HERS

HOME ENERGY RATING SYSTEM

TECHNICAL MANUAL

CALIFORNIA ENERGY COMMISSION

DRAFT TECHNICAL MANUAL

DRAFT

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ABSTRACT

This Technical Manual explains the requirements for Home Energy Rating System (HERS) software, requirements for HERS providers, and procedures that California Home Energy Auditors shall use to conduct California Home Energy Audits, procedures that California Whole House Home Energy Raters shall use to conduct California Whole House Home Energy Ratings, and the requirements and limitations on California Home Energy Inspectors, California Home Energy Analysts, and California Field Verification and Diagnostic Testing Raters. HERS software is used to calculate the California HERS Index, to generate recommendations on how to improve the energy performance of the rated home, and to analyze customers' utility bills.

Keywords: Whole-House Home Energy Rater, Home Energy Auditor, Home Energy Inspector, Home Energy Analyst, Building Performance Contractor, California Home Energy Rating System Program, HERS, HERS rating scale, utility bills, cost-effectiveness, field verification and diagnostic testing

1. Overview

This Technical Manual explains the requirements for Home Energy Rating System (HERS) software, requirements for HERS providers, and procedures that HERS Raters shall use to conduct a whole-house HERS rating. HERS software is used to calculate the California HERS Index, to generate recommendations on how to improve the energy performance of the rated home, and to analyze customers' utility bills. The document is organized as follows:

- Chapter 2 specifies the minimum and optional reports that shall be produced by the HERS provider.
- Chapter 3 explains how the California HERS Index is calculated.
- Chapter 4 details the modeling rules and assumptions for calculating energy use for both the rated home and the reference home.
- Chapter 5 covers the procedures for analyzing energy bills history for the rated home.
- Chapter 6 spells out the procedures for determining cost-effective energy efficiency measures for the rated home using both the Standard Approach and the Customized Approach.
- Chapter 7 identifies inputs to the model and provides guidelines on how this information is to be collected from on-site inspections.
- Chapter 8 reviews quality control procedures and discusses the roles of the various parties involved in the rating process.

The software approval procedure is one of self-testing and self-certification by the HERS provider. The provider certifies in writing that the HERS software meets the requirements of this Technical Manual. The California Energy Commission (Energy Commission) will perform spot checks and may require additional information to verify that the proposed HERS software is suitable for the intended purposes.

1.1 Minimum Modeling Capabilities

HERS software shall meet the minimum and optional modeling capabilities specified in Chapters 4 and 5 of the *2008 Residential ACM Approval Manual* (Energy Commission publication 400-2008-002). The minimum modeling capabilities are summarized below:

- Conduction gains and losses through opaque and fenestration surfaces
- Slab edge gains and losses
- Infiltration gains and losses
- Solar gains through glazing including the effects of internal shading devices.
- Natural ventilation cooling

- Mechanical ventilation for Indoor Air Quality (IAQ)
- Thermal mass effects to dampen temperature swings
- Space conditioning equipment efficiency and distribution systems
- Water heating equipment efficiency and distribution systems
- Building additions
- Attic modeling (Unconditioned Zone Model - UZM)
- Maximum cooling capacity
- Raised floors with automatically operated crawl space vents
- Zonal control or multi-zone modeling of the sleeping and living areas of the house
- Attached sunspaces for collection and possible storage of heat for transfer to the main house
- Exterior mass walls
- Overhangs and side-fin shading
- Combined hydronic space and water heating
- Building alterations
- Solar water heating
- Gas-fired and absorption cooling
- Evaporatively cooled condensing units
- Ice storage air conditioner
- Evaporative coolers
- Photovoltaic performance modeling

1.2 Application Checklist

The following is a checklist of all the items that shall be included in an application package for HERS software. Some materials are required only for general purpose HERS software and are so indicated.

- Evidence that the software has met the requirements of the *2008 Residential ACM Approval Manual*. Including:
    - HERS software Vendor Certification Statement.
    - Computer run summary sheets.
    - Computer runs.

- Copy of the HERS software. A computer readable copy of the HERS software (in a format agreed to by the Energy Commission staff) for verification of analyses and random verification of compliance analyses. Weather data shall be included.
- Application fee. An application fee of $1,000.00 (one thousand dollars) is required to cover costs of evaluating the application.

1.3 Types of Approval

This Technical Manual addresses three types of HERS software approval: full approval, streamlined approval of new program features, and amendments to full approvals.

1.3.1 Full Approval

Full approval is required when a candidate HERS software has never been previously approved by the Energy Commission, and/or when the HERS provider makes changes to the executable program code or algorithms, or any other change that in any way affects the results. The Commission may also require that all HERS software be approved again when the standards are updated on the three-year cycle or whenever substantial revisions are made to the approval process, for instance, if new analysis capabilities come into widespread use, and the Commission declares them to be minimum capabilities for all HERS software.

When re-approval is necessary, the Energy Commission will notify all HERS software providers of the timetable for renewal. There will also be a revised *HERS Technical M*anual published, with instructions for re-approval.

Full approval is required for all HERS software changes unless they qualify for the streamlined approval process or for an addendum, as discussed below.

1.3.2 Streamlined Approval

Certain types of changes may be made to approved residential HERS software through a streamlined procedure. Examples of changes that qualify for streamlined approval are modifications to the user interface or implementation on a different operating system as long as there are no changes to the executable program code that would in any way affect the results.

If a HERS software modification qualifies for streamlined approval, then the following procedure is followed:

- The HERS provider prepares a summary of the changes to the HERS software.
- The HERS provider notifies the Energy Commission by letter of the change. The letter shall describe in detail the nature of the change and why it is being made.
- Provide the Energy Commission with an updated copy of the HERS software and include any new reports created by the HERS software (or modifications in the standard reports).

- The Energy Commission responds in 45 days. The Commission response may take several forms. The Commission may request additional information, refuse to approve the change, or require that the HERS provider make specific changes to the HERS software.
- With Energy Commission approval, the provider may issue new copies of the HERS software and notify HERS software users.

1.3.3 Amendments

HERS software approval shall be amended when optional modeling capabilities are added. The HERS provider shall provide the additional computer runs required for the optional modeling capability. It is not necessary to include computer runs previously submitted. The HERS provider shall provide a cover letter explaining the type of amendment requested, and copies of supporting information as necessary. All items on the application checklist should be submitted, when applicable. The timetable for approval of amendments is the same as for full approval.

1.3.4 When Approval Is Not Required

Changes that do not affect the determination of the California HERS Index or the Standard Approach recommendations do not require full or streamlined approval. However, the HERS provider shall notify the Energy Commission and provide the Commission with an updated copy of the program. Any questions regarding applicable approval procedures should be directed to the Commission.

1.4 Challenges

Program users, providers, or other interested parties may challenge any HERS software approval. If any interested party believes that an algorithm or calculation method used in HERS software provides inaccurate results or that a HERS report is being improperly produced, the party may challenge the program.

1.5 Decertification of HERS Software

The Energy Commission may decertify (rescind approval of) previously approved HERS software through the following:

- All HERS software are decertified when the substantial changes are made to the *HERS Technical Manual*.
- Any HERS software can be decertified by a letter from the HERS provider and the HERS software vendor requesting that a particular version (or versions) of the HERS software be decertified. The decertification request shall briefly describe the nature of the program errors or "bugs" which justify the need for decertification.

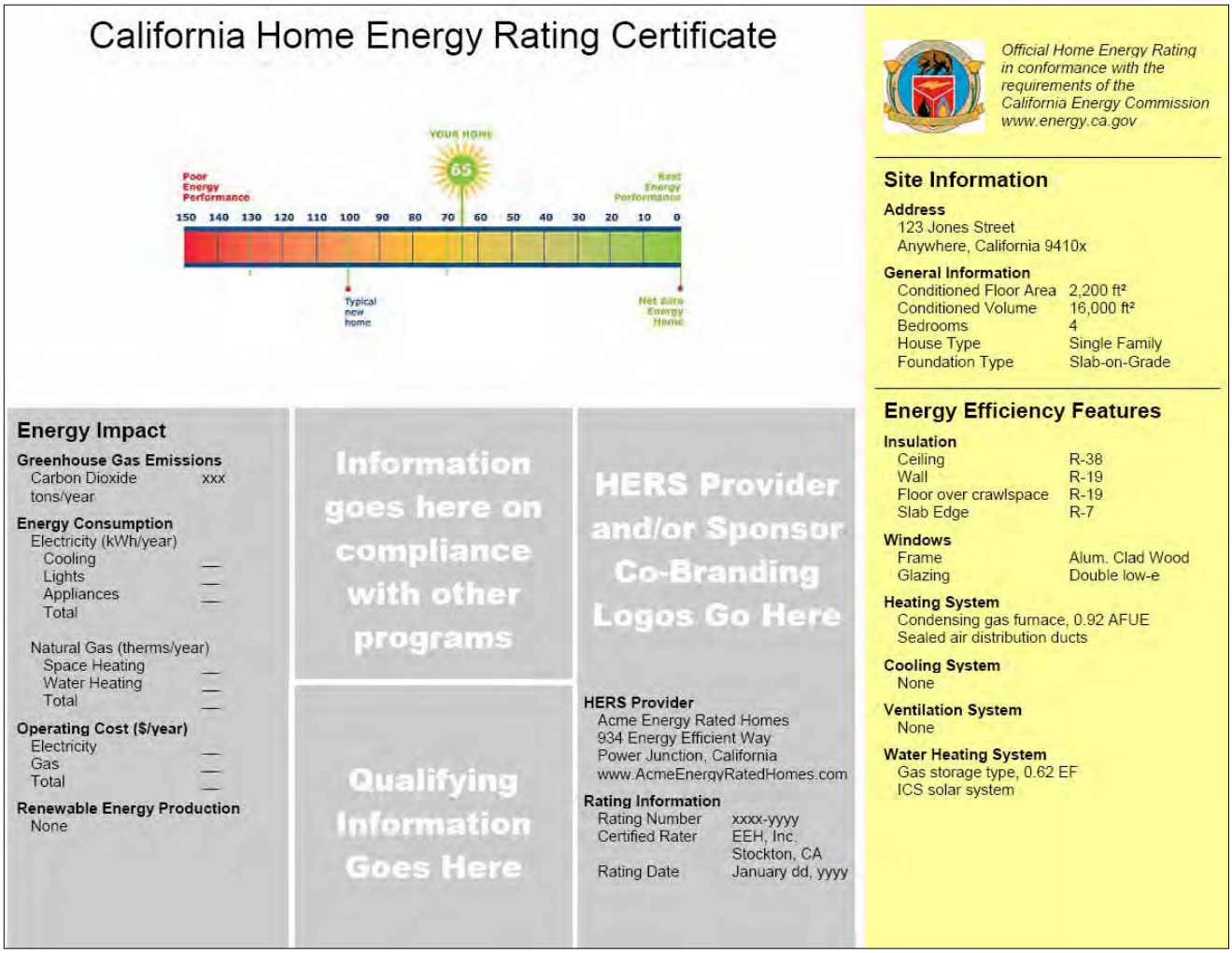
- Any "initiating party" may commence a procedure to decertify a HERS software according to the steps outlined below. The intent is to include a means whereby serious program errors, flawed numeric results, improper forms, and/or incorrect program documentation not discovered in the certification process can be verified, and use of the particular HERS software version discontinued. In this process, there is ample opportunity for the Energy Commission, the HERS provider, and all interested parties to evaluate any alleged errors in the HERS software program.

The process for challenging HERS software or initiating a decertification procedure is described in the *2008 Residential ACM Approval Manual*.

