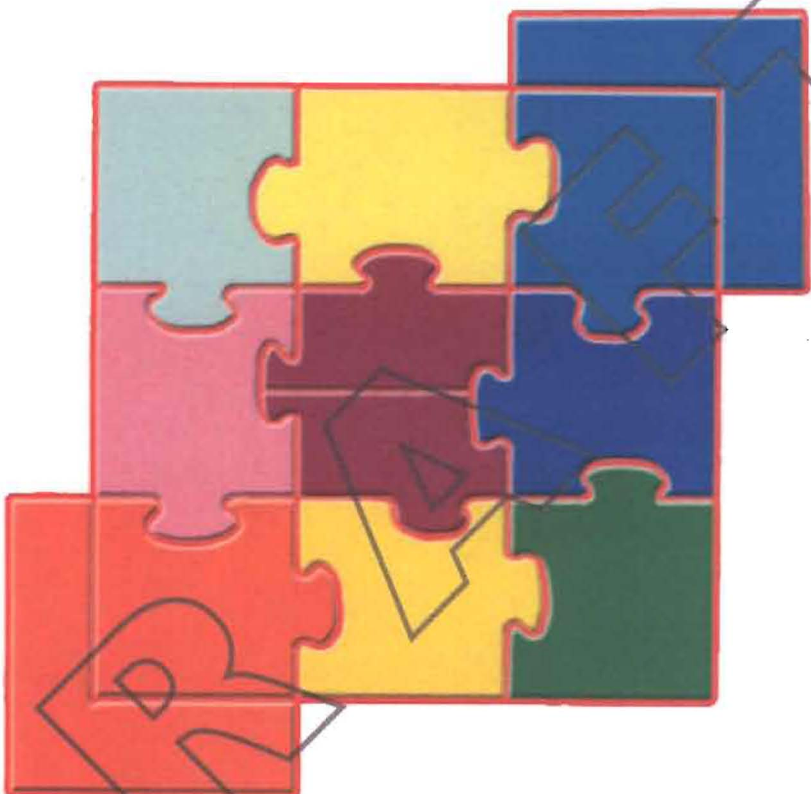
CALIFORNIA
ENERGY
COMMISSION

HERS

HOME ENERGY RATING SYSTEM

TECHNICAL MANUAL

DRAFT TECHNICAL MANUAL



DRAFT

August 2008
CEC-400-2008-012-D-Rev1

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Please use the following citation for this report:

California Energy Commission, *HERS Technical Manual*, California Energy Commission, Buildings and Appliances Office. CEC-400-2008-012-D.

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ABSTRACT

This Technical Manual explains the requirements for the California Home Energy Rating System (HERS) Program, including requirements for software, requirements for HERS providers, modeling procedures and assumptions for HERS software, and procedures for California Whole-House Home Energy Raters. HERS rating software is used to calculate the California HERS Index, generate recommendations on how to improve the energy performance of the rated home, and analyze customers' utility bills. The Technical Manual also explains the roles, requirements, and procedures for persons certified to perform specific functions related to HERS ratings. The Technical Manual explains the requirements for completion of California Home Energy Auditors shall use to conduct California Home Energy Audits that are provided for people who do not wish to have a formal rating but want recommendations for cost-effective energy efficiency improvements. The Technical Manual also explains the HERS reports, data collection procedures, and certification and quality assurance procedures., 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-HouseWhole-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~~California Whole-House Home Energy ~~HERS r~~Rating. HERS rating 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 Custom~~ized~~ 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 rating software meets the requirements of this Technical Manual. The California Energy Commission will perform spot checks and may require additional information to verify that the proposed HERS rating software is suitable for the intended purposes.

1.1 Minimum Modeling Capabilities

HERS rating software shall meet the minimum and optional modeling capabilities specified in Chapters 4 and 5 of the *2008 Residential ACM Approval Manual* (Energy Commission ~~p~~Publication Number 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 Approval Requirements for HERS Rating Software

Approval of HERS rating software is required as part of the approval and certification of a HERS provider when candidate HERS rating software has never been previously approved by the Energy Commission, and/or when the HERS rating software vendor 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 rating software be reapproved when the *2008 Building Energy Efficiency Standards* or the HERS regulations are updated 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 rating software. When reapproval is necessary, the Commission will notify all HERS rating software vendors of the timetable for renewal. Full approval is required for all HERS rating software changes.

