group of the Lawrence Berkeley Laboratory (LBL) was contracted by CEC to develop a specific rating tool for each of the pilot areas. LBL has extensive experience with energy consumption analysis for residential buildings. This expertise, in conjunction with CEC's own work in establishing the recent Title 24 Residential Buildings Standards for California, provides a firm analytical base for the Rating Tool's development.

A "slide rule" format was chosen for the design of the Rating Tool. The Rating Tool is sensitive to the interrelationship between a home's individual building characteristics and their collective impacts on energy consumption, and adjusts for the influence of building type (one-story or two-story) and climate on energy usage. The Rating Tool is also simple enough to allow its use by individuals with a minimum amount of training.

In this report, we provide a summary of the technical assumptions and methodology used to develop Rating Tools for the three demonstration areas. First, we define the prototype buildings and modeling assumptions employed in the computer simulations and compare them to those used to establish Title 24 energy budgets. Second, we describe the process employed to develop the Rating Tool values, including the energy calculation procedure and the process for normalizing the simulation results to the Rating Tool scales. We also list and discuss the assumptions and calculations used for the standard hot water systems and for supplementary conservation measures such as, low-flow showerheads and roof overhangs. Next, we summarize how to use the Rating Tool with examples given in Appendix A. Finally, we briefly define the research activities planned for the future.

MODELING ASSUMPTIONS

We based the energy numbers used in the Rating Tool on computer simulations performed with the DOE-2.1A program. Throughout its development, we sought to maintain maximum compatibility between the Rating Tool and Title 24 by retaining, whenever appropriate, CEC methodology, engineering assumptions, and operating conditions. This applies to the choice of building prototype, thermostat settings, internal load schedules, window operations, venting assumptions, and weather tapes. However, there remain some modeling differences because the inherent capabilities of the CALPAS program used to develop Title 24 differed from those of the DOE-2 program used for the Rating Tool. There are also some differences in engineering assumptions since Title 24 applies to new houses, while the Rating Tool is designed to cover existing as well as new houses. We clarify these differences in the brief discussion of methodology and assumptions given below.

Building Prototype and Operating Conditions

We used the CEC's 1384 ft^2 one-story prototype house with a few modifications to better represent existing housing conditions [1]. For example, we assumed a 6 in. south overhang instead of the 2 to 3 feet required by Title 24. We also assumed that the floor slab was completely covered by a rug instead of being half exposed and thus it had a limited thermal mass effect. Longer south overhangs and exposed floor slabs are included in the Rating Tool as conservation features. We also chose to simulate a gabled rather than a flat roof and to model the crawl space as a separate unconditioned space. For the two-story prototype, we used a 2240 ft^2 house described in more detail elsewhere [2].

Table 1 compares the assumptions used in the DOE-2 simulations for the Rating Tool to those used by the CEC for the Title 24 analysis, with the major differences shown in italics. As noted in the table, the operating conditions are identical except for the inclusion of latent internal loads, which are considered in DOE-2 but not in CALPAS. Another inherent difference between the two simulation codes is that DOE-2 models natural ventilation at a fixed air change rate (10 air changes per hour), while in CALPAS it varies by wind speed.

Engineering Assumptions

There are two significant differences in the engineering assumptions used in the work supporting the Rating Tool as compared to Title 24. The first relates to the calculation of foundation heat losses, and the second to the assumed infiltration rates.

Table 1. Comparison of Title 24 and Rating Tool—Base Case Conditions

Description	Title 24 Prototype	Rating Tool Prototype†	Comments
Building Prototype			
Size (ft^2)	1384	1384	CEC prototype
Geometry (ft.)	45 x 30 x 8	45 x 30 x 8	CEC prototype
Perimeter (ft.)	158	158	CEC prototype
Window Area (%)	16, 6.4 south	16, 6.4 south	CEC prototype
Foundation condition	slab	slab	Crawl space covered as parameter
Roof shape	flat	*gabled*	
South overhang (ft.)	2 (Zone 3) 2.5 (Zone 9) 3 (Zone 12)	*6 in. all zones*	*Overhangs covered as parameter*
Thermal Mass	50% exposed slab	*rug covered*	*Exposed slab condition covered as parameter*
Equipment			
Furnace efficiency (%)	71	71	Title 24 assumption
Air Conditioner (ACOP)	2.34	2.34	Title 24 assumption
Operating Conditions			
Shading schedules	varies by climate zone and season	0.63 summer 0.80 winter	Additional summer shading for west windows covered as parameter
Internal loads (Btu/day)			
Sensible	86,991	86,991	Title 24 assumption
Latent	-	*12,225*	*Latent loads not calculated in CALPAS*
Temperature Settings			
Heating thermostat (°F)	65	65	Title 24 assumption
Cooling thermostat (°F)	80	80	Title 24 assumption
Natural Venting	see note	see note	*Fixed: 10 air changes per hour*

† The two-story prototype has the following dimensions: 2240 ft^2 floor area, 40' x 28' x 16', 136 ft. perimeter, 10% window area with 2.5% south windows, and slab foundation.

Note: During the summer season, natural venting is assumed when the outdoor temperature is lower than the indoor temperature, but not higher than 80°F. During the winter season, natural venting is assumed when the indoor temperature is higher than 80°F.

The LBL foundation model uses equivalent steady-state conductances generated by a finite difference program developed at Dow Chemical [3]. In addition, in the DOE-2 modeling we included a 3 ft. soil layer outside the slab to simulate thermal lag and storage effects. We are unclear as to the engineering model used by the CEC to determine Title 24 budgets for foundation measures, but published CEC documents show that the resultant effective thermal transmittance values ($U_{effective}$) are different from those used in the LBL model (see Table 2).

Table 2. LBL and CEC Foundation Heat Losses

Slab Condition	LBL Conductance Per lineal ft. (Btu/hr-°F-ft)	LBL Conductance Total (Btu/hr-°F)	CEC Conductance Per lineal ft. (Btu/hr-°F-ft)	CEC Conductance Total (Btu/hr-°F)
R-0	0.974	153.89	0.81	127.98
R-5 16"	-	-	0.58	90.85
R-7 16"	-	-	0.54	86.11
R-5 24"	0.534	84.37	0.54	85.32
R-10 24"	0.459	72.52	-	-
R-5 48"	0.263	61.46	-	-

The residential infiltration model in DOE-2 is based on the Achenbach-Coblenz equation, which relates hourly infiltration rates to temperature differences and wind speed [4]:

$$Infiltration\ rate\ (ach) = 0.252 + 0.0251\ x\ Wind\ speed + 0.0084\ x\ \Delta\ Temperature \qquad (1)$$

We followed the procedure described by CEC for scaling infiltration coefficients to produce actual infiltration rates of 0.9 ach (air changes per hour) and 0.6 ach at 10 miles per hour wind speed and average wintertime temperature differences, but found that the resultant seasonal infiltration rates differed from those given in the CEC Application Package for Interim Certification and shown in Table 3 for the three climate zones [5]. We chose to follow the CEC scaling procedure and ignored the differences in the seasonal infiltration rates.

Table 3 compares the major engineering assumptions used in the DOE-2 simulations for the Rating Tool to those for Title 24. The differences in ceiling, wall, and window conductivities are insignificant in all cases.

Comparison of Rating Tool to Title 24 Budgets

To address questions about the compatability of the Rating Tool results to existing Title 24 guidelines, we compared DOE-2 results using the described LBL methodology to Title 24 budgets for the three climate zones in the pilot program.