2. The HERS Reports

2.1 Rating Certificate

Figure 1 – Sample California Home Energy Rating Certificate



The *California Home Energy Rating Certificate* is the principal product of the rating. Each provider shall produce this document in format similar to Figure 1. The *California Home Energy Rating Certificate* shall contain the following elements:

2.1.1 The Rating Scale

A graphic scale similar to the image in Figure 1 shall be prominently displayed on the *California Home Energy Rating Certificate*. The scale shall run from 250 on the left to 0 on the right. The score of the rated home shall be displayed above the scale. If the home has on-site generation capacity, two

points shall be displayed above the scale: one without on-site generation and one with on-site generation. Below the scale at the 100 mark, a label shall identify this position as a typical new home in compliance with the California energy efficiency standards. The right side of the scale shall be labeled "Net Zero Energy Home".

2.1.2 Official Designation

The official seal of the California Energy Commission shall be displayed in the upper right corner of the *California Home Energy Rating Certificate* with the message, "Official Home Energy Rating in conformance with the requirements of the California Energy Commission www.energy.ca.gov."

2.1.3 Energy Impact

The following information shall be provided for the rated home:

1. Estimated annual Carbon Dioxide (CO_2) emissions in tons.
2. Estimated annual energy usage of the home in both kilowatt hours (kWh) and therms. These estimates shall be based on the simulation model and be broken down by major end uses.
3. Estimated annual energy bill for the rated home. This shall be based on simulation results and use the utility bill in place for the rated home.
4. Estimated power production from on-site renewable energy sources such as photovoltaic systems.

2.1.4 Site Information

The following information shall be provided:

1. The address of the home.
2. Conditioned floor area.
3. Conditioned volume.
4. Number of bedrooms.
5. House type: single family detached, single family attached, or multi-family.
6. Foundation type.

2.1.5 Energy Efficiency Features

The *California Home Energy Rating Certificate* shall include a high level summary of the energy efficiency features of the rated house, including the following:

1. Insulation levels for major components.
2. Window type and construction.
3. Heating system type and efficiency.

4. Cooling system type and efficiency.
5. Water heating type and efficiency.
6. Renewable energy system type and description.

2.1.6 Rater/Provider Information

The *California Home Energy Rating Certificate* shall identify the HERS provider and the name of the rater who performed the rating along with the date of the inspection and a serial number or reference number that may be used to locate the house in the provider's database.

In this part of the certificate, the provider may display its logo and/or the logo of organizations that it is partnering with for the rating or program.

2.1.7 Other Programs

The information for EnergySTAR®, Build-it-Green, Comfort Wise, or other home evaluation program may be displayed if the home qualifies for these other programs.

2.1.8 Qualifying Information

This block of information shall contain qualifying information or caveats on the confidence band associated with the estimates. It should also note that the estimates are based on typical occupancy patterns with regard to thermostat settings, hot water use, appliance use, and other factors.

2.2 Recommended Improvements

One or more reports shall be provided separately from the *California Home Energy Rating Certificate* that contain recommendations for measures to improve the energy efficiency of the rated home and reduce energy bills. The Standard Approach recommendations report is always required, and this report shall be produced on a single page and generated using the procedures specified in Chapter 6. This report shall include:

1. A descriptive list of the cost-effective recommendations for energy efficiency improvements.
2. The cumulative projected annual energy bill savings of implementing each successive component of the recommended energy efficiency improvements.
3. Expected California HERS Index reduction for each successive energy efficiency improvement.

Additional recommendations reports may be optionally produced using the Custom Approach defined in Chapter 6. The optional recommendations reports shall include detail as needed to disclose the assumptions that are the basis of the recommendations.

2.3 Energy Consumption Analysis

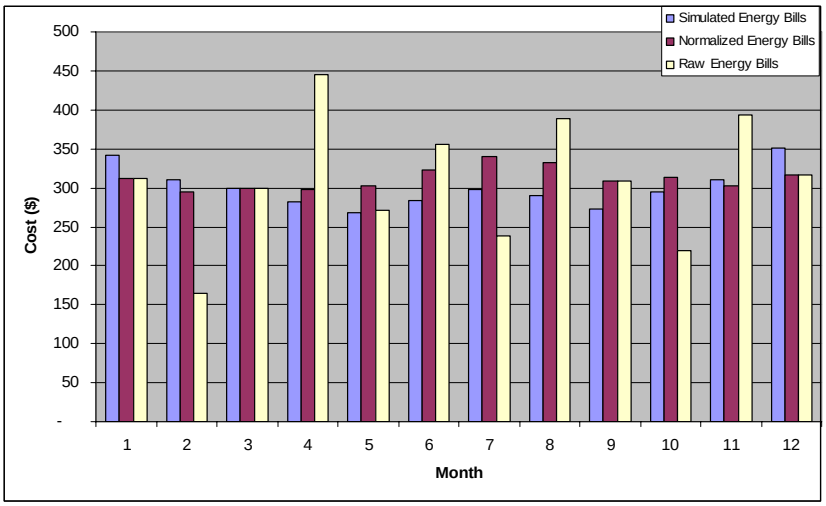
This report shall be presented on a separate page and display three graphs for monthly electricity consumption, gas consumption and energy costs. Each graph shall show the following:

1. *Calculated Consumption* – The projected energy use for the home per month based on the modeled energy use of the home. For electricity and gas consumption the modeled energy uses shall be broken down by end uses.
2. *Normalized Energy Bills* – The weather normalized historic energy use of the home using the inverse modeling procedures described in this technical manual.
3. *Raw Energy Bills* – The actual energy use of the home for the most recent 12-month period for which records are available during normal occupancy.

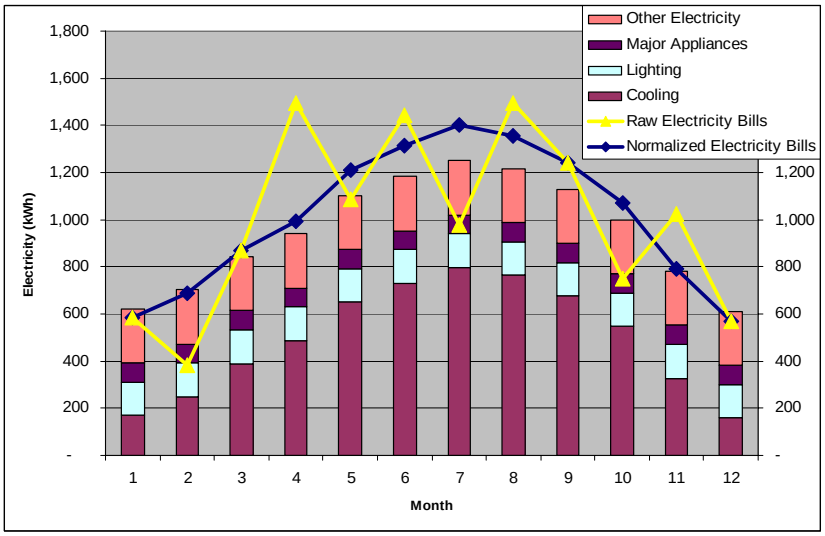
Figure 2 is an example of an Energy Consumption Analysis.

Figure 2 – Example Energy Consumption Analysis

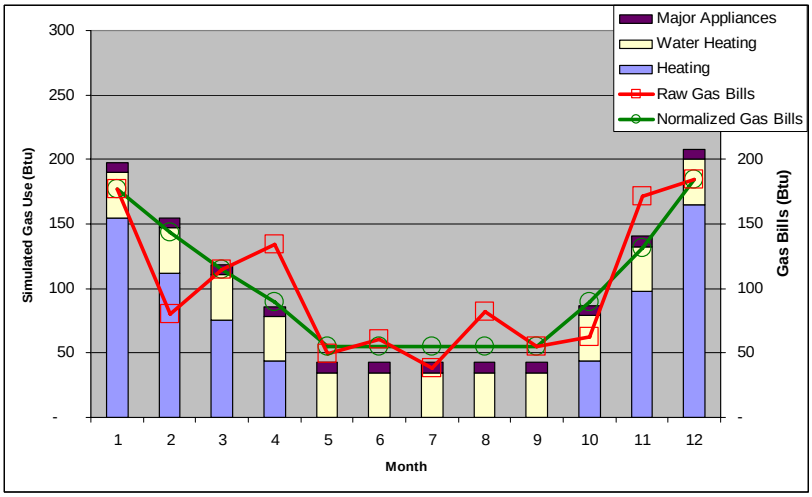
Energy Cost



Electricity Use



Gas Use



2.4 Data Input Summary

The Data Input Summary shall provide a detailed listing of the inputs to the HERS software. The level of detail shall be similar to the CF-1R report specified in the Residential ACM Approval Manual.

2.5 Post-Retrofit Utility Bill Analysis (Optional)

In the event that the homeowner implements the recommendations provided in the rating, the post-retrofit utility bill analysis would verify these savings by comparing the post-retrofit utility bills to estimates from the pre-retrofit inverse model. See Figure 5 on Page 37 for an example of this type of analysis.

3. The California HERS Index

The California HERS Index is the ratio of the Time Dependent Value (TDV) energy of the rated home to the TDV energy of the reference home as shown in the following equation:

Equation 1

$$\text{HERS Index} = \frac{\text{TDV}_{\text{Rated}} - \text{TDV}_{\text{PV}}}{\text{TDV}_{\text{Reference}}} \times 100$$

where

$\text{TDV}_{\text{Rated}}$ The TDV energy of the rated home, excluding ancillary energy use outside the boundaries of the building envelope.

TDV_{PV} The TDV energy produced by on-site PV systems or other renewable energy systems.

$\text{TDV}_{\text{Reference}}$ The TDV energy of the reference home.

The TDV energy of the rated home and reference home shall include heating, cooling and water heating (the traditional energy uses included in Title 24 energy compliance calculations) but also all other interior gas and electric energy for appliances, interior lighting, and miscellaneous use. Energy shall also be included for outdoor lighting that is attached to the building or located in the garage, but all other outdoor energy uses shall be excluded from the California HERS Index. Procedures for calculating the components of energy to be considered in the California HERS Index are described in Chapter 4.

The TDV energy of the rated home and the reference home shall not include ancillary energy such as swimming pools and associated heaters and pumps, spas, barns, sheds, well pumps, grinder pumps, and lighted tennis courts.

When the rated house has a photovoltaic (PV) system, the California HERS Index shall be calculated both with and without the PV system.

If the conditioned floor area of the rated home is larger than 2,500 square feet (ft²), the TDV energy of the reference home shall be based on a 2,500 ft² home. Heating and cooling energy shall be scaled according to the area of the rated home using Equation 2. Other energy uses for the reference house shall be calculated by the rules stated in Table 1.

Equation 2

$$\text{TDV}_{\text{Reference,ScaledBack}} = \frac{2{,}500\ \text{ft}^2}{\text{Area}_{\text{RatedHome}}} \times \text{TDV}_{\text{Reference,FullSize}}$$

Table 1 – Adjustments to Reference House Energy Use When Rated Home Is Greater Than 2,500 ft²

Component of Energy Use	*Method of Reference House Adjustment*
Heating	See Equation 2
Cooling	See Equation 2
Interior Lighting	Calculate for a 2,500 ft² reference home using the methods in Chapter 4
Refrigerator	No adjustment
Dishwasher	No adjustment
Other Appliances	Calculate for a 2,500 ft² reference home using the methods in Chapter 4
Outdoor/Garage Lighting	Calculate for a 2,500 ft² reference home using the methods in Chapter 4

4. Modeling Procedures and Assumptions for the Rated Home and Reference Home

The modeling rules and assumptions specified in Chapter 3 of the *2008 Residential ACM Approval Manual* shall be used to calculate the TDV energy for the rated home and the reference home, except as otherwise stated in this document. The reference home shall be identical to the standard design home specification of the residential ACM approval manual, and the rated home shall be identical to the proposed design specification in the residential ACM approval manual, except as otherwise stated in this chapter.