1.3 Application for Approval

1.3.1 Residential ACM Approval

Before applying for HERS rating software approval, the HERS rating software shall receive approval as low-rise residential compliance software for the *2008 Building Energy Efficiency Standards* as described in the *2008 Residential ACM Approval Manual*. Approved low-rise residential compliance software shall be modified to incorporate the specific features, algorithms, and assumptions required to perform the analyses for a California Whole-House Home Energy Rating and a California Home Energy Audit.

When the software is set in the mode to determine and produce a California Whole-House Home Energy Rating or a California Home Energy Audit, it must automatically disable *2008 Building Energy Efficiency Standards* compliance output and the internal assumptions for *2008 Building Energy Efficiency Standards* calculations that differ from the assumptions used to produce a California Whole-House Home Energy Rating or a California Home Energy Audit.

~~1.2~~ 1.3.2 Application Checklist

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

- Evidence that the software has met the requirements of the *2008 Residential ACM Approval Manual*~~.~~, ~~I~~including:
  - HERS rating software Vendor Certification Statement~~.~~
  - Computer run summary sheets~~.~~
  - Computer runs~~.~~
- Copy of the HERS rating software. A computer readable copy of the HERS rating 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~~ 1.4 Types of Approval

This Technical Manual addresses three types of HERS rating software approval: (1) full approval~~,~~; (2) streamlined approval of new program features~~,~~; and (3) amendments to full approvals.

1.3.11.4.1 Full Approval

Full approval is required when a candidate HERS rating 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 rating software be approved again when the standards are updated on the three-year cycle or whenever substantial revisions are made to the approval process,. This would occur, for instance, when if new analysis capabilities come into widespread use, and the Commission declares them to be minimum capabilities for all HERS rating software.

When reapprove reapproval is necessary, the Energy Commission will notify all HERS rating software providers of the timetable for renewal. There will may also be a revised *HERS Technical Manual* published, with instructions for reapproval.

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

1.4.2 Approval Timeline

The approval process for HERS Rating software shall begin after Energy Commission approval of the software as compliance software for the *2008 Building Energy Efficiency Standards* in accordance with the requirements of the *2008 Residential ACM Approval Manual*.

1. If the application is complete, the Executive Director shall make the application available to interested parties. Comments from interested parties shall be submitted within 60 business days after acceptance of the application or approval of the software as compliance software for the *2008 Building Energy Efficiency Standards*, whichever is later.
2. Within 75 business days of receipt of an application or approval of the software as compliance software for the *2008 Building Energy Efficiency Standards*, whichever is later, the Executive Director may request any additional information needed to evaluate the application. If the additional information is incomplete, consideration of the application shall be delayed until the applicant submits complete information.
3. Within 75 business days of receipt of the application or approval of the software as compliance software for the *2008 Building Energy Efficiency Standards*, whichever is later, the Executive Director may convene a workshop to gather additional information from the applicant and other interested parties. Interested parties shall have 15 business days after the workshop to submit additional information regarding the application.
4. Within 90 business days after the Executive Director receives the application, or within 30 business days after receipt of complete additional information requested, or within 60 business days after the receipt of additional information submitted by interested parties, whichever is later, the Executive Director shall submit to the Energy Commission a written recommendation on the application.

5. The application and the Executive Director's recommendation shall be placed on the business meeting agenda and considered at a business meeting within 30 business days after submission of the recommendation.

6. The Executive Director may charge a fee to recover the costs of processing and reviewing applications.

7. All applicants have the burden of proof to establish that their applications should be approved.

1.3.21.4.3 Streamlined Approval

Certain types of changes may be made to approved residential HERS rating 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 rating software modification qualifies for streamlined approval, then the following procedure is followed:

- The HERS provider prepares a summary of the changes to the HERS rating 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.
- The HERS provider furnishesProvide the Energy Commission with an updated copy of the HERS rating software and includes any new reports created by the HERS rating software (or modifications in the standard reports).
- The Energy Commission responds in 45 business days after receipt of the streamlined approval request. The Commission response may take several forms. The Commission may: (1) request additional information,; refuse to approve (2) require that the HERS provider make specific changes to the HERS rating software; or (3) deny the change request approval, or require that the HERS provider make specific changes to the HERS software.
- With Energy Commission approval, the HERS provider may issue new copies of the HERS rating software and notify HERS rating software users.

1.3.31.4.4 Amendments

HERS rating 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~~1.4.5 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.