Table 3. Comparison of Engineering Assumptions Used for Title 24 and Rating Tool

Item	Title 24	Rating Tool	Comments
Ceiling U-values*			
R-0	-	0.239	LBL values lower due
R-7	-	0.092	to inclusion of
R-11	-	0.069	attic air layer
R-19	0.053	0.048	
R-30	0.037	0.031	
Wall U-values*			
R-0	-	0.359	LBL values higher due
R-7	-	0.132	to 1/2 in. instead of
R-11	0.093	0.103	7/8 in. stucco
R-13	-	0.090	
R-19	0.060	0.064	
R-24	0.045	0.048	
R-27	0.043	0.041	
Window U-values*			
1 glazing	1.10	1.10	LBL values assume
2 glazing	0.65	0.49	1/2 in. air gap
3 glazing	0.41	0.35	
Foundation U-values*			
Slab			
R-0	0.81	0.974	LBL Wang foundation
R-5 (2 ft) slab	scaled from R-0	0.534	model includes
R-5 (4 ft) slab	scaled from R-0	0.263	3 ft. soil layer
Crawl space			
R-0 floor	scaled from slab†	0.240	Crawl space modeled
R-11 floor	scaled from slab†	0.070	as separate zone for
R-19 floor	scaled from slab†	0.049	Rating Tool
Infiltration**			
High (1.2)	not covered in Title 24	scaled from below	
Medium (0.9)	0.99 in Zone 3	0.80 in Zone 3	"Standard" in Title 24
	0.51 in Zone 9	0.73 in Zone 9	
	0.74 in Zone 12	0.75 in Zone 12	
Low (0.6)	0.66 in Zone 3	0.56 in Zone 3	"Medium" in Title 24
	0.50 in Zone 9	0.49 in Zone 9	
	0.50 in Zone 12	0.50 in Zone 12	

*All U-values in Btu/ft^2 °F hr, except slab perimeter U-values in Btu/ft °F hr.

**The terms "High", "Medium", and "Low" used in the Rating Tool differ from those used in Title 24 in order to include existing as well as new houses. CEC infiltration rates from Interim Certification Package, LBL infiltration rates based on DOE-2 output.

† Private communication with CEC staff

We made two sets of simulations using the LBL prototype house with conservation levels set at the Title 24 prescriptive levels. For the first set, we assumed the same thermal mass conditions as Title 24, i.e., the floor slab was half exposed. For the second set, which was used as the Rating Tool base case, we assumed no thermal mass, i.e., the floor slab covered by a rug.

In spite of the slight differences in building prototypes and engineering assumptions described earlier, we found the space conditioning budgets from the two sets of simulations to be within 9% in climate zone 2, 13% in zone 9, and 15% in zone 12 to CEC's Title 24 budgets (see column 2 in Table 4). The comparison summarized in Table 4 shows that the Rating Tool is generally compatible with Title 24, since the observed variations are similar to those recorded for independent simulation programs such as SUNPAS and MICROPAS that have been certified by the CEC for Title 24 compliance [5].

Table 4. Comparison of Heating and Cooling Energies Predicted the LBL Rating Tool to Title 24 Budgets

	CALPAS	LBL DOE-2.1A	
	(1) CEC Title 24 Budget (kBtu-yr/ft²)	(2)* Modified Title 24 Prototype with Mass† (kBtu-yr/ft²)	(3)** Modified Title 24 Prototype without Mass‡ (kBtu-yr/ft²)
Climate Zone 3			
Heating Energy	11.3	9.24	10.91
Cooling Energy	2.8	3.98	3.89
Total Energy	14.1	12.82	14.80
Climate Zone 9			
Heating Energy	6.9	6.01	8.51
Cooling Energy	17.8	15.50	18.10
Total Energy	24.7	21.51	26.61
Climate Zone 12			
Heating Energy	15.8	19.48	19.91
Cooling Energy	14.2	14.95	16.15
Total Energy	30.0	34.43	36.06

* Gabled roof, LBL foundation losses, LBL infiltration, ½ ft. overhangs all sides, with mass.
** Gabled roof, LBL foundation losses, LBL infiltration, ½ ft. overhangs all sides, without mass.
† Floor is 50% exposed slab (thermal mass base case for Rating Tool).
‡ Floor is totally covered with rug (base case for Rating Tool).

DEVELOPMENT OF THE RATING TOOL

Energy Calculations

All values used in the Rating Tool, with the exception of those for domestic hot water, are based on DOE-2.1A simulations. (Test runs with a more recent version, DOE-2.1B, showed differences in total loads of less than 0.4 MBtu.) The procedure used to calculate the Rating Tool values was first developed by LBL for a U.S. Department of Energy project on energy guidelines for site-built, single-family houses [7]. The methodology consists of two phases: development of Δ loads (i.e., the change in loads due to the addition of conservation measures) and regression analyses to calculate building component loads.

We first calculated Δ loads for key conservation measures, such as added insulation, glazing layers, and reduced infiltration. We based these reductions on the load difference between successive DOE-2 simulations with a single measure added (e.g., R-30 ceiling compared to R-19 ceiling), while holding other parameters constant. We performed DOE-2 simulations on the one-story and two-story prototypes for various levels of ceiling, wall and floor insulation, infiltration rate, window area, number of window panes, and window shading in three climate zones: 3 (Marin), 9 (Pasadena), and 12 (Roseville). This analysis results in a database of Δ heating and cooling loads for various conservation measures in each housing type and climate zone.

In the second phase of the analysis, we calculated the net annual contribution of each building component (***component loads***) resulting from linear regressions of the Δ loads to key physical characteristics for that component, such as conductivity. The results of this analysis were then normalized by the building size to produce loads per ft^2 of floor area for each individual building component (see Tables 5 through 7). A more complete documentation of the procedure and tests of its accuracy are presented elsewhere [8]. These component loads, with few modifications such as eliminating negative numbers and normalizing for ease of use, are the values that appear on the Rating Tool.

Because of the large number of possible window combinations, we developed the window component loads from regression analyses of a database of window sensitivity simulations. This database covers the range of total and south window areas, thermal mass properties (with or without exposed floor slab), shaded conditions shown on the Rating Tool for single and double-glazed windows (see Table 8). We extrapolated values for triple glazed windows from the single and double-glazed results. For each glazing type and thermal mass condition, we ran multiple regressions in the form of:

$$Component\ Load_{window} = A * Shading\ coefficient * Window\ area_{total} + B * Shading\ coefficient * Window\ area_{south} \quad (2)$$

Table 5. Components Load per Sq Ft for Climate Zone 3 (In kBtu/yr)

Heating Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	13.16	R-0	12.00	R-0	3.51
R-7	4.46	R-7	4.49	R-5 2 ft	1.10
R-11	3.37	R-11	3.55	R-10 2 ft	0.78
R-19	2.27	R-13	3.26		
R-30	1.50	R-19	2.21		

Infiltration	
Hi (1.2)	9.68
Med (.9)	7.26
Low (.6)	4.84

Cooling Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	0.83	R-0	0.20	R-0	-0.01
R-7	0.24	R-7	0.06	R-5 2 ft	0.00
R-11	0.16	R-11	0.05	R-10 2 ft	0.00
R-19	0.11	R-13	0.04		
R-30	0.08	R-19	0.03		

Infiltration	
Hi (1.2)	-0.12
Med (.9)	-0.09
Low (.6)	-0.06

RCTZ03 No Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	0.8	0.9	1.2	1.4	1.6	0.3	0.3	0.4	0.5	0.5	0.0	0.0	0.0	0.0	0.0
2	-0.3	-0.4	-0.4	-0.5	-0.6	-0.8	-1.0	-1.2	-1.5	-1.7	-1.1	-1.3	-1.6	-2.0	-2.2
3	-1.3	-1.6	-2.0	-2.4	-2.7	-1.7	-2.1	-2.6	-3.1	-3.4	-1.9	-2.3	-2.9	-3.5	-3.9
.0	0.4	0.5	0.6	0.7	0.8	0.4	0.5	0.6	0.7	0.8	0.4	0.5	0.6	0.7	0.8
2.0	0.1	0.2	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.5
5.0	-0.4	-0.3	-0.2	-0.1	0.0	-0.4	-0.3	-0.2	-0.1	0.0	-0.4	-0.3	-0.2	-0.1	0.0
10.0	-	-1.1	-1.0	-0.9	-0.8	-	-1.1	-1.0	-0.9	-0.8	-	-1.1	-1.0	-0.9	-0.8
16.0	-	-	-	-1.9	-1.8	-	-	-	-1.9	-1.8	-	-	-	-1.9	-1.8