4.1 Overview

The reference home is a building similar to the rated home, but one that is modified to just meet the requirements of the 2008 California energy efficiency standards, and other specifications of this chapter. This chapter of the *HERS Technical Manual* describes how the rated home and reference home are defined and describes the modeling assumptions and algorithms to be used in calculating TDV_{Rated} and $TDV_{Reference}$.

For the rated home, the user enters information to describe the thermal characteristics of the building envelope including its surface areas, air leakage, shading structures and attachments, thermal mass elements, heating and cooling equipment and distribution systems, and water heating equipment and distribution systems. These inputs are subject to a variety of restrictions which are defined in this section. The process of generating the reference home and calculating $TDV_{Reference}$ shall be performed automatically by the HERS software, based on the allowed and default inputs for the rated home as well as the fixed and restricted inputs and assumptions for both the rated home and the reference home.

The process of reference home generation shall not be accessible to program users for modification when the program is used for rating purposes or when HERS reports are generated. The reference home generator shall automatically take user input about the rated home and create the reference home, using all the applicable fixed and restricted inputs and assumptions described in this Chapter. All assumptions and algorithms used to model the rated home shall also be used in a consistent manner in the reference home.

The basis of the building envelope, HVAC and water heating features of the reference home is prescriptive Package D, which is contained in Section 151(f) of the California Building Energy Efficiency Standards. Defining the rated home involves two steps.

- First, the geometry of the proposed building is modified from the description entered for the rated home.
- Second, building features and performance characteristics are modified to meet the minimum requirements of compliance with Package D.

The fixed and restricted modeling assumptions apply to both the reference home and the rated home. The standard fixed and restricted modeling assumptions always apply to the reference home and are the default for the rated home. In some cases, the Energy Commission has approved alternate fixed and restricted modeling assumptions that may be used in the rated home, when qualifying energy efficiency measures are provided. This chapter specifically identifies when the modeling assumptions differ between the reference home and the rated home, otherwise they are assumed to be the same. The alternate modeling assumptions may only be used when the rated home has a special building feature (for example, zonal control) that is recognized for credit, and the HERS rating software has been approved with this modeling capability. The modeling of such building features for compliance purposes shall always be documented in the Special Features Inspection Checklist on the HERS Detailed Inputs Report.

4.2 Residential ACM Modeling Assumptions

For space conditioning (heating and cooling) and water heating energy, the modeling assumptions and procedures for the *rated home* shall be the same as the *standard design* home as defined in the residential ACM approval manual, and the modeling assumptions and procedures for the *rated home* shall be the same as the *proposed design* home as defined in the residential ACM approval manual, except as stated in this section.

4.2.1 General Modeling Rules

ACM Section	*Applicability*
3.2.1 Weather Data	No changes from Residential ACM
3.2.2 Ground Reflectivity	No changes from Residential ACM
3.2.3 Building Physical Configuration	No changes from Residential ACM
3.2.4 Thermostats	No changes from Residential ACM
3.2.5 Internal Gains	Internal gains shall be determined based on the HERS lighting and appliances models described later in this chapter. See Section 4.7
3.2.6 Joint Appendix 4	No changes except that uninsulated walls and roofs shall be modeled with a minimum of R-4 insulation. See Section 4.8
3.2.7 Quality Insulation Installation	Field verification not applicable for existing insulation but could be applicable for insulation retrofits or new homes that are rated.

4.2.2 Zone Level Data Modeling Rules

ACM Section	*Applicability*
3.3.1 Building Zone Information	No changes from Residential ACM
3.3.2 Thermal Mass	No changes from Residential ACM
3.3.3 Natural Ventilation and Infiltration	Default infiltration rates are different for existing homes. See Section 4.9

4.2.3 Attics Modeling Rules

ACM Section	*Applicability*
3.4.1 Roof Pitch and Attic Geometry	No changes from Residential ACM
3.4.2 Ceiling/Framing Assembly	No changes from Residential ACM except uninsulated surfaces shall be modeled with R-4. See Section 4.8
3.4.3 Attic Ventilation	No changes from Residential ACM
3.4.4 Roof Deck	No changes from Residential ACM
3.4.6 Calculations	No changes from Residential ACM

4.2.4 Exterior Surfaces Other Than Attics Modeling Rules

ACM Section	*Applicability*
3.5.1 Non-Attic Ceiling and Roof Constructions	Uninsulated surfaces shall be modeled with R-4. See Section 4.8
3.5.2 Exterior Walls	Uninsulated surfaces shall be modeled with R-4. See Section 4.8
3.5.3 Basement Walls and Floors	No changes from Residential ACM
3.5.4 Raised Floors	No changes from Residential ACM

4.2.5 Slabs-on-Grade Modeling Rules

3.6.1 Inputs for Proposed Design and Standard Design	No changes from Residential ACM
3.6.3 Slab Calculations	No changes from Residential ACM

4.2.6 Fenestration and Doors Modeling Rules

ACM Section	*Applicability*
3.7.1 Doors	No changes from Residential ACM

3.7.2 Fenestration Types and Areas	No changes from Residential ACM
3.7.3 Overhangs and Sidefins	No changes from Residential ACM
3.7.4 Interior Shading Devices	No changes from Residential ACM
3.7.5 Exterior Shading Screens	No changes from Residential ACM
3.7.7 Fenestration Calculations	No changes from Residential ACM

4.2.7 HVAC System Overview Modeling Rules

ACM Section	*Applicability*
3.9.1 System Type	No changes from Residential ACM
3.9.2 Multiple System Types	No changes from Residential ACM
3.9.3 No Cooling	No changes from Residential ACM

4.2.8 Heating Systems Modeling Rules

ACM Section	*Applicability*
3.10.1 Proposed Design	No changes from Residential ACM
3.10.2 Standard Design	No changes from Residential ACM
3.10.3 Heating System Calculations	No changes from Residential ACM

4.2.9 Cooling Systems Modeling Rules

ACM Section	*Applicability*
3.11.1 Proposed Design	No changes from Residential ACM
3.11.2 Standard Design	No changes from Residential ACM
3.11.3 Refrigerant Charge or Charge Indicator Light	No changes from Residential ACM
3.11.5 Adequate Airflow	Not applicable for existing systems but could be applicable for equipment replacements or new homes that are rated.
3.11.6 Fan Energy	Not applicable for existing systems but could be applicable for equipment replacements or new homes that are rated.
3.11.7 Cooling System Calculations	Not applicable for existing systems but could be applicable for equipment replacements or new homes that are rated.

4.2.10 Air Distribution Systems Modeling Rules

ACM Section	*Applicability*
3.12.1 Air Distribution Ducts.	No changes from Residential ACM
3.12.2 Building Information and Defaults	No changes from Residential ACM
3.12.3 Special Credit	No changes from Residential ACM
3.12.4 Duct System Insulation	No changes from Residential ACM
3.12.5 Duct/Air Handler Leakage	No changes from Residential ACM
3.12.7 Seasonal Distribution System Efficiency	No changes from Residential ACM
3.12.8 Seasonal Delivery Effectiveness	No changes from Residential ACM
3.12.9 Calculation of Duct Zone Temperatures for Multiple Locations	No changes from Residential ACM
3.12.10 Temperature Difference Across Heat Exchanger	No changes from Residential ACM
3.12.11 Indoor to Duct Location Temperature Differences	No changes from Residential ACM
3.12.12 Thermal Regain (Fregain)	No changes from Residential ACM
3.12.13 Recovery Factor (Frecov)	No changes from Residential ACM

4.2.11 Mechanical Ventilation Modeling Rules From Residential ACM

ACM Section	*Applicability*
3.13.1 Proposed Design	Mechanical ventilation is assumed for existing homes even when they do not have it. See 4.10
3.13.2 Standard Design.	No changes from Residential ACM

4.2.12 Special Systems Modeling Rules

ACM Section	*Applicability*
3.14 - Hydronic Distribution Systems and Terminals	No changes from Residential ACM

4.2.13 Water Heating Modeling Rules

ACM Section	*Applicability*
3.15.1 Water Heating	No changes from Residential ACM
3.15.2 Water Heating Calculations	No changes from Residential ACM

4.3 Utility Rates Model

HERS rating software shall have the capability to produce an hourly estimate of electricity and gas consumption and apply common utility rate structures to obtain an estimate of energy operating cost. This feature is needed when the Custom Approach is used for generating recommendations. At a minimum, software shall have the capability to model the following features.

- Seasonal variations: a separate rate structure can be defined for at least three periods of the year (summer, winter and shoulder).
- Tiered rates: a different price per unit applies for different blocks of consumption, for example, one price for the first 500 kWh/month of consumption with a different price applying for consumption that exceeds 500 kWh/month.
- Monthly service charge: a fixed or seasonally variable charge that is added to the bill for each month, regardless of consumption.
- Demand charges.
- Time-of-use charges.
- Ratcheted rates.

4.4 Schedules for Lights, Appliances, People, and Equipment

The hourly schedules shown in Table 2 shall be used.

Table 2 – Hourly Schedules for Lighting and Appliances Model (Percent of Daily Total)

Time	Refrigerators	People	Equipment	Interior Lighting	Exterior Lighting
1	4.2%	5.9%	3.1%	2.3%	0%
2	4.2%	5.9%	3.1%	1.9%	0%
3	4.2%	5.9%	3.2%	1.5%	0%
4	4.2%	5.9%	3.3%	1.7%	0%
5	4.2%	5.9%	3.6%	2.1%	0%
6	4.2%	5.9%	3.9%	3.1%	0%
7	4.2%	5.9%	4.0%	4.2%	0%
8	4.2%	4.6%	4.0%	4.1%	0%
9	4.2%	1.9%	4.2%	3.4%	0%
10	4.2%	1.9%	4.2%	2.9%	0%
11	4.2%	1.9%	4.2%	2.7%	0%
12	4.2%	1.9%	4.3%	2.5%	0%
13	4.2%	1.9%	4.4%	2.1%	0%
14	4.2%	1.9%	4.4%	2.1%	0%
15	4.2%	1.9%	4.6%	2.1%	0%
16	4.2%	1.9%	4.9%	2.6%	0%
17	4.2%	3.7%	5.4%	3.1%	0%
18	4.2%	4.3%	5.9%	4.4%	0%
19	4.2%	4.9%	5.5%	8.4%	0%
20	4.2%	4.9%	4.7%	11.7%	0%
21	4.2%	4.9%	4.3%	11.3%	25%
22	4.2%	5.2%	3.8%	9.6%	25%
23	4.2%	5.6%	3.6%	6.3%	25%
24	4.2%	5.9%	3.3%	3.8%	25%

4.5 Appliances and Miscellaneous Energy Use

HERS software shall include an estimate of TDV energy use for lighting and appliances using the procedures in this section.

4.5.1 Refrigerator

The refrigerator in the reference home shall use 775 kWh/year. If the rated house has a refrigerator and the EnergyGuide data for the refrigerator is known, then this information is used for the rated house, otherwise the rated house shall use the same value as the reference home. The refrigerator in both the rated house and the reference house shall use the *Refrigerator* schedule from Table 2.

In those instances when the rater observes the presence of a second refrigerator in the rated home, the rated home shall include the energy of the second refrigerator using Equation 3.

Equation 3

$$\text{Electricity}_{\text{SecondRefrig}} = -50 + 0.717 * \text{CFA}$$

where

$\text{Electricity}_{\text{SecondRefrig}}$	Annual electricity use of the second refrigerator (kWh/year)
CFA	Conditioned floor area of the rated home

4.5.2 Dishwasher

The dishwasher in the reference house shall be modeled with an energy factor (EF) of 0.46. The dishwasher in the rated house shall be the same as the reference house, unless the EF can be determined by the rater for the equipment that exists in the house at the time of the rating.