1.5 Requirements for Approval

1.5.1 Residential ACM Approval

HERS rating software shall receive approval as low-rise residential compliance software for the *2008 Building Energy Efficiency Standards* as described in the *2008 Residential ACM Approval Manual* prior to approval as HERS rating software. The software shall be able to pass all of the tests specified in the *2008 Residential ACM Approval Manual*. The software shall receive all of the inputs and produce all of the required outputs specified by the *2008 Building Energy Efficiency Standards* compliance software. For HERS rating software approval the software shall be modified to incorporate the specific features, algorithms, and assumptions required to perform the analyses for a California Whole-House Home Energy Rating and a California Home Energy Audit and produce the required certificates, forms, and information specified in this Technical Manual.

When the software is set in the mode to determine and produce a California Whole-House Home Energy Rating or a California Home Energy Audit, it shall automatically disable *2008 Building Energy Efficiency Standards* compliance output and the internal assumptions for *2008 Building Energy Efficiency Standards* calculations that differ from the assumptions used to produce a California Whole-House Home Energy Rating or a California Home Energy Audit, and use the assumptions and inputs required for the rating, audit, and other information specified in this Technical Manual.

1.5.2 Additional Tests Required for HERS Rating Software Approval

In addition to the tests required in the *2008 Residential ACM Approval Manual*, HERS rating software shall pass the HERS BESTEST suites developed by the National Renewable Energy Laboratory, "Home Energy Rating System Building Energy Simulation Test (HERS BESTEST)," Vols. 1 & 2 (NREL/TP-472-7332), using the criteria and example acceptability ranges as set forth in Appendix H of the above document.

1.5.3 Basic Input and Output Requirements

HERS rating software shall be capable of producing a HERS Rating Certificate for a California Whole-House Home Energy Rating or a HERS Audit Certificate for a California Home Energy Audit. HERS rating software shall also be capable of producing the reports specified in Chapter 2 of this Technical Manual. The vendor or applicant for HERS rating software approval shall certify that the applicant's software is capable of producing all of the reports specified in Chapter 2, and the Energy Commission shall verify that these reports are produced by the software as a condition of approval.

HERS rating software shall be able to receive all inputs required to produce a California Whole-House Home Energy Rating or a California Home Energy Audit for a home or an apartment building, including the information needed for the *Rating Certificate*, the *Audit Certificate*, the Utility Bill Analyses, and recommended energy efficiency measures using either the Standard or Custom Approaches. The applicant shall certify and the Energy Commission shall randomly verify that the software accepts the required inputs and that the verified inputs produce appropriate changes in the expected results.

~~1.4~~ 1.6 Challenges

Program users, providers, or other interested parties may challenge any HERS rating software approval. If any interested party believes that an algorithm or calculation method used in HERS rating software provides inaccurate results or that a HERS report is being improperly produced, the party may challenge the program as described in the *2008 Residential ACM Approval Manual*.