RCTZ03 w/ Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.6	-0.7	-0.9	-1.1	-1.2	-0.9	-1.0	-1.3	-1.6	-1.7
2	-0.7	-0.8	-1.0	-1.2	-1.3	-1.2	-1.4	-1.8	-2.1	-2.4	-1.5	-1.8	-2.2	-2.6	-2.9
3	-1.5	-1.9	-2.3	-2.8	-3.1	-1.9	-2.3	-2.9	-3.5	-3.9	-2.2	-2.6	-3.2	-3.9	-4.3
.0	0.6	0.7	0.9	1.0	1.2	0.6	0.7	0.9	1.0	1.2	0.6	0.7	0.9	1.0	1.2
2.0	0.1	0.2	0.4	0.6	0.7	0.1	0.2	0.4	0.6	0.7	0.1	0.2	0.4	0.6	0.7
5.0	-0.6	-0.5	-0.3	-0.1	0.0	-0.6	-0.5	-0.3	-0.1	0.0	-0.6	-0.5	-0.3	-0.1	0.0
10.0	-	-1.6	-1.4	-1.3	-1.2	-	-1.6	-1.4	-1.3	-1.2	-	-1.6	-1.4	-1.3	-1.2
16.0	-	-	-	-2.7	-2.5	-	-	-	-2.7	-2.5	-	-	-	-2.7	-2.5

RCTZ03 No Mass Cooling

	10	12	15	18	20
1	0.5	0.6	0.8	0.9	1.1
2	0.5	0.6	0.8	1.0	1.1
3	0.5	0.6	0.8	1.0	1.1
.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
5.0	-0.0	-0.0	-0.0	-0.0	0.0
10.0	-	-0.1	-0.1	-0.0	-0.0
16.0	-	-	-	-0.1	-0.1

RCTZ03 w/ Mass Cooling

	10	12	15	18	20
1	0.4	0.5	0.6	0.7	0.8
2	0.4	0.5	0.7	0.8	0.9
3	0.5	0.6	0.7	0.9	1.0
.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
5.0	-0.0	-0.0	-0.0	-0.0	0.0
10.0	-	-0.1	-0.1	-0.1	-0.0
16.0	-	-	-	-0.1	-0.1

Table 6. Components Load per Sq Ft for Climate Zone 9 (In kBtu/yr)

Heating Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	11.40	R-0	9.20	R-0	1.95
R-7	3.61	R-7	3.31	R-5 2 ft	0.59
R-11	2.64	R-11	2.57	R-10 2 ft	0.42
R-19	1.76	R-13	2.37		
R-30	1.26	R-19	1.64		

Infiltration	
Hi (1.2)	5.43
Med (.9)	4.07
Low (.6)	2.72

Cooling Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	9.38	R-0	3.30	R-0	0.91
R-7	3.00	R-7	1.07	R-5 2 ft	0.26
R-11	2.21	R-11	0.80	R-10 2 ft	0.19
R-19	1.45	R-13	0.74		
R-30	1.05	R-19	0.54		

Infiltration	
Hi (1.2)	-0.23
Med (.9)	-0.17
Low (.6)	-0.11

RCTZ09 No Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	0.9	1.1	1.3	1.6	1.8	0.5	0.6	0.7	0.9	1.0	0.3	0.4	0.4	0.5	0.6
2	0.3	0.4	0.4	0.5	0.6	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7
3	-0.4	-0.5	-0.7	-0.8	-0.9	-0.8	-0.9	-1.1	-1.4	-1.5	-0.9	-1.1	-1.4	-1.7	-1.8
.0	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.3
2.0	0.0	0.1	0.1	0.2	0.2	0.0	0.1	0.1	0.2	0.2	0.0	0.1	0.1	0.2	0.2
5.0	-0.2	-0.1	-0.1	-0.0	0.0	-0.2	-0.1	-0.1	-0.0	0.0	-0.2	-0.1	-0.1	-0.0	0.0
10.0	-	-0.5	-0.4	-0.4	-0.3	-	-0.5	-0.4	-0.4	-0.3	-	-0.5	-0.4	-0.4	-0.3
16.0	-	-	-	-0.8	-0.7	-	-	-	-0.8	-0.7	-	-	-	-0.8	-0.7

RCTZ09 w/ Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	0.1	0.2	0.2	0.3	0.3	-0.3	-0.3	-0.4	-0.5	-0.5	-0.4	-0.5	-0.7	-0.8	-0.9
2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.7	-0.8	-1.0	-1.2	-1.4	-0.9	-1.1	-1.3	-1.6	-1.8
3	-1.0	-1.2	-1.4	-1.7	-1.9	-1.3	-1.5	-1.9	-2.3	-2.5	-1.4	-1.7	-2.2	-2.6	-2.9
.0	0.4	0.5	0.6	0.8	0.8	0.4	0.5	0.6	0.8	0.8	0.4	0.5	0.6	0.8	0.8
2.0	0.1	0.2	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.5
5.0	-0.4	-0.3	-0.2	-0.1	0.0	-0.4	-0.3	-0.2	-0.1	0.0	-0.4	-0.3	-0.2	-0.1	0.0
10.0	-	-1.2	-1.0	-0.9	-0.8	-	-1.2	-1.0	-0.9	-0.8	-	-1.2	-1.0	-0.9	-0.8
16.0	-	-	-	-1.9	-1.8	-	-	-	-1.9	-1.8	-	-	-	-1.9	-1.8

RCTZ09 No Mass Cooling

	10	12	15	18	20
1	5.6	6.7	8.4	10.1	11.2
2	5.3	6.3	7.9	9.5	10.5
3	5.0	6.0	7.5	9.0	10.0
.0	0.2	0.2	0.3	0.4	0.4
2.0	0.0	0.1	0.1	0.2	0.2
5.0	-0.2	-0.2	-0.1	-0.0	0.0
10.0	-	-0.6	-0.5	-0.4	-0.4
16.0	-	-	-	-0.9	-0.9

RCTZ09 w/ Mass Cooling

	10	12	15	18	20
1	4.6	5.5	6.9	8.3	9.2
2	4.6	5.6	6.9	8.3	9.3
3	4.7	5.6	7.0	8.4	9.3
.0	0.2	0.2	0.3	0.4	0.4
2.0	0.0	0.1	0.1	0.2	0.2
5.0	-0.2	-0.2	-0.1	-0.0	0.0
10.0	-	-0.6	-0.5	-0.5	-0.4
16.0	-	-	-	-0.9	-0.9

Table 7. Components Load per Sq Ft for Climate Zone 12 (In kBtu/yr)

Heating Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	13.36	R-0	12.02	R-0	4.09
R-7	4.56	R-7	4.56	R-5 2 ft	1.32
R-11	3.46	R-11	3.63	R-10 2 ft	0.93
R-19	2.36	R-13	3.33		
R-30	1.51	R-19	2.24		

Infiltration	
Hi (1.2)	10.40
Med (.9)	7.80
Low (.6)	5.20

Cooling Loads Per Sq Ft (in kBtu/yr)

Ceiling		Wall		Foundation	
R-0	8.50	R-0	3.33	R-0	1.02
R-7	2.82	R-7	1.21	R-5 2 ft	0.38
R-11	2.12	R-11	0.95	R-10 2 ft	0.27
R-19	1.42	R-13	0.87		
R-30	0.96	R-19	0.60		

Infiltration	
Hi (1.2)	0.03
Med (.9)	0.03
Low (.6)	0.02

RCTZ12 No Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	1.5	1.8	2.3	2.7	3.1	1.0	1.2	1.5	1.8	2.0	0.8	0.9	1.2	1.4	1.5
2	0.5	0.6	0.7	0.9	1.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.3	-0.4	-0.5	-0.6	-0.6
3	-0.5	-0.6	-0.8	-1.0	-1.1	-0.9	-1.1	-1.4	-1.7	-1.9	-1.1	-1.4	-1.7	-2.1	-2.3
.0	0.5	0.6	0.8	0.9	1.0	0.5	0.6	0.8	0.9	1.0	0.5	0.6	0.8	0.9	1.0
2.0	0.1	0.2	0.4	0.5	0.6	0.1	0.2	0.4	0.5	0.6	0.1	0.2	0.4	0.5	0.6
5.0	-0.5	-0.4	-0.3	-0.1	0.0	-0.5	-0.4	-0.3	-0.1	0.0	-0.5	-0.4	-0.3	-0.1	0.0
10.0	-	-1.4	-1.3	-1.1	-1.0	-	-1.4	-1.3	-1.1	-1.0	-	-1.4	-1.3	-1.1	-1.0
16.0	-	-	-	-2.3	-2.2	-	-	-	-2.3	-2.2	-	-	-	-2.3	-2.2