Dishwasher energy use shall only include the electricity used by the dishwasher, not the hot water delivered by the water heater, since this is accounted for separately. Energy use shall be calculated based on the following equation:

Equation 4

$$\text{Electricity}_{\text{Dishwasher}} = 0.27 \times \frac{\text{Cycles / year}}{\text{EnergyFactor}}$$

where

$\text{Electricity}_{\text{Dishwasher}}$	The annual electricity use of the dishwasher in kWh/year.
Cycles/year	The cycles per year of dishwasher use from Table 3. .
Energy Factor	The energy factor of the dishwasher taken from the EnergyGuide label or from the EPA EnergySTAR database.

Table 3 – Dishwasher Use Assumptions

Bedrooms	Cycles/year	Reference Dishwasher kWh/year
1	154	90
2	214	126
3	247	145
4	296	174
5 or more	345	203

The dishwasher in both the rated house and the reference house shall use the *Equipment* schedule from Table 2.

4.5.3 Clothes Dryer

If a clothes dryer is present in the rated house or if there is a space and hookup for a clothes dryer, then the energy use of the clothes dryer shall calculated for both the rated home and the reference home using the following equations. Use Equation 5 for an electric dryer and Equation 6 for a gas

dryer. The same electricity or gas use shall be used for both the rated home and the reference home. Both the reference home and the rated home shall use the *Equipment* schedule from Table 2. If the rated home has no clothes dryer and there is no hookup, then dryer energy use (both electricity and gas) shall be assumed to be zero.

Equation 5

$$\text{Electricity}_{\text{Dryer}} = 263 + 0.254 \times \text{CFA}$$

Equation 6

$$\text{Gas}_{\text{Dryer}} = 13 + 0.010 \times \text{CFA}$$

4.5.4 Clothes Washer

If a clothes washer is present in the rated house or if there is a space and hookup for a clothes washer, then the energy use of the clothes washer shall calculated for both the rated home and the reference home using Equation 7. This does not include the hot water used by the washer. The same electricity use shall be used for both the rated home and the reference home. Both the reference home and the rated home shall use the *Equipment* schedule from Table 2. If the rated home has no clothes washer and there is no hookup, then clothes washer energy use shall be assumed to be zero for both the reference home and the rated home.

Equation 7

$$\text{Electricity}_{\text{Washer}} = -64 + 0.108 \times \text{CFA}$$

4.5.5 Oven/Range

If the rated home has an electric range and oven or hookups, then electricity use for both the rated home and the reference home shall be calculated using Equation 8. If the rated home has a gas range and oven or hookups, then gas use for both the rated home and the reference home shall be calculated using Equation 9. In the event that the rated home has both an electric and gas range oven, then both Equation 8 and Equation 9 shall be used for both the rated home and the reference home. Both the rated home and the reference home shall use the *Equipment* schedule from Table 2.

Equation 8

$$\text{Electricity}_{\text{Range/Oven}} = 92 + 0.118 \times \text{CFA}$$

Equation 9

$$\text{Gas}_{\text{Range/Oven}} = 31 + 0.008 \times \text{CFA}$$

4.5.6 Miscellaneous Electricity

Equation 10 shall be used to determine miscellaneous electricity use for both the rated home and the reference home. Both the reference home and the rated home shall use the equipment schedule from Table 2.

Equation 10

$$Electricity_{Misc} = 1{,}650 + 0.410 \times CFA$$

4.6 Lighting

Interior lighting energy and outdoor lighting (attached to the house) shall be included in the energy use tabulated for both the rated home and the reference home

4.6.1 Interior Lighting

The electricity for interior lighting is calculated using Equation 11.

Equation 11

$$Electricity_{InteriorLights} = (214 + 0.601 \times CFA) \times (Fract_{Portable} + (1 - Fract_{Portable}) \times PAM_{Interior})$$

where

$Electricity_{InteriorLights}$ Annual electricity use for interior lighting (kWh/year).

CFA Conditioned floor area (ft²).

$Fract_{Portable}$ Fraction of interior lighting power represented by portable lighting fixtures. This value shall be 0.22 or the value from Equation 13, whichever is greater.

$PAM_{Interior}$ Power adjustment multiplier to account for high efficacy luminaires, location of the luminaires and the type of control for permanent luminaires. The $PAM_{Interior}$ for the reference house shall be fixed at 0.625. The PAM for the rated house is determined from Equation 12.

Equation 12

$$PAM_{Interior} = \frac{\sum PAM_{Fixture,i} \times PAM_{Control,i} \times DailyHours_i \times Count_i}{\sum DailyHours_i \times Count_i}$$

where

$PAM_{Fixture,i}$ Power adjustment multiplier based on the type of the i^{th} fixture: 0.33 is used for hardwired high efficacy fixtures as defined in §150(k) of the California Building Energy Efficiency Standards; 0.67 is used for permanently mounted luminaires that are fitted with screw-in compact fluorescent lamps; and 1.00 is

used for permanently mounted incandescent luminaires. See Table 6 for permanently installed luminaire types.

$PAM_{Control,i}$ Power adjustment multiplier based on the type of control serving the i^{th} fixture: 1.00 is used for a conventional on/off switch; 0.90 is used for a dimming control; and 0.80 is used for an occupant sensor.

$DailyHours_i$ The average daily hours of lighting operation based on the type of room in which the i^{th} fixture is located (see Table 4).

$Count_i$ The number of fixtures of this type. The count is determined following the rules in Table 5.

Equation 13

$$Fract_{Portable} = 0.22 \times \frac{28}{F} \times \frac{CFA}{2200}$$

where

$Fract_{Portable}$ Fraction of fixtures that are Portable (unitless)

F Number of hardwired fixtures for rated house

CFA Conditioned floor area (ft^2)

Table 4 – Daily Lighting Hours – Interior

Location	$DailyHours_i$
Small Closet	0.5
Bedroom/WIC	1.4
Hall/Entry/Stairs/Other	2.0
Living	2.6
Utility/Laundry	2.6
Kitchen/Dining/Nook	3.4

Source: HMG 1999 Lighting Efficiency Technology Report, Volume 1, Figure 1-6

Table 5 – Rules for Determining Luminaire (Lighting Fixture) Count

Luminaire Type	Examples/Description	Method of Counting
Track Lighting	Line-voltage or low-voltage track	Larger of: • One luminaire for each 3′ of track length rounded up to 3 foot multiple, or • Actual number of track heads installed.
Linear Fluorescent (see Note 1)	Linear fluorescent luminaire, factory-installed ballast	One luminaire per individual factory made luminaire, regardless of number of lamps per luminaire
LED (see Note 2)	Single diodes or clusters of diodes	One luminaire per cluster
	Linear row of diodes	One luminaire for each 3 ft length, rounded up to 3 ft multiple.
All Other	Incandescent luminaires including low voltage or line voltage	Count = 1 for luminaries with one lamp or one socket. Count = 1 luminaire for every two sockets, rounded up to the nearest whole number, for luminaires with multiple lamps or sockets
Note 1: A factory-made luminaire is a complete lighting unit consisting of lamps and the parts designed to distribute the light, to position and protect the lamps, and to connect the lamp to the power supply. Note 2: LED system, no screw bases, includes optics and power supply.		

Table 6 – Permanently Installed Luminaire Types

Classification	Definition
Permanently Installed High efficacy	Meets the requirements of §152(k). Includes luminaires that can accept only linear fluorescent, compact fluorescent, or LED lamps.
Low Efficacy	Any luminaire that accepts any type of incandescent lamp, and that has incandescent lamps installed
Screw-in High Efficacy	Any luminaire that accepts screw based incandescent lamps, but that has screw based compact fluorescent or screw based LED installed. Any track lighting track that accepts medium screw based incandescent lamps, but that has medium screw-base track head with screw-in CFL, CFL track heads with factory installed ballast, or LED track heads

4.6.2 Exterior Lighting

Equation 14

$$\text{Electricity}_{\text{OutdoorLights}} = (-81 + 0.152 \times \text{CFA}) \times \text{PAM}_{\text{Exterior}}$$

where

$\text{Electricity}_{\text{OutdoorLights}}$ Annual electricity use for interior lighting (kWh/year).

CFA Conditioned floor area (ft²).

$PAM_{Exterior}$ Power adjustment multiplier to account for permanently mounted high efficacy luminaires, the type of control, and the location for the luminaire. The PAM for the reference house shall be fixed at 0.49 The PAM for the rated house is determined from Equation 15.

Equation 15

$$PAM_{Exterior} = \frac{\sum PAM_{Fixture,i} \times PAM_{Control,i} \times DailyHours_i \times Count_i}{\sum DailyHours_i \times Count_i}$$

where

$PAM_{Fixture,i}$ Power adjustment multiplier based on the type of the i^{th} fixture: 0.33 is used for hardwired high efficacy fixtures as defined in §150(k) of the California Building Energy Efficiency Standards; 0.67 is used for permanently mounted luminaires that are fitted with screw-in compact fluorescent lamps; and 1.00 is used for permanently mounted incandescent luminaires.

$PAM_{Control,i}$ Power adjustment multiplier based on the type of control serving the i^{th} fixture (see Table 7).

$DailyHours_i$ The average daily hours of lighting operation based on the location of the luminaire (see Table 8).

$Count_i$ The number of fixtures of this type. The count is determined following the rules in Table 5.

Table 7 – Exterior Lighting Control Power Adjustment Multipliers

Control Type	$PAM_{Control}$
On/Off	1.00
Photocontrol with motion sensor (outdoor lighting only)	0.50
Occupant sensor (interior garage only)	0.80

Table 8 – Daily Lighting Hours – Exterior

Location	DailyHours
Indoor Garage	2.3
Outdoor – Front entry	6.0
Outdoor - Other (side/back)	2.0

Source: Impact Analysis of the 2005 Title 24 Energy Efficiency Standards, Eley Associates, Table 7.

4.7 Internal Heat Gain

The total daily internal gains shall be equal to the heat content generated by interior lighting, appliances and miscellaneous electricity, as calculated in the previous sections. Electricity use shall be converted to heat at the rate of 3,413 Btu/kWh and gas shall be converted to heat at the rate of 100,000 Btu/therm. Outdoor lighting shall not contribute to internal heat gain. Only 30 percent of the heat generated by dryers and 90 percent of the heat for range/ovens shall be considered to manifest itself as internal heat gain, with the rest vented to the outdoors. The internal heat gain from lights and appliances shall be calculated separately for the rated house and the reference house. These heat gains shall follow the schedules in Table 2.

Table 9 – Internal Heat Gain Multipliers

		Internal Gain Percent
Electricity Uses	Refrigerator	100%
	Dishwasher	100%
	Dryer (Electric)	30%
	Range/Oven (Electric)	90%
	Clothes Washer	100%
	Interior Lighting	100%
	Outdoor Lighting	0%
	Other (Miscellaneous)	100%
Gas Uses	Range/Oven	90%
	Dryer (gas)	30%

In addition to the heat generated by lights and appliances, an additional 4,140 Btu (230 Btu per occupant times 18 hours per day per occupant) shall be included for each bedroom in the rated house and the reference house. The "people" heat gain shall follow the People schedule in Table 2.

4.8 U-Factors for Uninsulated Construction Assemblies

U-Factors for uninsulated wall and ceiling construction assemblies in existing homes shall be modeled with a U-Factor no greater than 0.25.

4.9 Infiltration

The default specific leakage area for new and existing homes is specified in Table 10 – Default Infiltration Rates (SLA). The values for new homes are identical to the *2008 Residential ACM Approval Manual* (RACM). Mechanical ventilation meeting the requirements of ASHRAE 62.2-2007 is required when credit is taken for infiltration reduction through testing. Testing shall be performed according to the procedures specified in Standards Reference Appendix RA3.