~~1.5~~ 1.7 Decertification of HERS Rating Software

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

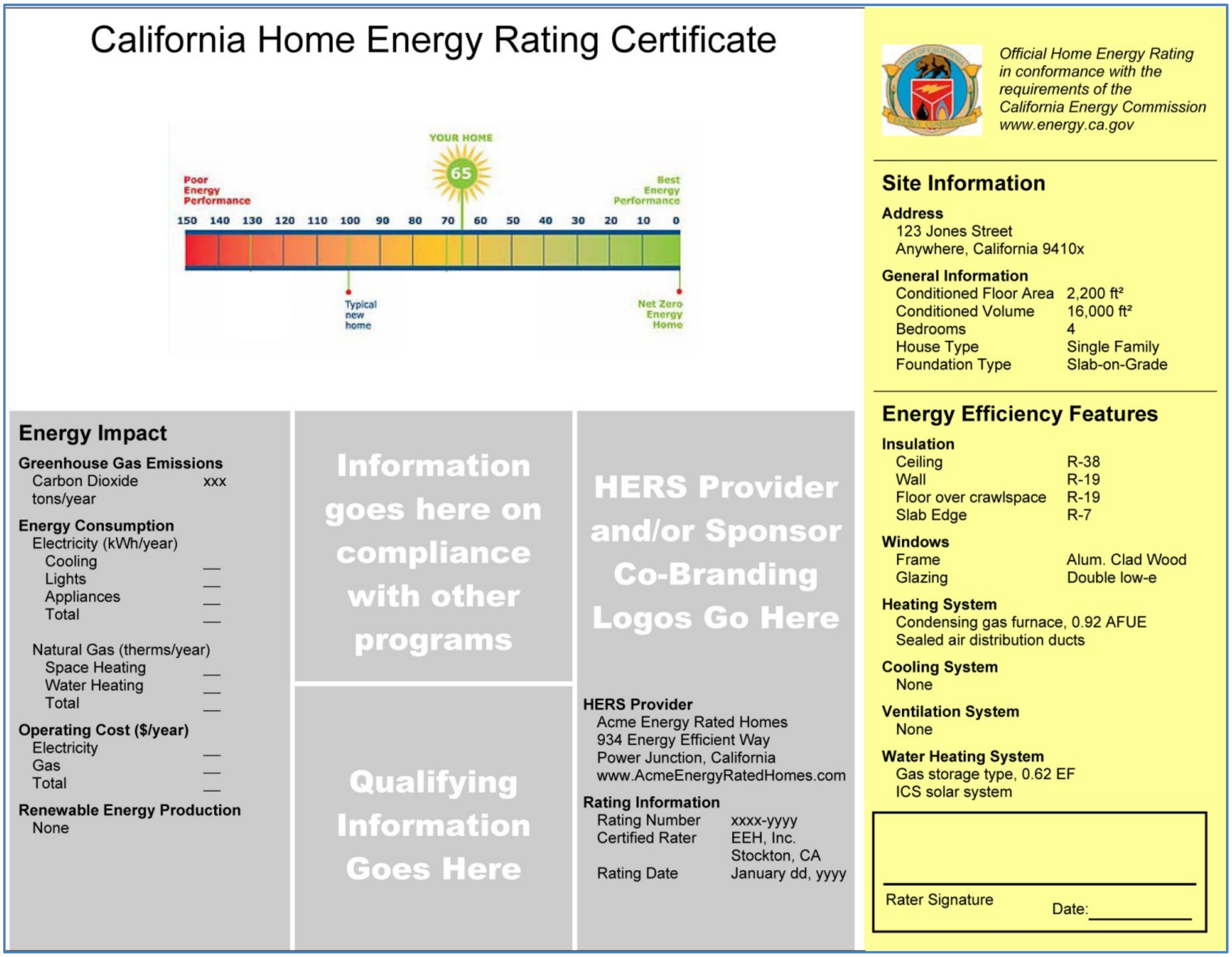
- All HERS rating software is ~~are~~ decertified when ~~the~~ substantial changes are made to the *HERS Technical Manual*.
- Any HERS rating software can be decertified by a letter from the HERS provider and the HERS rating software vendor requesting that a particular version (or versions) of the HERS rating 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 rating software according to the steps outlined ~~below~~ in the *2008 Residential ACM Approval Manual*. 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 rating 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 rating 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



California Home Energy Rating Certificate

YOUR HOME
65
Poor Energy Performance
Best Energy Performance
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
Typical new home
Net Zero Energy Home

Official Home Energy Rating in conformance with the requirements of the California Energy Commission www.energy.ca.gov

Site Information

Address
123 Jones Street
Anywhere, California 9410x

General Information

Conditioned Floor Area	2,200 ft²
Conditioned Volume	16,000 ft²
Bedrooms	4
House Type	Single Family
Foundation Type	Slab-on-Grade

Energy Efficiency Features

Insulation

Ceiling	R-38
Wall	R-19
Floor over crawlspace	R-19
Slab Edge	R-7

Windows

Frame	Alum. Clad Wood
Glazing	Double low-e

Heating System
Condensing gas furnace, 0.92 AFUE
Sealed air distribution ducts

Cooling System
None

Ventilation System
None

Water Heating System
Gas storage type, 0.62 EF
ICS solar system

Rater Signature Date:

Energy Impact

Greenhouse Gas Emissions
Carbon Dioxide tons/year xxx

Energy Consumption
Electricity (kWh/year)
Cooling __
Lights __
Appliances __
Total __

Natural Gas (therms/year)
Space Heating __
Water Heating __
Total __

Operating Cost ($/year)
Electricity __
Gas __
Total __

Renewable Energy Production
None

Information goes here on compliance with other programs

Qualifying Information Goes Here

HERS Provider and/or Sponsor Co-Branding Logos Go Here

HERS Provider
Acme Energy Rated Homes
934 Energy Efficient Way
Power Junction, California
www.AcmeEnergyRatedHomes.com

Rating Information

Rating Number	xxxx-yyyy
Certified Rater	EEH, Inc. Stockton, CA
Rating Date	January dd, yyyy

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 150 ~~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~~ newly constructed home in compliance with the *2008 ~~California~~ Building ~~e~~Energy ~~e~~Efficiency ~~s~~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 California 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 building 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 rate ~~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 Provider/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. The California Whole-House Home Energy Rater shall sign the Certificate. The name of the HERS rating software and version number shall be listed.