RCTZ12 w/ Mass Heating

	Alum					Alum w/ Thermal Breaks					Wood				
	10	12	15	18	20	10	12	15	18	20	10	12	15	18	20
1	0.9	1.1	1.4	1.7	1.8	0.4	0.5	0.6	0.7	0.8	0.2	0.2	0.2	0.3	0.3
2	0.2	0.2	0.3	0.3	0.3	-0.4	-0.4	-0.5	-0.7	-0.7	-0.6	-0.8	-0.9	-1.1	-1.3
3	-0.8	-0.9	-1.1	-1.4	-1.5	-1.2	-1.4	-1.7	-2.1	-2.3	-1.4	-1.6	-2.1	-2.5	-2.7
.0	0.6	0.7	0.9	1.1	1.2	0.6	0.7	0.9	1.1	1.2	0.6	0.7	0.9	1.1	1.2
2.0	0.1	0.2	0.4	0.6	0.7	0.1	0.2	0.4	0.6	0.7	0.1	0.2	0.4	0.6	0.7
5.0	-0.6	-0.5	-0.3	-0.1	0.0	-0.6	-0.5	-0.3	-0.1	0.0	-0.6	-0.5	-0.3	-0.1	0.0
10.0	-	-1.7	-1.6	-1.4	-1.2	-	-1.7	-1.6	-1.4	-1.2	-	-1.7	-1.6	-1.4	-1.2
16.0	-	-	-	-2.9	-2.7	-	-	-	-2.9	-2.7	-	-	-	-2.9	-2.7

RCTZ12 No Mass Cooling

	10	12	15	18	20
1	5.0	6.0	7.5	9.0	10.0
2	4.8	5.8	7.3	8.7	9.7
3	4.7	5.6	7.1	8.5	9.4
.0	0.3	0.4	0.5	0.6	0.6
2.0	0.1	0.1	0.2	0.3	0.4
5.0	-0.3	-0.3	-0.2	-0.1	0.0
10.0	-	-0.9	-0.8	-0.7	-0.6
16.0	-	-	-	-1.5	-1.4

RCTZ12 w/ Mass Cooling

	10	12	15	18	20
1	4.5	5.4	6.7	8.0	8.9
2	4.5	5.4	6.7	8.0	8.9
3	4.5	5.4	6.7	8.0	8.9
.0	0.4	0.4	0.5	0.6	0.7
2.0	0.1	0.1	0.2	0.4	0.4
5.0	-0.4	-0.3	-0.2	-0.1	0.0
10.0	-	-1.0	-0.9	-0.8	-0.7
16.0	-	-	-	-1.6	-1.6

Table 8. Summary of Window Runs

Case Number *	Amount of Window Area: South (ft^2)	North (ft^2)	East (ft^2)	West (ft^2)	Total (ft^2)	Total (%) †	Shaded Window Condition ‡
1	-	69.2	-	69.2	138.4	10	SS
3	44.3	31.4	31.4	31.4	138.4	10	SS
4	88.6	16.6	16.6	16.6	138.4	10	OV
5	-	110.7	-	110.7	221.4	16	SS
7	44.3	59.1	59.1	59.1	221.4	16	SS
8	88.6	44.3	44.3	44.3	221.4	16	OV
9	166.1	18.4	18.4	18.4	221.4	16	OV
10	-	138.4	-	138.4	276.8	20	SS
12	44.3	77.5	77.5	77.5	276.8	20	SS
13	88.6	62.7	62.7	62.7	276.8	20	OV
14	160.1	36.9	36.9	36.9	276.8	20	OV

* Cases 2, 6, 11 for houses with no south windows were modeled but not used.
† The percent (%) indicates percent of floor area.
‡ The criteria used to define 'shaded window' runs are:
(1) If the amount of south-facing glass is equal to or greater than 5% of total window and if, simultaneously, the area is greater than three other equally distributed windows, then overhang (OV) is required.
(2) If the amount of south window is smaller than 5% of total window floor area, then movable sun screens (SS) are required on west window.

We performed all simulations assuming an ASHRAE window with no sash effects. We estimated the impact of differing sash types on window heating loads by scaling wall Δ loads with the ratio of Δ conductances as indicated below:

$$\Delta Heating_{sash} = \Delta Heating_{wall} * \frac{\Delta Conductance_{sash}}{\Delta Conductance_{wall}} \quad (3)$$

Normalization and the Rating Scale

The rating scale is an integral part of the Rating Tool. For the demonstration tools, we used a simple numerical scale from 1 to 6 for comparing the energy consumption of different sizes and types of houses. We set the scale using the energy budget for a house that met 1978 new building standards as a "3," and a house meeting current Title 24 standards as a "5". We scaled the other rating numbers linearly from these two benchmarks so that the estimated savings are the same between any two ratings. For Table 9, we list the conservation levels for the two conditions.

Table 9. Conservation Levels for 1978 and 1982 Building Standards

Conservation Measures	1978 Standards All Zones	1982 Standards Zone 3	Zone 9	Zone 12
Ceiling	R-19	R-30	R-30	R-30
Wall	R-11	R-11	R-11	R-11
Foundation	R-0	R-5, 2ft	R-5, 2ft	R-0
Infiltration	1.2	0.9	0.9	0.9
Window Panes	Single	Single	Single	Double
Window Sash	Aluminum	Aluminum	Aluminum	Aluminum
Window Shading	No	Yes	Yes	Yes
Thermal Mass	No	Yes	Yes	Yes
Heating AFUE	63	71	71	71
Cooling SEER	7.04	8.0	8.0	8.0
DHW Recovery Eff.	65%	76%	76%	76%

For the purposes of the Rating Tool, we modified the component loads (kBtu/ft^2) shown in Tables 5 through 7 to make them easier to use. For each climate zone, we added a multiplier to the component loads so that the energy use (per ft^2 of floor area) for the worst house was 100. We then divided the building component loads for ceiling, wall, floor, windows, and infiltration by these multipliers, which are: 1.515 kBtu in zone 3, 1.614 kBtu in zone 9, and 1.954 kBtu for zone 12. If a need arises to convert the normalized loads shown on the Rating Tool to typical engineering units such as kBtu per ft^2 of floor area, the user should use the appropriate multiplier for that climate zone.

The other changes to the component loads in Tables 5 through 7 were to apportion the *residual loads* and eliminate negative numbers. The *residual load* is the difference between the sum of the component loads and the total loads from the database. It represents the net effect of internal loads and interactions ignored by the component-by-component regression analysis. Residual loads do not appear on the Rating Tool, but are apportioned among other terms, such as the ceiling or wall component loads.

In order to avoid negative numbers on the Rating Tool, we added constants to the loads for certain components and subtracted the same constants from other components. Since the ratings are based only on the total loads, these modifications have no effect on the calculations. However, we did retain negative numbers for the window component loads to differentiate between window configurations that saved or consumed energy.

Due to the multipliers, the worst case house covered by the Rating Tool in any climate zone will have an energy use value of 100. We did not include the worst case house on the Rating Tool scale since this would greatly extend the scale and reduce legibility for houses of typical to good energy efficiency. Instead, we have limited the scale on the Rating Tool to range from 1 to 60 with a note to the users that all houses with energy use values greater than 60 fall within the lowest rating of 1.

Assumptions and Calculations for Hot Water Systems

The domestic hot water values used on the Rating Tool are based on published CEC procedures [9]. We present the basic engineering assumptions in Table 10.