Table 10 – Default Infiltration Rates (SLA)

Case	New Homes	Existing Homes
Unsealed ducts	4.3	4.9
Sealed ducts	3.8	4.4 (see Note 1)
No ducts	3.2	3.8
Measured leakage	May be no lower than 1.5	May be no lower than 1.5
Mechanical ventilation	Mandatory Measure	Required as retrofit when leakage is measured
Note: To use the 4.4 SLA value for existing ducts, they shall be tested to a leakage of 6%.		

4.10 Mechanical Ventilation

Mechanical ventilation became a mandatory feature for homes constructed in compliance with the 2008 Title 24 energy efficiency standards, and these Standards are the basis of the reference home specification used to calculate the California HERS Index. This section of the *HERS Technical Manual* defines how mechanical ventilation is modeled for both the rated home and the reference home.

For the common situation when the rated home does not have mechanical ventilation, it shall be modeled with mechanical ventilation having the same specification as the reference home. The ventilation rate of the reference home is determined using Equation R3-56 of the *2008 Residential ACM Approval Manual* (RACM). The fan shall be assumed to operate continuously with a power to volume ratio of 0.25 W/cfm.

In those cases when the rated home has a mechanical ventilation system, the home inspector shall collect data on the fan volume of the mechanical ventilation system, the fan power and the schedule of operation (in those cases when the fan does not operate continuously). These data shall be used calculate the fan energy for the rated home. The mechanical ventilation system in the standard design shall be as specified in the RACM for new homes.[1]

4.11 Ancillary Energy Uses

The California HERS Index considers only energy uses that occur inside the rated home and outdoor lighting that is permanently attached to the home. The residential utility meter could see other quite significant loads that are not part of the California HERS Index, such as a swimming pool, spa, lighted tennis courts, shops in adjacent buildings, well water pumps, well water treatment systems, and other ancillary energy uses.

[1] The air flow rate shall be equal to the proposed design. For standalone IAQ fan systems, the fan power ratio, shall be equal to the proposed design value or 1.2 W/cfm, whichever is smaller. The sensible heat recovery effectiveness shall be zero. For central air handler fans, the fan power ratio is 0.58 W/cfm of central system airflow in ventilation mode.

While these ancillary energy uses are to be excluded from the California HERS Index, they shall be included in the estimate of simulated energy use. Table 11 has estimates for the common and most significant energy uses that are not included in the California HERS Index. These estimates shall be included in the estimated energy use produce by the HERS software and these uses shall assume the time pattern of the schedules in Table 12 when required by the utility rate.

Table 11 – Average Energy Consumption Data for Ancillary Energy Uses

End Use	Features	Electricity (kWh/year)	Gas (therms/year)
Swimming Pool	Gas heated with cover	2671	352
	Gas heated with no cover	2671	703
	Solar heated or not heated	2671	0
	Electric heated with cover	4169	0
	Electric heated with no cover	5667	0
Spa	Gas heated with cover	467	81
	Solar/gas heated with cover	467	20
	Electric heated with cover	2186	0
	Solar/electric heated with cover	897	0
Well Pump	All	862	0
Grinder Pump	All	104	0

Assumptions:

1. Pool pump, spa pump, and well pump kWh from KEMA-Xnergy 2004, Residential Appliance Saturation Study.
2. Pool heating estimate is from RETSCREEN simulation tool and assumes 512 ft² pool (16 ft x32 ft average size) and spring-fall heating season.
3. Cover assumed to reduce heating requirement by 50% (conservative).
4. Electric pool heat assumes heat pump with Coefficient of Performance (COP) of 5.5.
5. Spa heating estimate for gas and electric heated from KEMA-Xenergy study. Spa estimate for single-family homes.
6. Solar spa heating assumed to provide 75% of heat required (due to nighttime use).
7. Grinder pump annual kWh estimate from E/One assumes 1 hp pump and 250 gpd flow.

Table 12 – Schedules for Ancillary Energy Uses

Time of Day	Pools	Spas	Well Pumps	Grinder Pumps
1	0%	0%	Use *Equipment* schedule from Table 2	Use *Equipment* schedule from Table 2
2	0%	0%		
3	0%	0%		
4	0%	0%		
5	0%	0%		
6	0%	0%		
7	3%	0%		
8	5%	0%		
9	6%	0%		
10	10%	0%		
11	10%	0%		
12	10%	0%		
13	10%	0%		
14	10%	0%		
15	10%	0%		
16	10%	0%		
17	8%	0%		
18	6%	0%		
19	3%	25%		
20	0%	25%		
21	0%	25%		
22	0%	25%		
23	0%	0%		
24	0%	0%		

4.12 On-Site Photovoltaic (PV) Production

The benefit of on-site renewable energy generation systems shall be accounted for in the rating. Calculations of PV production shall be determined on an hourly basis following the procedures of the *2008 Residential ACM Approval Manual*, Appendix B.

5. Energy Bill Analysis

HERS software shall have the capability to perform a statistical analysis of utility bill data and to provide a correlation against outdoor temperature data for the same period as the utility data. The utility bill analysis serves several purposes:

1. The energy bills may be adjusted for the standard temperature conditions used to calculate the California HERS Index and to develop the recommendations.
2. Seasonally dependent energy uses (heating and cooling) may be disaggregated from baseline energy for both electricity and gas. The disaggregated energy use can then be compared to end-use predictions for the model and with the Custom Approach to developing recommendations; model inputs can be tweaked to achieve better agreement.
3. Energy savings from improvements may be verified.

5.1 Inverse Modeling[2]

The utility bill analysis shall be consistent with ASHRAE Research Paper 1050, *Inverse Modeling Toolkit: Numerical Algorithms*.[3] The four-parameter change-point model shall be used for heating only and cooling only analysis while the five-parameter change-point model shall be used for both heating and cooling analysis. In both cases, the independent variable shall be outside temperature. These modes of operation are described in greater detail below:

- *Heating Only*: This mode is used to analyze gas consumption in rated homes that use gas for space heating. The heating only mode would also be used to analyze electricity consumption in rated homes that are not air conditioned and use electricity for space heating.
- *Cooling Only*: This mode is used to analyze electricity consumption in rated homes that electricity for space conditioning and gas or other non-electric energy for space heating.
- *Heating and Cooling*: This mode is used to analyze electricity consumption in rated homes that use electricity for both space cooling and space heating, for instance, an electric heat pump.

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[2] Energy code compliance and the HERS rating index would be calculated through direct modeling, whereby data on the physical characteristics of the building are entered and estimates of electricity and gas consumptions are produced. Inverse modeling is a technique whereby the answers are inputs to the model and a simple expression is generated that explains variations in energy use, usually as a function of outdoor temperature, but other independent variables may be considered if they can be quantified. Direct energy modeling looks forward, where inverse modeling looks back. The most common application of inverse modeling has been to verify savings in utility programs or performance contracts.

[3] Kissock, K., Haberl, J., Claridge, D. 2003. Inverse Model Toolkit (1050RP): *Numerical Algorithms for Best-Fit Variable-Base Degree-Day and Change-Point Models*, ASHRAE Transactions-Research, KC-03-2-1 (RP-1050).

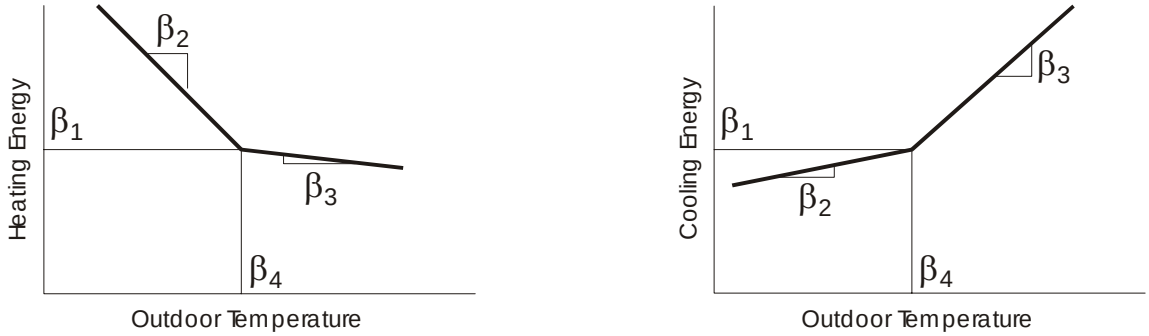
5.1.1 Four-Parameter Model

The four-parameter model has two forms as shown in Figure 3. The form of the equation is shown in Equation 16. In this equation, E is the estimate of daily energy (either electricity or gas), T is the daily average outside temperature, β_1 is the constant term, β_2 is the slope to the left of the balance point temperature, β_3 is the slope to the right of the balance point temperature, and β_4 is the balance point temperature. Each of the beta coefficients shall be calculated from utility bills and concurrent weather data using procedures described in the Inverse Model Toolkit.[4]

Equation 16

$$E = \beta_1 + \beta_2(T - \beta_4) + \beta_3(T - \beta_4)$$

Figure 3 – Four-Parameter Regression Model



Source: Inverse Model Toolkit (1050RP)

5.1.2 Five-Parameter Model

The five-parameter model is shown in Figure 4 and Equation 17. E is the estimate of daily energy (electricity), T is the daily average outside temperature, β_1 is the constant term, β_2 is the slope to the left of the balance point temperature, β_3 is the slope to the right of the balance point temperature, β_4 is the balance point temperature for heating, and β_5 is the balance point temperature for cooling. Each of the beta coefficients shall be calculated from utility bills and concurrent weather data using procedures described in the Inverse Model Toolkit.[5]

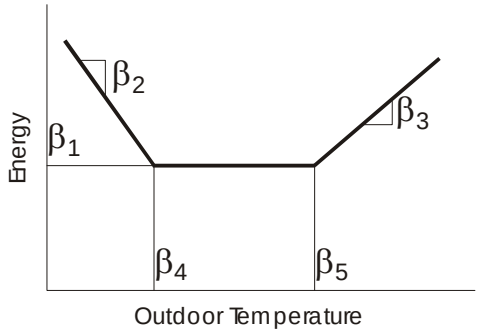
Equation 17

$$E = \beta_1 + \beta_2(T - \beta_4) + \beta_3(T - \beta_5)$$

[4] *Ibid.*

[5] *Ibid.*

Figure 4 – Five-Parameter Regression Model



Source: Inverse Model Toolkit (1050RP)

5.2 Data Input

The following format is recommended for the climate data and the utility bill data to standardize input and reduce the need for data input.