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-iIt-Green, Comfort Wise, or other home evaluation program may be displayed if the home qualifies for these other programs.

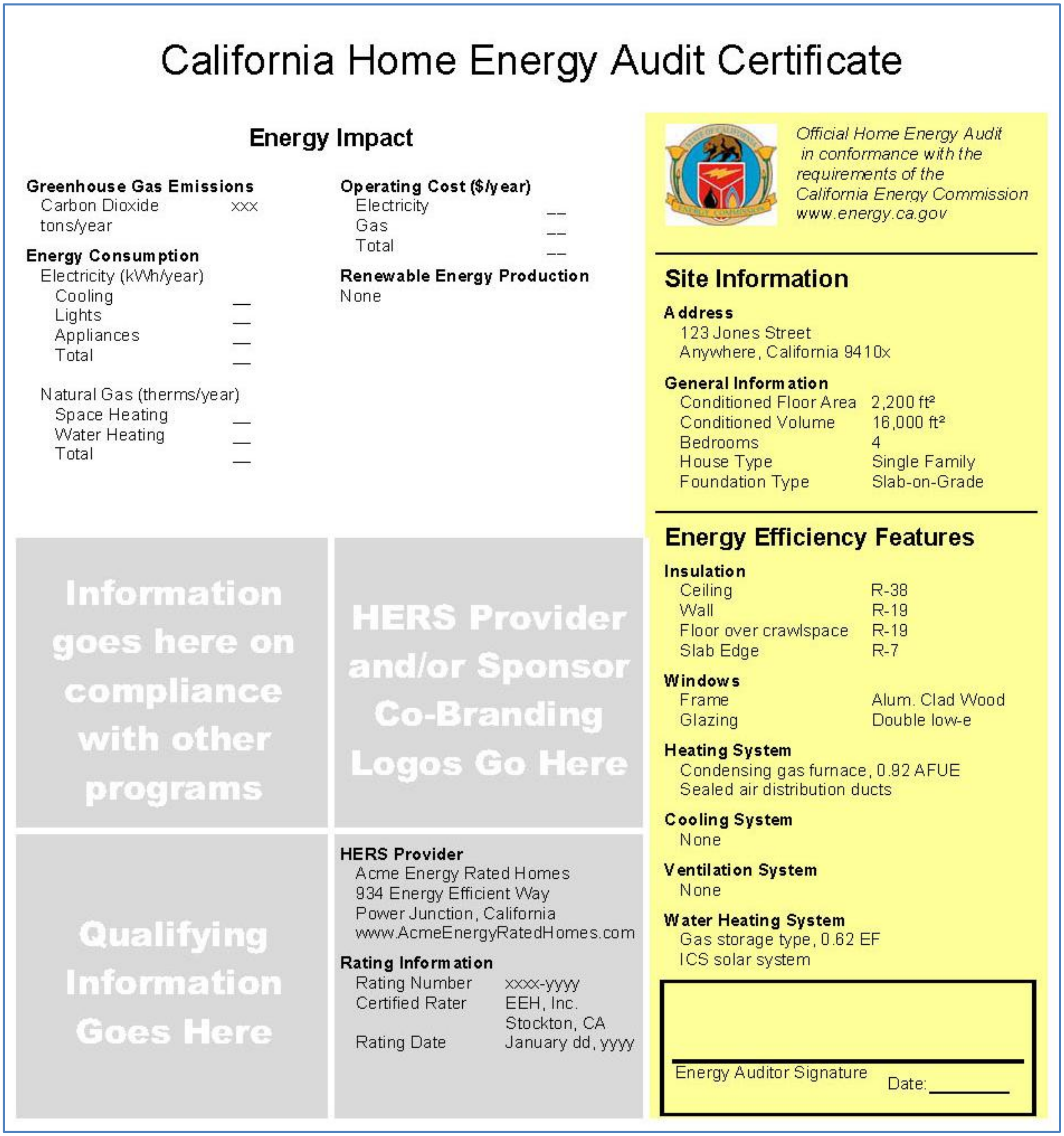
2.1.8 Qualifying Information

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 California Home Energy Audit Certificate

California Home Energy Audits shall produce a California Home Energy Audit Certificate instead of the Rating Certificate. The Energy Audit Certificate shall include all the information described for the Rating Certificate, with the exception of the California HERS Index. Figure 2 is an example.