Table 10. Domestic Hot Water Assumptions

Parameter	Code†	Assumption	Basis
Daily Hot Water Load	L	50 gallons/day	CEC assumption
Tank Set Temperature	T_T	140 °F	CEC assumption
City Water Main Temperature	T_M	65 °F (Zones 3 and 12) 70 °F (Zone 9)	CEC data† (Table 2, p.6)
Water Heater Recovery Efficiency	RE	65% for Old Gas* 76% for New Gas* 100% for Electric	discussion with D. Ware (CEC)
Water Heater Input Rate	I_R	55 kBtu/hr	CEC assumption (discussion with M. Horne)
Tank Capacity	C_T	40 gallons	discussion with D. Ware (CEC)
Ambient Air Temperature	T_A	56.9 °F for Zone 3 63.6 °F for Zone 9 60.3 °F for Zone 12	CEC data† (Table 2, p.6)
Standby Loss Energy	Q_S	3.98% for gas, 0.80% for electric	Title 24 assumption (discussion with D. Ware, CEC)
Standby Loss Adjustment	A	71% for gas, 80% for electric	CEC data†, (Table 3, assuming C_T = 40 gallons)
Adjusted Standby Loss Energy	Q_{SA}	2.8% for New Gas 4.8% for Old Gas 0.64% for Electric	Q_S(gas) x A(gas) Average of Q_S(gas) and Q_{SA}(new gas) x 2 Q_S(elec) x A(elec)

† Code and tables refer to those in CEC document, "Methodology for Calculating Water Heating Energy Pursuant to the Residential Building Standards" (Staff Draft). These designations are used in the remaining equations.

* "Old Gas" and "New Gas" refers to the efficiency of pre- and post-1976 gas water heaters.

We calculated the annual energy recovery (Q_R) using the formula:

$$Q_R = [L(8.25)(T_T)(365)]/RE = (150.56)(T_T - T_M)/RE \quad (4)$$

The resulting annual energy recovery values for the three climate zones in the demonstration project are shown below in Table 11.

Table 11. Annual Energy Recovery (Q_R)

		Old Gas (kBtu/yr)	New Gas (kBtu/yr)	Electric (kBtu/yr)
		RE =0.65	RE =0.76	RE =1.00
Zone 3	$T_M = 65\,^\circ F$	17,372	14,858	11,292
Zone 9	$T_M = 70\,^\circ F$	16,214	13,868	10,539
Zone 12	$T_M = 65\,^\circ F$	17,372	14,858	11,292

We calculated annual standby loss energy (Q_S) using the formula:

$$Q_S = [24 - Q_R / I_R (365)](8.25)(C_T)(Q_{SA})(365)(T_T - T_A)\ x\ .001 \quad (5)$$

$$= [24 - Q_R / 20{,}075](120.45)(Q_{SA})\Delta T$$

where: $\Delta T = T_T - T_A$

The annual standby loss energy (Q_S) values for the three climate zones are shown in Table 12.

Table 12. Annual Standby Loss Energy (Q_S)

		Old Gas (kBtu/yr)	New Gas (kBtu/yr)	Electric (kBtu/yr)
		$Q_{SA} = 0.048$	$Q_{SA} = 0.028$	$Q_{SA} = 0.0064$
Zone 3	$\Delta T = 83.1\,^\circ F$	11,114	6,519	1,502
Zone 9	$\Delta T = 76.4\,^\circ F$	10,2245	6,006	1,386
Zone 12	$\Delta T = 79.7\,^\circ F$	10,659	6,252	1,440

Using the sum of the annual energy recovery values from Table 11 and the annual standby loss energy from Table 12, we calculated total annual consumptions for standard domestic hot water systems in the three climate zones (see Table 13). We divided these values by the floor area of the one-story prototype house before combining them with the space conditioning energy budgets calculated earlier.

Table 13. Total Annual Consumption

	Old Gas (kBtu/yr)	New Gas (kBtu/yr)	Electric (kBtu/yr)	Electric x Fuel Multiplier* (kBtu/yr)
Zone 3	28,486	21,377	12,794	38,382
Zone 9	26,459	19,874	11,922	35,766
Zone 12	28,031	21,110	12,732	38,196

*CEC fuel multiplier of 3 used for electric water heaters.

For solar hot water systems, we calculated average savings (Q_{ANN}) resulting from the use of various solar models using data provided by the CEC staff. We grouped the solar hot water systems by the number of solar panels; other groupings, such as by type of system, were tried but proved unworkable. We calculated average Q_{ANN}s for 1 and 2-panel systems for each climate zone, and then subtracted these savings from the "new gas" values, the assumed backup system, to derive the net domestic hot water consumption. Table 14 summarizes the average savings and the net estimated energy consumption for 1 and 2-panel systems in each climate zone. We divided these net consumption values for solar systems by the floor area of the one-story prototype before incorporating them into the Rating Tool.

Table 14. Total Annual Consumption for Solar Hot Water Systems

	Average Savings (Q_{ANN})		New Gas Consumption	Net Consumption*	
Climate Zone	1-panel (kBtu/yr)	2-panel (kBtu/yr)	(kBtu/yr)	1-panel (kBtu/yr)	2-panel (kBtu/yr)
Zone 3	6,150	9,200	21,377	15,227	12,177
Zone 9	6,350	9,500	19,874	13,524	10,374
Zone 12	6,600	9,600	21,110	14,510	11,510

*These values are used on the Rating Tool.

After the domestic hot water annual consumption was converted to per ft^2 values for the CEC prototype house (as shown in Table 15), we divided them by the same multiplier as used for space conditioning to convert the hot water budgets to "normalized units". We show these normalized values for each climate zone in Table 16.

Table 15. Total Annual Consumption per Square Foot

(kBtu/ft^2-yr for 1384 ft^2 CEC Prototype House)

	Old Gas	New Gas	Electric	1-Panel Solar	2-Panel Solar
Zone 3	20.58	15.45	27.73	11.01	8.80
Zone 9	19.11	14.36	25.84	9.77	7.50
Zone 12	20.25	15.25	27.60	10.48	8.31

Table 16. Total Annual Consumption per Square Foot in Normalized Units:

	Old Gas	New Gas	Electric	1-Panel Solar	2-Panel Solar
Zone 3	13.58	10.20	18.31	7.27	5.81
Zone 9	11.84	8.90	16.01	6.05	4.65
Zone 12	10.36	7.80	14.12	5.36	4.25

Supplementary Conservation Measures

In addition to the typical energy conservation features such as ceiling, wall or floor insulation, infiltration controls, window measures, equipment efficiencies, and hot water measures, we provide estimated savings for three optional conservation measures: thermostat setback, low-flow showerheads, and outlet gaskets. Although not part of the Rating Tool, these measures are included in an accompanying rating sheet. We based the estimated savings for low-flow showerheads and gaskets on data from the CEC and discussions with CEC staff.

We calculated energy savings estimates for automatic thermostat setback using data and procedures as described in a CEC staff report [10]. We first calculated the difference in energy consumption for a moderately tight house with and without night setback (heating) or day setup (cooling). For the house thermal integrity, we assumed a conservation level halfway between the 1978 and 1982 Title 24 standards that consisted of a R-19 ceiling, R-11 wall, double-glazed windows, and weatherstripping. We modeled this configuration to avoid overpredicting setback savings had we assumed a "loose" house.

We used the following equation from the CEC calculation procedure (see Tables A.8 and A.9 of reference 9) to determine total annual consumption:

$$UEC_{SC} = (SF_{TSA} \ x \ Base) - [SF_{FL} \ x \ (Attic + WC)] - (SF_{WL} \ x \ Wall) - (SF_{GL} \ x \ Glazing) \quad (6)$$

Where:

UEC_{SC} = Annual unit energy consumption for space conditioning (heating or cooling);
SF_{TSA} = Total surface area (3968 ft^2);
Base = Energy consumption per square foot of surface area of a building envelope;
SF_{FL} = Ceiling and floor areas (1384 ft^2);
Attic = Energy savings per square foot of floor area for installing the specified R-value of attic insulation;
WC = Energy savings per square foot of floor area for installing weatherstripping and caulking;
SF_{WL} = Net wall area (973 ft^2);
Wall = Energy savings per square foot of wall area for installing wall insulation;
SF_{GL} = Net window areas (227 ft^2);
Glazing = Energy savings per square foot of glazing area for installing either storm windows or thermal drapes.