Table 13 – Standard Text Format for Climate Data

Sample Data				Notes
1	1	1995	43.0	Columns:
1	2	1995	40.6	
1	3	1995	47.5	
1	4	1995	49.2	1 Month
1	5	1995	48.6	
1	6	1995	48.0	
1	7	1995	51.9	2 Day
1	8	1995	52.9	
1	9	1995	58.4	
1	10	1995	56.3	3 Year
1	11	1995	53.5	
1	12	1995	53.9	
1	13	1995	56.1	4 Average Daily Temperature
1	14	1995	57.5	
1	15	1995	50.1	Columns (data fields) shall be separated by tabs, spaces, or commas.
1	16	1995	46.7	
1	17	1995	41.2	
1	18	1995	46.1	
1	19	1995	45.3	File may contain any amount of data as long as it encompasses the period of time for which utility bill data is provided (see Table 14 below)
1	20	1995	43.9	
1	21	1995	48.1	
1	22	1995	50.9	
1	23	1995	52.4	
1	24	1995	52.0	
1	25	1995	51.5	
1	26	1995	49.3	Data for several California cities is available at http://www.engr.udayton.edu/weather/.
1	27	1995	49.7	

Table 14 – Standard Text Format for Utility Bill Data

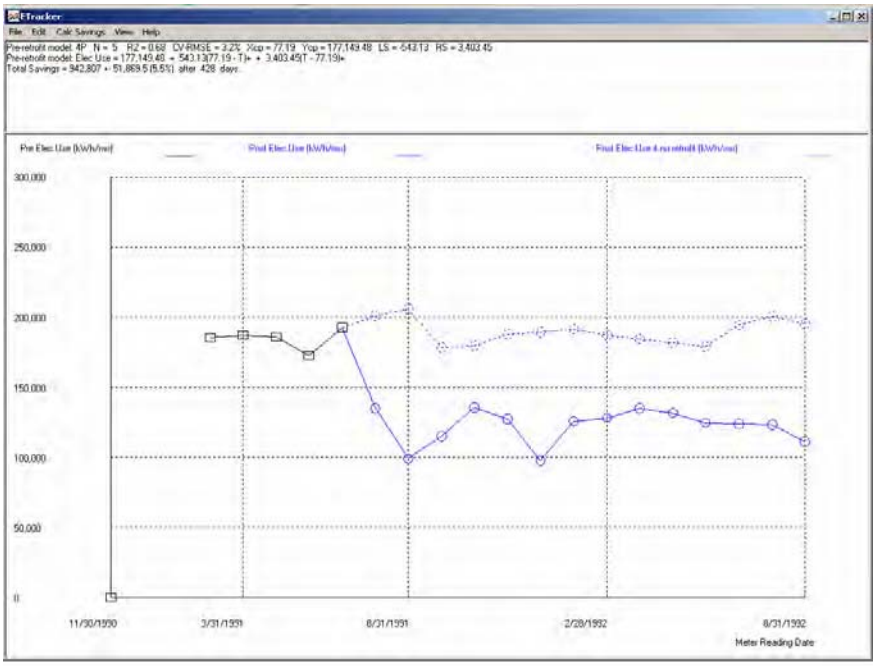
Sample Data	Notes
10 31 1990 -99 722 527 1 1 11 30 1990 -99 1409 1126 1 1 12 31 1990 -99 1093 1443 1 1 1 31 1991 -99 809 1301 1 1 2 28 1991 185200 1180 1392 1 1 3 31 1991 187000 1461 1351 1 1 4 30 1991 185700 1690 872 1 1 5 31 1991 172300 2021 914 1 1 6 30 1991 192500 2420 770 1 1 7 31 1991 134700 1747 701 2 2 8 31 1991 99000 1470 577 2 2 9 30 1991 115100 1013 343 2 2 10 31 1991 135400 753 299 2 2 11 30 1991 127400 572 351 2 2 12 31 1991 97700 634 334 2 2 1 31 1992 125700 436 414 2 2 2 28 1992 128000 615 383 2 2 3 31 1992 134500 717 412 2 2 4 30 1992 131500 775 423 2 2 5 31 1992 124500 905 445 2 2 6 30 1992 123500 1271 435 2 2 7 31 1992 123100 1439 437 2 2 8 31 1992 110900 1224 449 2 2	Columns 1. meter reading month 2. meter reading day 3. meter reading year 4. electricity consumption (kWh/month) 5. peak electrical demand (kW) 6. thermal energy consumption (units/month) 7. pre/post indicator for electricity use 8. pre/post indicator for thermal energy use Each column should be separated by at least one space, a tab or a comma. If energy use data are missing or unavailable, enter no-data flags "-99" in their place; The "pre/post" indicators in columns 7 and 8 define the pre and post retrofit periods. Enter "1" to represent data from before the retrofit, and "2" to represent data from after the retrofit.

5.3 Post-Retrofit Evaluation

The HERS software and utility bill analysis feature shall have the capability to evaluate post-retrofit energy consumption through inverse modeling (described above) and to compare it to what the home would have used had there been no retrofit. Figure 5 is an example produced by the ETracker software, which implements the recommended procedure.[6]

[6] The procedure for described above along with the standardized data is implemented in the ETracker software, which may be downloaded from http://www.engr.udayton.edu/weather/. This tool may be used for comparison and to verify a correct implementation of the procedure.

Figure 5 – Example Post-Retrofit Utility Bill Analysis



5.4 Energy Bill Estimates

This energy cost information is intended to supplement the information provided by the California HERS Index. While the California HERS Index provides comparative information on the energy efficiency of the rated home, the utility bill estimate provides an estimate of the cost to operate the home.

The HERS reports shall include an estimate of the monthly and annual energy cost to operate the rated house, based on the utility rate that is in effect at the time of the rating. As a minimum requirement, the HERS software shall produce an estimate of monthly and annual energy consumption and energy costs using the procedures of Chapter 4. When at least 12 months of utility bill history is available for the rated home, the simulated estimate of energy consumption and costs shall be compared to both normalized energy bills and raw energy bills. These data sets are described in greater detail below:

- **Calculated by the Model**. The energy uses calculated for the rated home through the procedures of Chapter 4, shall be used as the basis of the utility bill estimate, using the utility rates in place at the time of the rating. However, if the rated home does not have an air conditioner, then the air conditioner portion of the rated home estimate shall be excluded from the utility bill estimate. Estimates of ancillary energy shall be added to the model results to account for the usage of items such as pools, spas, barns, sheds, well pumps, grinder pumps, and lighted tennis courts. This estimate is always required, even when energy bills are not available.

- **Raw Billing History.** The raw energy bills shall be averaged for each month for which there is billing history. When the billing period is different than the number of days in each month, the consumption data shall be scaled for the actual days in the month, for example, if the billing period was 40 days and the month has 30 days, the consumption for the month would be scaled by the ratio of 30/40 or 0.75.
- **Billing History Normalized to Standard Weather Files.** The inverse model developed using the Chapter 5 procedures shall be used with temperature data for the climate zone to produce normalized estimates of monthly and annual energy consumption. These weather-adjusted results shall then be combined with the applicable utility rate to yield an estimate of monthly and annual energy costs.

Energy costs shall be calculated using the utility rates that are in effect at the time of the rating shall be used to generate the monthly and annual energy cost for the rated home. If there is no account with the utility and the rated home qualifies for more than one utility rate, the more common utility rate shall be used to estimate the energy cost.

5.5 Equivalent Utility Programs

Utilities often offer information about expected utility bills on their website using bill disaggregation methods. HERS providers may use information from these utility programs when available to satisfy the requirements of this chapter, instead of the inverse modeling procedures.

6. Recommendations

As part of the rating process, California home energy rating systems shall produce a list of cost-effective recommendations which would reduce energy costs and improve the California HERS Index. This section of the HERS Technical Manual describes how these recommendations are to be developed and other related requirements for HERS providers.

6.1 The Standard and Custom Approaches

The HERS system shall have the capability to generate recommendations using both a Standard Approach and a Custom Approach. The Standard approach is also referred to as Path A, and the Custom Approach is referred to as Path B. Approved HERS systems shall be able to accommodate both approaches, however, the Standard approach is mandatory for every rating and the Custom Approach is optional. Alternative assumptions used with the Custom Approach shall be reported to the HERS provider by the rater and approved by the provider.

The Standard Approach will result in the same set of recommendations, no matter who does the rating or which HERS system is used. The "cost-effective" set of recommendations resulting from the Custom Approach may change depending on how the process is customized for the individual homeowner or investor. The two approaches are summarized and contrasted in the following table.

Table 15 – Standard and Custom Approaches to Generating Recommendations

	Path A – Standard Approach	Path B - Custom Approach
Cost-Effectiveness Method	The list of recommendations shall include all measures that are cost-effective, considering the interactions between the measures.	The Custom Approach may use any of the following methods: • *All that is Cost-Effective*. Same as Path A. • *Fixed Budget*. Include recommendations to achieve the greatest energy savings for a given cost. • *Minimum Level of Performance.* Include recommendations to bring the house up to some specified level of energy performance at the least cost.
Determining Cost-Effectiveness of Energy Efficiency Measures	Determine cost-effectiveness of measures using the method used for the 2008 Title 24 energy efficiency standards.[7]	Consider cost-effectiveness from the perspective of the homeowner or investor, including one or more of the following financial instruments: • Conventional mortgage • Energy efficient mortgage. • Green financing programs • Utility financing programs • Cash outlay by owner. • Home equity financing. Non-energy benefits may also be considered in the analysis such as thermal comfort, indoor air quality, and acoustics. Each homeowner's individual tax bracket and mortgage rate may be considered.
Utility Rates	CEC adopted forecasts of energy costs are incorporated in Title 24 method of determining cost-effectiveness.	Use the utility rates in effect for each home that is rated.
Modeling Assumptions	Use all modeling assumptions as specified in the *HERS Technical Manual* and this chapter.	The rater may modify certain modeling assumptions to better approximate the specific occupant patterns of the rated house, considering factors such as: • Thermostat schedules • Intermittent occupancy • Presence of special energy using equipment. • Life-style patterns

[7] "Life Cycle Cost Methodology", *2008 California Building Energy Efficiency Standards*, February 15, 2006, California Energy Commission contractor report prepared by Architectural Energy Corporation.

Table 15 – Standard and Custom Approaches to Generating Recommendations

	Path A – Standard Approach	Path B - Custom Approach
Measures and Costs that Affect the California HERS Index	All raters and HERS providers shall use the same database of energy efficiency measures and costs.	Raters may modify measure costs and add additional measures to address the field conditions of a particular home. • Measure costs used in the cost-effectiveness analysis may be based on bids the homeowner has received or other localized costs that the rater considers to be more relevant. • Additional measures may be added as long as the measure may be directly modeled using the approved HERS modeling tool. When the rater deviates from the standard database of measures and costs, the alternate measures or costs shall be reported to the HERS provider and the HERS provider shall approve the use of the alternate measures or costs. Such costs shall be considered when the standard database is periodically updated. The providers shall collaborate with Commission staff to cross review costs for measures from different providers and reconcile differences for updating of the standard database.
Measures and Costs That Do Not Affect the California HERS Index	Standard (non-customized) recommendations shall be provided based on the presence of energy using systems or equipment that are not considered in the California HERS Index such as pools, spas, well pumps, and lighted courts.	The rater, using methods approved by the provider, may evaluate the cost-effectiveness of specific measures to improve the energy efficiency of swimming pools, spas, well pumps, and other energy uses not considered in the California HERS Index.
Energy Bill History	Rater is expected to collect utility bill data and enter it into the tool. If utility bill data is unavailable, then the rater should disclose why it is not available. When data is available, utility bills shall be analyzed using Inverse Modeling and normalized for the standard Energy Commission weather data. The normalized results shall be compared with the simulated results and presented as one of the HERS reports. Existing utility programs may be used to meet this requirement (see Section 5.5).	Same requirements as the Standard Approach, except that results of the inverse modeling may be used to "calibrate" the model (see Modeling Assumptions above).

6.2 Cost-Effectiveness Method

6.2.1 Standard Approach

The Standard Approach shall evaluate all the measures that are applicable for the rated home and include measures if they are determined to be cost-effective using the procedures described in Section 6.3. The measures shall be listed in order of their cost-effectiveness. The cost-effectiveness of each additional measure added to the list shall be evaluated in combination with previous measures determined to be cost-effective.

The list of rank ordered recommendations shall be developed using a rolling basecase approach. With the rolling basecase method, the initial basecase is the home in its present condition. From this base, all possible and applicable measures[8] are identified and the energy savings, implementation costs, and possibly maintenance costs are estimated. Future maintenance costs are discounted to present value at an agreed to discount rate and added to the implementation costs. The energy savings are translated to monetary savings by applying the net present value multipliers described in Section 6.3. The next step is to calculate the benefit cost ratio of each of the possible measures (the net present value of the energy savings divided by the measure cost. The measure with the highest benefit to cost ratio is then added to the home and the home with the new measure becomes the new basecase.