Figure 2 – Sample California Home Energy Audit Certificate



California Home Energy Audit Certificate

Energy Impact

Greenhouse Gas Emissions
Carbon Dioxide xxx
tons/year

Energy Consumption
Electricity (kWh/year)
Cooling —
Lights —
Appliances —
Total —

Natural Gas (therms/year)
Space Heating —
Water Heating —
Total —

Operating Cost ($/year)
Electricity —
Gas —
Total —

Renewable Energy Production
None

Official Home Energy Audit in conformance with the requirements of the California Energy Commission www.energy.ca.gov

Site Information

Address
123 Jones Street
Anywhere, California 9410x

General Information

Conditioned Floor Area	2,200 ft²
Conditioned Volume	16,000 ft²
Bedrooms	4
House Type	Single Family
Foundation Type	Slab-on-Grade

Energy Efficiency Features

Insulation

Ceiling	R-38
Wall	R-19
Floor over crawlspace	R-19
Slab Edge	R-7

Windows

Frame	Alum. Clad Wood
Glazing	Double low-e

Heating System
Condensing gas furnace, 0.92 AFUE
Sealed air distribution ducts

Cooling System
None

Ventilation System
None

Water Heating System
Gas storage type, 0.62 EF
ICS solar system

Energy Auditor Signature Date: ________

Information goes here on compliance with other programs

HERS Provider and/or Sponsor Co-Branding Logos Go Here

Qualifying Information Goes Here

HERS Provider
Acme Energy Rated Homes
934 Energy Efficient Way
Power Junction, California
www.AcmeEnergyRatedHomes.com

Rating Information

Rating Number	xxxx-yyyy
Certified Rater	EEH, Inc. Stockton, CA
Rating Date	January dd, yyyy

~~2.2~~ 2.3 Recommended Improvements

One or more reports shall be provided separately from the *California Whole-House Home Energy Rating Certificate* or the *California Home Energy Audit 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~~ 2.4 Energy Consumption Analysis Report

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

1. ~~*Calculated*~~ *Simulated Consumption* – The ~~projected~~ estimated energy use for the home per month based on the building simulation model'~~sed~~s energy use of the home. For electricity and gas consumption, the ~~modeled~~ simulated energy ~~uses~~ shall be broken down by end uses.
2. *Normalized Energy Bills* – The ~~weather normalized historic~~ actual energy use of the home is normalized to standard weather data used in the building simulation model. The actual energy use is normalized using the ~~inverse model~~Inverse Modeling procedures described in this ~~t~~Technical ~~m~~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 3 is an example of ~~an~~ the Energy Consumption Analysis graphs.

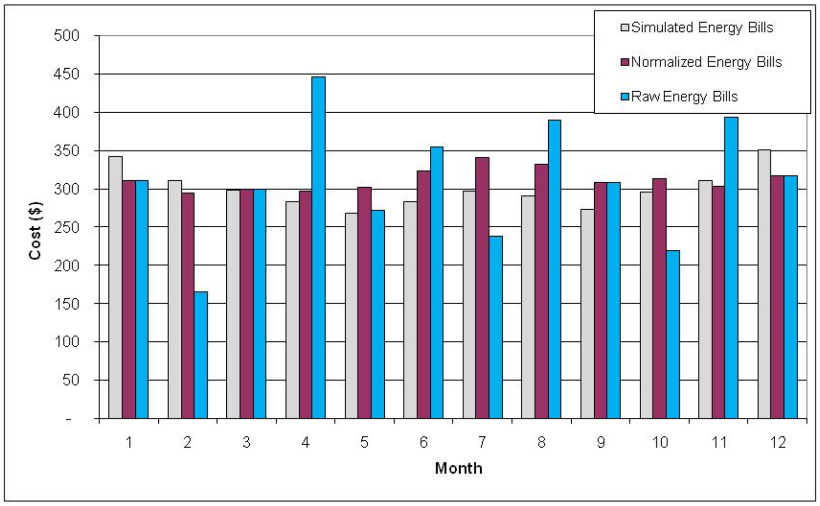
The Energy Consumption Analysis Report shall also contain a tabular report (on a second page if necessary) that breaks down the utility bill into the utility rate feature components that contribute to the total annual utility bill. The content and organization of information on this tabular form will depend on the features of the homeowner's utility rate. The following are examples of information to be included.