Since the CEC calculation procedure does not cover different window glazings, we accounted for double-glazed windows by averaging the setback savings for regular and storm windows. We discounted the predicted savings by 50% to avoid giving too much credit for automatic setback thermostats since (1) their existence do not guarantee that setbacks and setups will be used, and (2) occupants in houses without thermostat setback may still implement manually-operated setback and setup strategies.

We present the estimated savings for supplementary conservation measures in the three demonstration climate zones in Table 17.

Table 17. Estimated Savings for Supplementary Measures

Climate Zone	Setback Savings		Showerhead Savings		Gasket Savings	
	(kBtu/ft^2)	N.U.*	(kBtu/ft^2)	N.U.*	(kBtu/ft^2)	N.U.*
3	4.09	2.7	2.17	1.4	2.25	1.5
9	3.19	2.0	2.10	1.3	0.06	0.1
12	6.43	3.3	2.17	1.1	2.17	1.1

* N.U. = Normalized Units

THE RATING TOOL

We completed three draft versions of the energy Rating Tool in late 1984 and presented them to the CEC for their review and comment. The CEC was responsible for printing the Rating Tools and distributing them to each of the demonstration cities. Figure 1 shows a sample Rating Tool for Climate Zone 3 (i.e., County of Marin).

To use the Rating Tool, one aligns the tabs to the appropriate conservation levels and computes an energy rating by adding and multiplying the numbers in the small windows to the right. The step-by-step calculation procedure is indicated by the heavy lines on the Rating Tool sleeve and requires only simple arithmetic. Heating and cooling energy use are calculated separately and then added to the estimated hot water energy consumption to produce a final house energy rating. For documentation, there is an accompanying one-page rating sheet on which the user can record all calculations (see Fig. 2). A copy of this record can be left with the homeowner of the rated house for future reference.

Tabs A through F on the Rating Tool calculate the estimated energy requirements of the building based on its level of conservation. There are two sides to these tabs for use depending on the house type (one-story or two-story) or thermal mass condition (rug covered or exposed floor slab). The five tabs cover variations in the following items: ceiling, wall and foundation insulation, infiltration, and window conditions. The window calculations are more complex in order to cover various window combinations of total and south window areas, thermal mass condition, roof overhangs, reflective glazings, and different sash types and glazing layers.

Tabs G through I account for the characteristics of the furnace, air-conditioner, and domestic hot water heater. Heating and cooling efficiencies are treated as multiplicative terms, while the hot water usage is treated as an additive term.

In Appendix A, we provide a step-by-step procedure for using the Rating Tool. As an example, we go through the complete calculation procedure for a typical single-family house in climate zone 3.

FUTURE PLANS

The demonstration of the home rating and labeling process in Pasadena and Roseville will be completed by the end of 1986. We have initiated a project for the CEC to evaluate the effectiveness of the delivery mechanisms used in the two pilot studies. As part of the evaluation, we will review the ratings, address the technical and delivery problems identified by project participants during the demonstration phase, and recommend solutions.

If the rating tool in combination with any of the delivery mechanisms being tested should prove successful, it may be applicable to other California locations as well as to other parts of the country. The work described here illustrates the feasibility of translating complex technical information into a simplified slide rule format that can be used by a non-technical audience. If such a simplified tool can be used to encourage homeowners to retrofit existing houses by increasing their attic and wall insulation levels, improving water heater practices, and installing storm windows and setback thermostats, the state's total residential energy demand can be reduced significantly.

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10. California Energy Commission, "Measurement and Evaluation of the Energy Conservation Potential in California's Residential Sector," (Staff Report), June 1983.

ACKNOWLEDGEMENTS

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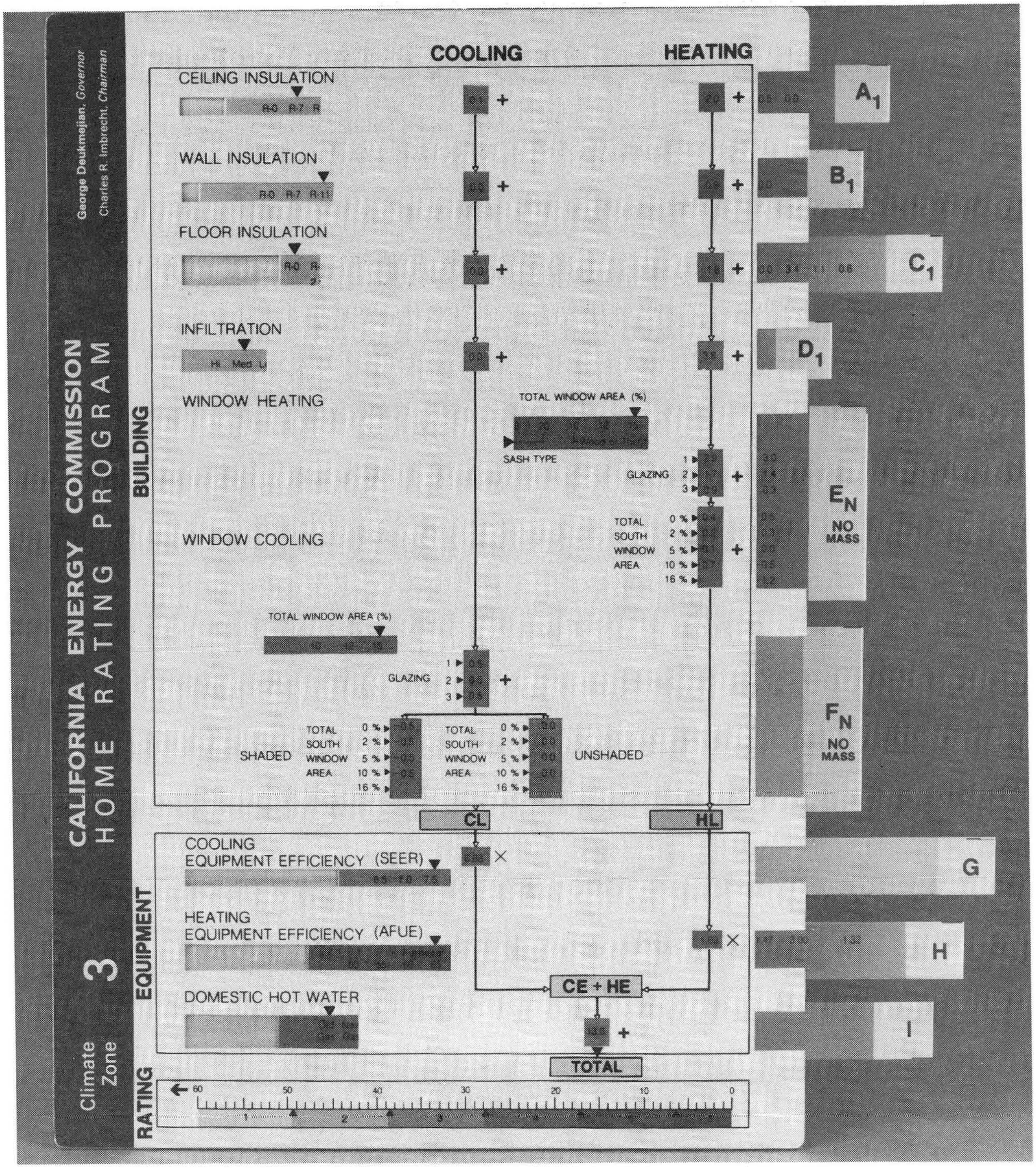
Figure 1. Home Energy Rating Tool



CBB 850-10177

Figure 2. Home Rating Certification Form

State of California — California Energy Commission
CERTIFICATION FORM
CALIFORNIA HOME RATING AND LABELING — Climate Zone Three

(Please Print)
Homeowner ____________________

Address ____________________

City/Zip ____________________

Phone Number ____________________

Is Home Currently for Sale? [ ] Yes [ ] No

BUILDING CHARACTERISTICS

Number of Stories 1 2 — Approximate Square Footage ______
Thermal Mass [ ] Yes [ ] No

	Value	Cooling Load	Heating Load
Ceiling Insulation	____	____	____
Wall Insulation	____	____	____
Floor Insulation	____	____	____
Infiltration	____	____	____
Window Area	____	____	____
South Window Area	____	____	____
% Shaded	____	____	____
% Unshaded	____	____	____