The whole process is repeated again for the new basecase, that is, all applicable measures are identified and their benefit cost ratio is determined relative to the new basecase. The measure with the highest benefit to cost ratio is added to the basecase and a new basecase is created. This process is repeated, iteratively, as long as measures are available that have a benefit to cost ratio greater than one. When all remaining measures have a benefit to cost ratio of one or less, then the minimum point on the life-cycle cost curve has been found, and the process is complete. The rank order of measures is the sequence in which they were added to the basecase.

With the above approach, many measures are mutually exclusive, and the list of possibilities become smaller with each new basecase, for example, once a new air conditioner is installed, all the other air conditioner upgrades drop off the list.

6.2.2 Custom Approach

The Standard Approach uses the "all that's cost-effective" approach to generating recommendations, that is, everything that is cost-effective is included in the list. As an alternative the Custom Approach may also consider, the following strategies:

- *Fixed Budget*. With this strategy, the homeowner or homebuyer would specify a construction budget for energy efficiency improvements and the HERS program would determine the package of measures that fit the budget and produce the greatest energy savings.
- *Minimum Level of Performance*. With this strategy, recommendations would be produced that would bring the house up to some specified level of energy performance at the least cost. This approach would be appropriate to achieve compliance with an energy efficiency program that required a maximum California HERS Index, for instance. If the minimum level of performance to quality for a program were a California HERS Index of 80, for instance, then with this strategy, the recommendations would include a collection of measures that would bring the house to the desired level of performance at the least cost.
- *Customer Identified Measures*. With this strategy, homeowners may propose one or more measures they prefer in combination with other measures that are determined to be cost-effective as a whole.

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[8] Applicability may be determined by comparing the starting condition for each measure to the basecase. If the two match, then the measure is applicable to that case.

The Custom Approach can evaluate these strategies while varying all of the assumptions and parameters identified in Table 15 that are relevant to the specific homeowner or investor and project.

6.3 Determining Cost-Effectiveness of Energy Efficiency Measures

6.3.1 Standard Approach

With the Standard Approach, the cost-effectiveness of measures is determined using the method of the 2008 Title 24 energy efficiency standards.[9] With this method a measure is cost-effective if it reduces overall life-cycle cost. It is not necessary (or even desirable) to calculate absolute life-cycle cost. The change in life-cycle cost is given in the following equation. If the life-cycle cost is negative then the measure is cost-effective relative to the basecase. Negative life-cycle cost means that the present value of TDV energy savings is greater than the initial cost premium, that is, the total life-cycle cost is reduced.

Equation 18

$$\Delta LCC = \text{Cost Premium} - \text{Present Value of Energy Savings}$$

$$\Delta LCC = \Delta C - (PV_{TDV} \times \Delta TDV)$$

where

ΔLCC	change in life-cycle cost
ΔC	cost premium associated with the measure, relative to the basecase
PV_{TDV}	present value of a unit of TDV savings based on the TDV values established by the Energy Commission
ΔTDV	reduction in TDV energy from implementation of the measure

The 2008 TDV values can be found at www.ethree.com/TDV2008.html. These shall be incorporated in the HERS software.

6.3.2 Custom Approach

With the Custom Approach, alternative methods may be used to determine the cost-effectiveness of measures. The alternative methods shall be approved by the provider and may be based on the actual financing method proposed to be used by the homeowner or investor. The method may be developed to be compatible with energy efficient mortgages and energy efficiency improvements made at the time-of-sale.

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[9] "Life Cycle Cost Methodology", *2008 California Building Energy Efficiency Standards*, February 15, 2006, California Energy Commission contractor report prepared by Architectural Energy Corporation.

When energy efficiency measures are financed through the mortgage, the principal test of cost-effectiveness is that the first-year energy savings should be equal to or greater than the additional mortgage payments with consideration of tax benefits and other factors relevant to the homeowner.

The Custom Approach should consider cost-effectiveness from the perspective of the homeowner or investor, including one or more of the following financial instruments or other methods of financing:

- Conventional mortgage.
- Energy efficient mortgage.
- Green financing programs.
- Utility financing programs.
- Cash outlay by owner.
- Home equity financing.

6.4 Energy Rates

6.4.1 Standard Approach

Energy Commission-adopted forecasts of energy costs are incorporated in the present value of TDV energy savings discussed in Section 6.3.1.

6.4.2 Custom Approach

With the Custom Approach, the utility rate that is in effect for the rated house shall be used in the analysis. If the house is unoccupied and no utility rate is in effect, then the most common rate for homes in the area may be used. Most residential utility rates are tiered; that is, the price per unit of consumption increases as consumption increases. For this reason, it is important to include all energy uses in the analysis, even though recommendations may not be generated for them, especially big energy users such as pools and spas.

6.5 Modeling Assumptions

6.5.1 Standard Approach

To develop cost-effective recommendations, it is necessary to estimate the energy cost savings associated with individual measures. The energy models to be used to calculate the rating are well suited for this purpose. However, the modeling assumption that all homes have air-conditioning should be waived for the purposes of developing the recommendations. If a rated home does not have air-conditioning, then energy savings resulting from cooling measures should not be

considered, for example, no cooling measures would be included in the list of measures for homes that are not air conditioned.

6.5.2 Custom Approach

With the Custom Approach, the rater may modify certain modeling assumptions to better approximate the specific occupant patterns of the rated house. Alternative modeling assumptions used as part of the Custom Approach shall be approved by the HERS provider. Alternative modeling assumptions shall be developed to provide a better match between the energy bill history and the simulation results. When alternate modeling assumptions are used, the rater shall provide an explanation of why the alternate assumptions are appropriate and the alternate assumptions shall be approved by the HERS provider. Typical alternative modeling assumptions are shown in the following table.

Table 16 – Examples of Modeling Assumptions That May Be Modified With the Custom Approach

Modeling Assumption	Possible Reasons for Modification
Thermostat schedules	Retirees occupy the house continuously and require warmer temperatures. A professional (couple) occupies the home, and the home is occupied only from late at night until early morning.
Intermittent occupancy	The home is used only on weekends. The homeowner takes extended vacations.
Presence of special energy-using equipment	The homeowner runs a catering operation from the kitchen.
Lifestyle patterns	The home is occupied by an extended family. The family has a large number of teenagers.

6.6 Measures and Costs that Affect the California HERS Index

6.6.1 Standard Approach

Database for Energy Efficient Resources (D.E.E.R.)

With the Standard Approach, all energy efficiency measures and their associated costs shall be taken from a common database. The database shall be updated periodically by HERS providers, but no less frequently than annually. The starting point for the database shall be the Database for Energy Efficient Resources (D.E.E.R.) which is accessible from the Energy Commission website at www.energy.ca.gov/deer. This database has both measure costs and energy savings estimates. Only the measure costs portion of the database shall be used.

Adjustments for Local Conditions

Costs from the D.E.E.R. database shall be adjusted for California climates based on the multipliers for California locations and/or climate zones.

Required Database Fields

- Performance characteristics
- Starting point date
- Ending point date
- Cost
- Estimated useful life
- Others as necessary

Replacement and Maintenance Costs

Measures in the Standard Approach database shall include predictable replacement and maintenance costs. Future maintenance or replacement costs shall be discounted to present value at the rate of 3 percent and included in the initial cost of the measure.

Maintaining the Database

At least an annually, the HERS Standard Approach database shall be updated by the HERS providers. The basis of updates shall be alternative costs used by raters for the Custom Approach. When alternative costs are used by raters with the Custom Approach, these data shall be reported to the HERS provider. Periodically, the HERS provider shall evaluate the alternative costs to determine if it is necessary to make adjustments to the Standard Approach database. When changes are deemed to be appropriate, they shall be summarized in an appropriate format and compared to changes proposed by other California HERS providers. The HERS providers shall meet to reconcile any differences in proposed changes and agree on common changes to the Standard Approach database. When necessary, the Energy Commission will assist in reconciling differences.

6.6.2 Custom Approach

Raters may modify measure costs and/or add additional measures to address the field conditions of a particular home or local availability of products or services. When measures are added or costs modified, the proposed modifications shall be reported to the HERS provider so that the alternative costs may be considered when periodic updates are made to the Standard Approach database.

- Measure costs used in the cost-effectiveness analysis may be based on bids the homeowner has received or other localized costs that the rater considers to be more relevant.
- Additional measures may be added as long as the measure may be directly modeled using the approved HERS modeling tool.

When the rater deviates from the standard database of measures and costs, the alternate measures or costs shall be reported to the HERS provider and the HERS provider shall approve the use of the alternate measures or costs. Such costs shall be considered when the standard database is periodically updated. The providers shall collaborate with Energy Commission staff to cross review

costs for measures from different providers and reconcile differences for updating of the standard database.

6.7 Measures and Costs That Do Not Affect the California HERS Index

6.7.1 Standard Approach

Standard (non-customized) recommendations shall be provided based on the presence of energy using systems or equipment that are not considered in the California HERS Index such as pools, spas, well pumps, lighted courts, and other significant energy uses that the rater identifies. The process of determining cost-effectiveness described in the previous sections does not apply to measures that do not affect the California HERS Index.

Customized Approach

The rater, using methods approved by the provider and the Energy Commission, may evaluate the cost-effectiveness of specific measures to improve the energy efficiency of swimming pools, spas, well pumps, and other energy uses not considered in the California HERS Index.

6.8 Energy Bill History

6.8.1 Standard Approach

Rater is expected to collect utility bill data and enter it into the tool. If utility bill data is unavailable, then the rater should disclose why it is not available.

When data is available, utility bills shall be analyzed using Inverse Modeling and normalized for the standard Energy Commission weather data. The normalized results shall be compared with the simulated results and presented in the HERS Energy Bill Analysis report.

6.8.2 Custom Approach

Same requirements as the Standard Approach, except that results of the inverse modeling may used to "calibrate" the model (see Modeling Assumptions above).

6.9 Qualifying the Recommendations

6.9.1 Standard Approach

The *HERS Standard Approach Recommendations Report* shall contain the following caveats:

The recommendations in this report are based on the following assumptions:

- Standardized installation cost for energy efficiency measures.
- Standardized energy costs with Energy Commission estimates of future escalations.
- Consideration of the benefits and costs of the measures over a period of 30 years.
- Consideration of future maintenance and/or replacement costs.
- Typical occupancy patterns in terms of thermostat settings, hot water use, appliance use, and other factors.

When a utility bill analysis shows a considerable variation from the predictions of the energy model (greater than 30 percent), qualifying statements should be added to the recommendations page of the HERS report stating that the utility bills show higher or lower energy consumption from the model. The qualifying statements should explain the common reasons for variations between the model and bills, for example, lifestyle or unaccounted-for energy uses such as pools or spas.

6.9.2 Custom Approach

The *HERS Custom Approach Recommendations Report* shall contain the following caveats:

The recommendations in this report are based on the following assumptions (the report shall describe each of the following):

- Cost-Effectiveness Method.
- Determining Cost-Effectiveness of Energy Efficiency Measures.
- Utility Rates.
- Modeling Assumptions.
- Measures and Costs That Affect the California HERS Index.
- Measures and Costs That Do Not Affect the California HERS Index.

7. Data Collection Procedures

7.1 Existing Homes

Data used to produce a rating of an existing home should be collected pursuant to the guidelines set forth in Appendix A; however, providers may develop alternative and/or expanded procedures for their raters. Such alternative or expanded procedures shall be submitted to the Energy Commission for approval.