SUBTOTAL	____	SUBTOTAL ____
A.C X	____	Heat X ____
TOTAL	____	TOTAL ____

EQUIPMENT EFFICIENCY

Cooling Equipment (SEER) ____
Combined Total Cooling/Heating Load ______
Domestic Hot Water (type) ____________ +

HOME'S ENERGY RATING VALUE ________

ADDITIONAL ENERGY CONSERVATION FEATURES

SET-BACK THERMOSTAT	-2.7
LOW-FLOW SHOWERS	-1.4
OUTLET GASKETS	-1.2

FINAL RATING VALUE ________

Assigned Rating (enter on line) ____________
Label Serial Number (enter on line) ____________

Name of Certifier (Print) ____________ Homeowners Signature ____________ Date

Signature ____________ Date

APPENDIX A: HOW TO USE THE RATING TOOL

The procedure for using the Rating Tool is illustrated below for a single-family house in climate zone 3 (Marin County). This one-story house has the following characteristics:

Component	Rating Tool Input
Ceiling Insulation R-Value (insulation only)	R-7
Wall Insulation R-Value (insulation only)	R-11
Floor Insulation R-Value (insulation only)	R-0 (uninsulated concrete slab)
Windows:	
Sash Material:	Wood
Total Window Area:	16% of gross floor area (173.55 ft^2)
South Window Area:	4% of gross floor area (57.45 ft^2)
	with 1 ft of eave on all four sides (unshaded).
Glazing Layers:	Single
Infiltration Level:	Medium
Cooling Equipment Seasonal	None
Heating Equipment Efficiency:	Furnace model 1978
Gross Floor Area:	1080 ft^2
Domestic Hot Water:	Pre-1975, gas

Step 1 - Ceiling Insulation

Set **tab A_1** so that the arrow points to the correct ceiling insulation R-value (for this example, use R-7). Record the value (0.1 for cooling and 2.0 for heating) on the rating sheet (see Fig. A.1 as an example). A_1 indicates that the tab covers one-story houses, while the reverse side of the tab (A_2) is used for two-story houses. The same applies to the tabs for wall (B), floor insulation (C), and infiltration (D).

Note. If the insulation in your home is not exactly the same as a value on the slide rule, use the closest value. However, if you wish to interpolate more exact numbers, use the U-values listed in Table 3 as *Ceiling U-values*.

Step 2 - Wall Insulation

Set **tab B_1** so that the arrow points to the correct wall insulation R-value (for this example, use R-11). Record the value (0.0 for cooling and 0.9 for heating) on the rating sheet.

If you wish to interpolate more exact numbers, use the wall U-values listed in Table 3.

Step 3 - Floor Insulation

Set **tab C_1** so that the arrow points to the appropriate level of floor or foundation insulation (for this example, use R-0). Record the value (0.0 for cooling and 1.8 for heating) on the rating sheet.

Step 4 - Infiltration

Set **tab D_1** so that the arrow points to the appropriate infiltration level (for this example, use "Medium"). Write down the value (0.0 for cooling and 3.8 for heating). Rating the leakiness of a home requires some knowledge of the home's performance in the winter season. The characteristics listed below are helpful for estimating "infiltration levels".

- **High** (1.2 air change per hour (ach)): Drapes move on a windy day, and strong drafts can be felt around windows, doors, and electrical outlets. Typically, homes more than 30 years old without recent conservation measures, have a "high" rating.
- **Medium** (0.9 ach): Mild drafts can be felt on windy days around windows, doors and electrical outlets. Typically, an old home, with recent window and door caulking and weatherstripping, or a home built within the past 20 years, should have a "medium" rating.
- **Low** (0.6 ach): Few drafts can be felt around windows, doors and electrical outlets on windy days. More careful measures have been taken to reduce air infiltration, such as installing adequate weatherstripping of windows, putting gaskets on electrical outlets, and sealing sills and vents. This level of reduction can be realized as long as the materials used are of reasonably good quality and are properly installed. Typically, new homes built in the last 10 years have a "low" rating.

Note. The low infiltration case assumes at least one of two conditions: (1) the house has a natural infiltration rate of 0.5 ach plus 0.1 ach due to building use (opening of doors and windows) or, (2) the house is constructed with an air-to-air heat exchanger which, in combination with natural infiltration, achieves 0.6 ach. The heat exchanger has been added to maintain or improve indoor air quality.

Step 5 - Window Heating

Set **tab E_n** (no mass) so that the arrow points to the closest window area and correct sash type. The choices of sash types are "aluminum", "wood" or "thermal break". Align the tab so that the top arrow labeled *total window area (%)* points to the correct or closest value and the bottom arrow labeled *sash type* points to the appropriate sash condition. Read the top box for the value corresponding to the correct number of window panes and then the bottom box for the value corresponding to your south window area (for this example, since the south window area is 4% of the floor area, use 5%). Record the values from the top and bottom boxes (2.9 and -0.1 for heating), and circle the choice of thermal mass on the rating sheet (N).

Note. No thermal mass means that the floor is covered by a rug. Assume the thermal mass condition when at least 50% of the floor is exposed slab, or the sum of the total wall mass plus the exposed floor is greater than 50% of the floor area. The concrete slab can be covered with floor tiles. In the case of the thermal mass option, you should use the reverse side of the tab marked E_m.

Step 6 - Window Cooling

Set **tab F_n** (no mass) so that the arrow points to the same window area assigned on Tab E_n. Read the value in the top box that corresponds to the correct number of glazings and then the number in the bottom box that corresponds to your south window area (for this example, use "1" for single-pane, 5% of floor area, and unshaded window). Record the values from the top and bottom boxes (0.5 and 0.0 for cooling).

Note. If most glazing is on the west side of the house, and if there are long eaves, overhangs or movable shaded screens, use **shaded window** area; if there is no shading in the west, use **unshaded window** area.
If most glazing is on the south side of the house, use **shaded** or **unshaded** depending on whether there are long eaves, overhangs or movable shaded screen. The required sizes of overhangs for the different climate zones are: 2 ft. for Zone 3, 2.5 ft. for Zone 9, and 3 ft. for Zone 12.

Step 7 - Subtotal

Add the cooling unit values and write the sum (0.6) on the rating sheet. Add the heating values and record the sum (11.5) on the sheet.

Step 8 - Cooling Equipment Efficiency

Set **tab G** so that the arrow points to the appropriate SEER (Seasonal Energy Efficiency Ratio). If the home has no cooling equipment, enter zero on the sheet. If the SEER is unknown, use 7.0 for pre-1976, 7.5 for 1976-80, and 8.0 for post-1980 central air-conditioners.

Note. Room air-conditioners should not be included in this rating.

Step 9 - Heating Equipment Efficiency

Set **tab H** so that the arrow points to the rated Annual Fuel Utilization Efficiency (AFUE). If the AFUE is unknown, use 60 for pre-1976 65 for 1976-80, and 70 for post-1980 furnances. Use "electric resistance" for baseboard heaters (for this example, use an AFUE of 65 since the furnace is 1978). Record the multiplier (1.69) on the rating sheet.

Note. Portable room space heaters should not be included in this rating.

Step 10 - Domestic Hot Water

Set **tab I** so that the arrow points to the appropriate hot water system. "Old gas" refers to pre-1976, "new gas" refers to a post-1976 gas water heater plus R-12 blankets, and "electric" refers to electric water heaters. "Solar" includes both active and passive solar hot water systems. For this example, use "old gas" since the water heater is a pre-1975 gas model. Record the value (13.6) on the rating sheet.

Step 11 - Rating Your Home

The TOTAL value is the sum of the total heating and cooling energy values added to the domestic hot water value (for this example, it is 19.43 plus 13.6). Record this total (33.03) on the sheet. The poorest (least energy efficient) rating is a "1", the best (most energy efficient) is a "6", and a "5" corresponds to California's current Title 24 building standards.

SOME EXAMPLES OF HOW TO IMPROVE THE RATING OF YOUR HOME

Energy conservation improvements can also be estimated with this Rating Tool. For example, insulation can be added to the wall, ceiling, or floor; the infiltration rate can be decreased by reducing air flow into home; more glazing can be added on the south side of one's home, etc. Each individual option, or group of options, can be evaluated. The following example illustrates the steps that one can take to improve the base rating of the example house in Marin from a "3" to a "5". Since climate zone 3 is generally mild during the summer, our example will illustrate only heating strategies. However, in many other climate zones the most effective conservation strategies may be those producing cooling savings.

Conservation measures related to improvements in building envelope.

Step 1 - Improve infiltration rate from 0.4 to 0.6 ach by putting gaskets on electrical outlets, and sealing most of the sills and bypass pipes and ducts.
Reset only those tabs that are being modified. Set **tab D_1** so that the arrow points to "Low", and record the new heating value (2.2) on the another rating sheet (see Fig. A.2 as an example).

Step 2 - Increase south window area from 4% to 7% by adding a south-facing skylight in the living room, and add thermal mass by changing rugs to tiles in part of the living room and on most of the west and south-facing floor of the dining room.
Reset **tab E_m** with the arrow pointing to the 18% (previous setting of 16% plus 2% from the additional south window), in the wood sash range. Read the top box for the value that corresponds to single-glazing and the bottom box, for the 7% south window (interpolated value between the 5 and 10%). Record the heating values (1.9 and -0.4) next to the old values on the rating sheet.

Step 3 - Add the heating values and write down the new subtotal (8.3); multiply this value by the same heating equipment efficiency (1.69), and the result will be a new heating energy value of 14.03. Add the new heating energy value to the old hot water value, so that the new TOTAL is 27.8.

Step 4 - Add outlet gaskets. Subtract additional points (1.4) for the gaskets giving a final point score of 26.4, which is a "4" rating.

Conservation measures related to improvements in equipment characteristics

Step 1 - Install a new furnace or retrofit an old furnace to an AFUE of 75. Set **tab H** so that the arrow points to the new AFUE and and record the heating value of 1.47 on the next rating sheet (see Fig. A.3 as an example).
Step 2 - Install a new gas water heater. Set **tab I** so that the arrow points to "new gas", and record the energy value of 10.2.
Step 3 - Multiply the subtotal (8.3) calculated above from the first conservation measures by the new heating multiplier (1.47). Add this subtotal to the new hot water value of 10.2, to obtain a TOTAL of 22.4.
Step 4 - Install a setback thermostat and low-flow showerhead. Subtract additional points (2.7) for the thermostat and showerhead (1.4), giving a final point score of 17.25, which raises the rating to a "5".

Figure A.1 Rating Sheet for Base House in Zone 3

State of California
CERTIFICATION FORM
CALIFORNIA HOME RATING AND LABELING

California Energy Commission

Climate Zone Three

(Please Print)
Homeowner ____________________

Address ____________________

City/Zip Marin County

Phone Number ____________________

Is Home Currently for Sale? [ ] Yes [ ] No

BUILDING CHARACTERISTICS Base House

Number of Stories (1) 2
Thermal Mass [ ] Yes [X] No

Approximate Square Footage 1080

		Value	Cooling Load	Heating Load
Ceiling Insulation		R7	0.1	2.0
Wall Insulation		R11	0.0	0.9
Floor Insulation		R0	0.0	1.8
Infiltration		Medium	0.0	3.8
Window Area	(16%)	173.55 Use 15%	0.5	2.9
South Window Area	(4%)	57.45 Use 5%	-	-0.1
% Shaded (South or West)*		-	-	-
% Unshaded (South or West)*		5%	0.0	

SUBTOTAL	0.6	SUBTOTAL	11.50
A.C X	0	Heat X	1.69
TOTAL	0	TOTAL	19.43

EQUIPMENT EFFICIENCY

Cooling Equipment (SEER) None
Combined Total Cooling/Heating Load 19.43
Domestic Hot Water (type) 13.60 +

HOME'S ENERGY RATING VALUE 3

* see window cooling in appendix for more detailed explanation

ADDITIONAL ENERGY CONSERVATION FEATURES

SET-BACK THERMOSTAT -2.7
LOW-FLOW SHOWERS -1.4
OUTLET GASKETS -1.2

FINAL RATING VALUE 3

Assigned Rating (enter on line) ____________
Label Serial Number (enter on line) ____________

Name of Certifier (Print)

Homeowners Signature Date

Signature Date

Figure A.2 Rating Sheet for Base House with Envelope Improvements

State of California
CERTIFICATION FORM
CALIFORNIA HOME RATING AND LABELING

California Energy Commission
Climate Zone Three

(Please Print)
Homeowner ____________________

Address ____________________

City/Zip Marin County

Phone Number ____________________

Is Home Currently for Sale? [ ] Yes [ ] No

BUILDING CHARACTERISTICS First Cons. Measure

Number of Stories (1) 2 Approximate Square Footage 1080

Step 2 Thermal Mass [X] Yes [ ] No

		Value		Cooling Load	Heating Load
	Ceiling Insulation	R7		0.1	2.0
	Wall Insulation	R11		0.0	0.9
	Floor Insulation	R0		0.0	1.8
Step 1	Infiltration	Low		0.0	2.2
Step 2	Window Area	191.70	(use 18%)	0.5	1.9
	South Window Area	75.60	(use 7%)	-	-0.4
	% Shaded (South or West)*	-		-	-
	% Unshaded (South or West)*	7%		0.0	

	Cooling		Heating
SUBTOTAL	0.6	SUBTOTAL	
A.C X	0	Heat X	1.69
TOTAL	0	TOTAL	

EQUIPMENT EFFICIENCY

Cooling Equipment (SEER) None
Combined Total Cooling/Heating Load 14.20
Domestic Hot Water (type) 13.60 +

* see window cooling in appendix for more detailed explanation

HOME'S ENERGY RATING VALUE 3

ADDITIONAL ENERGY CONSERVATION FEATURES

SET-BACK THERMOSTAT -2.7
LOW-FLOW SHOWERS -1.4
Step 3 OUTLET GASKETS -1.2

FINAL RATING VALUE 4

Assigned Rating (enter on line) ____________
Label Serial Number (enter on line) ____________

Name of Certifier (Print) ____________ Homeowners Signature ____________ Date

Signature ____________ Date

Figure A.3 Rating Sheet for Base House with Equipment Improvements

State of California — California Energy Commission
CERTIFICATION FORM
CALIFORNIA HOME RATING AND LABELING — Climate Zone Three

(Please Print)
Homeowner ______________________
Address ______________________
City/Zip Marin County
Phone Number ______________________

Is Home Currently for Sale? [ ] Yes [ ] No

BUILDING CHARACTERISTICS Second Conserv. Measure

Number of Stories (1) 2 — Approximate Square Footage 1080
Thermal Mass [X] Yes [ ] No

	Value		Cooling Load	Heating Load
Ceiling Insulation	R7		0.1	2.0
Wall Insulation	R11		0.0	0.9
Floor Insulation	R0		0.0	1.8
Infiltration	Low		0.0	2.2
Window Area	191.70	(use 18%)	0.5	1.9
South Window Area	75.60	(use 7%)	-	-0.4
% Shaded (South or West)*	-		-	-
% Unshaded (South or West)*	7%		0.0	
		SUBTOTAL	0.6	SUBTOTAL 8.4
		A.C X	0	Heat X 1.47
		TOTAL	0	TOTAL 12.35

Step 1

EQUIPMENT EFFICIENCY

Cooling Equipment (SEER) None
Combined Total Cooling/Heating Load 12.35
Step 2 Domestic Hot Water (type) 10.20 +
* see window cooling in appendix for more detailed explanation

HOME'S ENERGY RATING VALUE 4

ADDITIONAL ENERGY CONSERVATION FEATURES

Step 4 SET-BACK THERMOSTAT -2.7
LOW-FLOW SHOWERS -1.4
OUTLET GASKETS -1.2

FINAL RATING VALUE 5

Assigned Rating (enter on line) ______
Label Serial Number (enter on line) ______

Name of Certifier (Print) ______ Homeowners Signature ______ Date

Signature ______ Date