7.2 Newly Constructed Homes

A newly constructed home may be rated based on the plans and associated compliance documentation (CF-1R). Data not shown on the plans such as the make and model of the refrigerator or dishwasher may be verified through correspondence with the builder. Any field verification needed to demonstrate proper installation of measures must be completed, especially field verification and diagnostic testing required by Title 24, Part 6. A California Whole House Home Energy Rater who is also a California Field Verification and Diagnostic Testing Rater may perform the field verification and diagnostic testing for Title 24, Part 6, verification and sign and submit the CF-4R for measures that are properly verified during the site visit.

7.3 Certifications Required for Collecting Data

7.3.1 California Whole House Home Energy Rater

A rater certified as a California Whole House Home Energy Rater may collect any data used to produce a California Home Energy Audit or California Whole House Home Energy Rating.

7.3.2 Data That May Be Collected Only by Certain Types of Certified Raters

A person who is not certified by a HERS provider as either a California Home Energy Auditor, a California Whole House Home Energy Rater, or a California Field Verification and Diagnostic Testing Rater may not field collect the types of data listed in Table 17. Only a person who is certified, by a HERS provider, as a California Home Energy Auditor or a California Whole House Home Energy Rater is permitted to collect this data to develop a California Home Energy Audit or a California Whole House Home Energy Rating. Similarly only a person certified as a California Field Verification and Diagnostic Testing Rater is permitted to collect this data pursuant to verifying compliance with Title 24, Part 6 field verification and diagnostic testing measures as a HERS rater.

Table 17 – Data That May Only Be Field-Collected by a California Home Energy Auditor, California Whole House Home Energy Rater, or a California Field Verification and Diagnostic Testing Rater

ACM Section	ACM Title	Data that must be collected by Rater possessing a Standard Certificate
3.3.2	Thermal mass	Determination of high mass residences, including identification of unit interior mass coefficients and surface areas
3.3.3	Natural Ventilation and Infiltration	Building pressurization tests to measure specific leakage area (SLA)
3.4.3	Attic Ventilation	Free ventilation area and percentage of ventilation located high in attic
3.4.4	Roof Deck	Above deck insulation Above deck mass
3.11.3	Refrigerant Charge or Charge Indicator Display	Verification of refrigerant charge Verification of charge indicator light
3.11.5	Adequate Airflow	Verification of adequate air flow over the cooling coil for credit
3.11.7	Fan Energy	Verification of fan power for credit
3.11.8	Cooling System Calculations	Verification of air conditioner sizing calculations for credit
3.12.3	Special Credits for Ducts	Verification of duct return location, supply location, surface area, R-value, and presence of buried ducts
3.12.5	Duct/Air Handler Leakage	Measurement and verification of duct and air handler leakage
3.14	Hydronic Distribution Systems and Terminals	Piping length, size and R-value

7.3.3 Data That May Be Collected by a California Home Energy Analyst

A California Home Energy Analyst may collect only data from plans and associated construction documentation or from information provided by a rater trained and certified to collect the data.

8. Supplemental Certification and Quality Assurance Procedures

The certification and quality assurance procedures for raters, providers, and building performance contractors specified in the HERS regulations are supplemented in this section.

8.1 Specialized Rater Certifications

The following certifications are available to raters who do not wish to be certified to perform all the functions of a California Whole House Home Energy Rater. Each certification has different training requirements as well as different rating authorities, as listed below. Applicants for certification shall be trained and tested by the HERS provider to demonstrate competence. In some cases, applicants may pass challenge tests to demonstrate competence for required certification skills.

8.1.1 California Field Verification and Diagnostic Testing Rater

To be certified as a California Field Verification and Diagnostic Testing Rater, an applicant shall demonstrate competence in elements (A)-(K) and (M) of Section 1673(a)(1) of the HERS regulations with special emphasis on elements (H)-(K) and emphasis on hands-on training and testing in the proper procedures and use of test equipment.

A California Field Verification and Diagnostic Testing Rater is certified to verify compliance with those elements of the Building Energy Efficiency Standards, Title 24, Part 6, that require HERS rater field verification and diagnostic testing and to complete similar field verification for beyond standards programs. The certification permits the rater to collect any data specified in Appendix RA3 of the Building Energy Efficiency Standards and to undertake analysis of that data as specified in Appendix RA3. The California Field Verification and Diagnostic Testing Rater shall also have a thorough knowledge of Appendix RA2.

8.1.2 California Home Energy Inspector

To be certified as a California Home Energy Inspector, an applicant shall demonstrate in-depth competence in elements (A)-(G) of Section 1673(a)(1) and general competence in elements (J) and (M) of Section 1673(a)(1) of the HERS regulations.

A California Home Energy Inspector directly supervised by a California Whole House Home Energy Rater may collect on-site data for the production of a California Whole House Home Energy Rating or a California Home Energy Audit. A California Home Energy Inspector certification does not permit the California Home Energy Inspector to conduct the modeling and analysis required to produce a rating or to make recommendations for energy efficiency improvements. The certification does not permit the collection of data for the measures requiring field verification and diagnostic testing outlined in Reference Appendix RA3 or Table 18.

8.1.3 California Home Energy Analyst

To be certified as a California Home Energy Analyst, an applicant shall demonstrate competence in elements (A)-(C), (E)-(H), and (J)-(N) of Section 1673(a)(1) of the HERS regulations. A California Home Energy Analyst shall also demonstrate in-depth competence in elements (G), (H), and (L) of Section 1673(a)(1).

Persons certified as a California Home Energy Analyst may complete a California Home Energy Audit or a California Whole House Home Energy Rating using Energy Commission-approved HERS software as long as they complete the analysis under the direct supervision of a California Whole House Home Energy Rater. The audit or rating shall be based either upon data collected from drawings or collected at the site by either a California Whole House Home Energy Rater, a California Home Energy Auditor, or a California Home Energy Inspector directly supervised by a California Whole House Home Energy Rater.

8.2 Provider Quality Assurance

HERS providers shall have a Quality Assurance Reviewer, who is independent from the rater, to verify the greater of one home site or installation for each rater or one percent of the home sites or installations that are rated by that rater to verify the accuracy and reliability of the ratings without the knowledge of the rater. For newly constructed homes, where the rating is derived primarily from plans and construction documentation, the quality assurance shall include a site visit and verification that the significant energy efficiency features were implemented. For rated homes using the building performance contractor exception to Section 1673(i)(3), at least 5 percent of the rated homes shall be verified by a Quality Assurance Reviewer.

For Title 24 Field Verification and Diagnostic Testing Ratings, houses or installations that are not tested by the rater may be passed by the HERS rater as part of a sample group. For each California Field Verification and Diagnostic Testing Rater, the greater of one untested house/installation or one percent of all untested houses/installations shall be verified by the HERS provider's Quality Assurance Reviewer.

8.3 Special Requirements for Building Performance Contractors

To be certified as a rater, Building Performance Contractors (BPC) are required to receive in-depth training in all of the elements listed in Section 1673(a)(1). In addition, they must have training and certification by the Building Performance Institute or other organization approved by the Energy Commission, in the health, comfort, and safety aspects of the operation of homes. To perform California Home Energy Audits or California Whole House Home Energy Ratings, a certified Building Performance Contractor shall meet the requirements of a specially approved HERS

provider program that incorporates certified Building Performance Contractors under the supervision of a HERS provider as part of the HERS provider's Home Energy Rating System.

Certified Building Performance Contractors qualify for the exception to Section 1673(i)(3). This exception permits the certified Building Performance Contractor to rate a home for which the Building Performance Contractor serves as either a general contractor or a specialty contractor in making improvements. The Building Performance Contractor may perform all tasks, or employ other certified raters, to conduct a California Home Energy Audit or a California Whole House Home Energy Rating. However, the Building Performance Contractor shall meet the requirements of Subsections 8.3.1 through 8.3.7.

8.3.1 Initial California Home Energy Audit

An initial California Home Energy Audit shall be performed for the home before improvements are made. This initial audit shall not be an official California Whole House Home Energy Rating. The building performance contractor shall only issue an official California Whole House Home Energy Rating for homes after they have made comprehensive energy efficiency improvements. The initial audit shall be performed to the standards specified in this technical manual and shall include a set of recommendations developed using the Standard Approach. These recommendations shall define a package of measures that shall be considered in the package of improvements implemented by the building performance contractor.

8.3.2 Package of Improvements

The objective of the building performance contractor that qualifies for the exception is to make a comprehensive set of improvements to the home that will improve energy efficiency and achieve other goals identified by the building performance contractor. The package of improvements that are proposed and implemented by the Building Performance Contractor shall consider all the measures identified in the Standard Approach list of recommendations produced as part of the initial audit. If recommended measures are not included in the package of improvements, then the Building Performance Contractor shall disclose to the owner and to the HERS provider the reason why the recommended measure was not implemented.

8.3.3 Field Verification and Diagnostic Testing of Improvements

All improvements to the home carried out by the Building Performance Contractor shall be field-verified and diagnostically tested following the procedures in Reference Appendix RA3 of Title 24, Part 6. See Table 18 for examples.

Table 18 – Example Field Verification and Diagnostic Testing Required of BPC

Improvement Implemented by BPC	Required Field Verification and Diagnostic Testing
Modifications or extensions of existing air distribution ducts triggering §152(b)D.	BPC shall seal ducts according to the requirements in §152(b)D. BPC shall verify duct location, surface area and R-value
Air handler or evaporator unit is replaced	BPC shall verify low leakage air handlers BPC shall verify adequate air flow BPC shall determine fan watt draw
Condenser unit is replaced	BPC shall size the unit following the procedures in RA1. BPC shall verify refrigerant charge or the presence of a charge indicator light BPC shall verify the EER
Insulation is replaced or upgraded	BPC shall verify insulation quality
PV system is installed	BPC shall verify performance

8.3.4 Final California Whole House Home Energy Rating

Once the improvements are completed, the Building Performance Contractor shall perform an official California Whole House Home Energy Rating of the home. Measurements and field verification and diagnostic testing performed as part of making the improvements may be used to generate the final rating, when appropriate. The final rating shall include the list of recommendations produced with the Standard Approach and a disclosure of measures recommended using the Standard Approach that were not included in the Building Performance Contractor package of improvements. Any work performed by the Building Performance Contractor that is normally subject to verification by a HERS rater under Title 24, Part 6, shall be verified by a California Field Verification and Diagnostic Testing Rater who is an independent entity from the Building Performance Contractor.

8.3.5 Disclosure

The Building Performance Contractor shall disclose the following to the building owner. This disclosure shall be included at the time the proposal is made to do the improvements and again as part of the final rating package. The following shall be addressed.

- The business and financial relationship between the Building Performance Contractor and the rater, including all conflicts of interest that are subject to these regulations for other raters and installers.
- Measures included in the implementation package that are included for reasons other than energy efficiency, such as, safety, amenity, comfort, or indoor air quality.
- An explanation of why recommendations based on the Standard Approach were not included in the implementation package.

8.3.6 Provider Quality Assurance

The HERS provider shall review a minimum of 5 percent of the ratings performed pursuant to the Building Performance Contractor exception. The Quality Assurance Reviewer shall verify the accuracy and procedures used for the following areas:

1. The rating and other contents of the rating report.
2. The initial rating and recommendation report produced before the Building Performance Contractor undertook work on the home.
3. Independent field verification of all field verified measures.

The review must assess how the rating conforms to the requirements of the HERS regulations and this manual.

8.3.7 Post Retrofit Utility Bill Analysis

Twelve months following implementation of the improvements, the Building Performance Contractor shall conduct a post retrofit utility bill analysis as described in Chapter 5 of this manual. The post-retrofit utility bill analysis shall be performed for every home using the Building Performance Contractor exception and shall be reported to the homeowner and the HERS provider.