Table 1 – Utility Rate Reporting Requirements

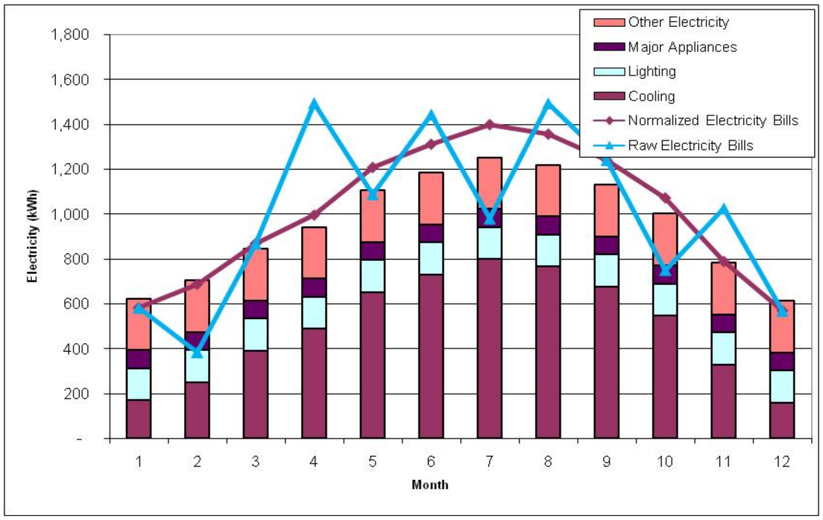
Utility Rate Feature	Example	Reporting Requirement
Seasonal Variations	Gas prices are often different between summer and winter.	Report consumption separately for each period of the year and the associated charge. Identify the beginning/ending of each season.
Daily Variations	Electric time-of-use rates have a different price for each time period and the time periods can change seasonally.	Report energy consumption for each time period and the associated charge. Identify the beginning and ending of each time period.
Tiered Rates	The price changes for different blocks of energy consumption.	Report consumption for each block and the associated charge. Describe the blocks.
Demand Charges	Demand charges	Report peak demand for each billing period and the associated charge.
Monthly Service Charge	Fixed monthly charges are often added on top of energy and demand charges.	Separate the monthly service charge.

Figure 3 – Example Energy Consumption Analysis

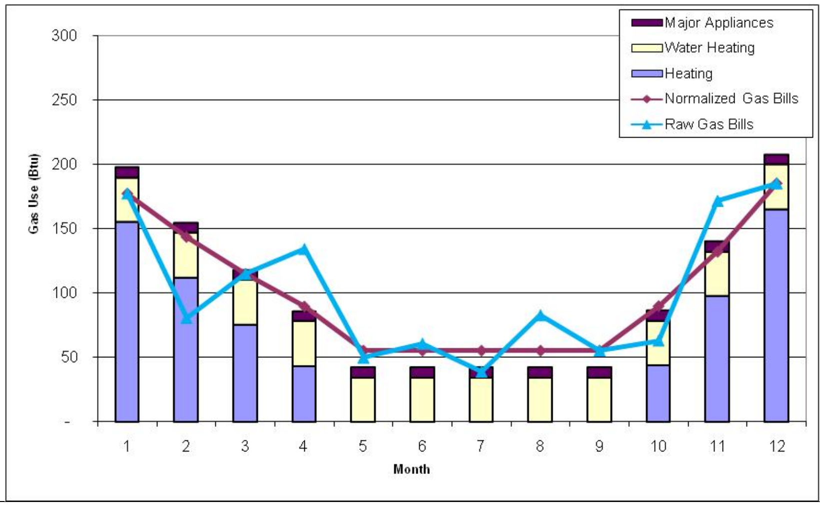
Energy Cost



Electricity Use



Gas Use



~~2.4~~ 2.5 Data Input Summary

The Data Input Summary shall provide a detailed listing of the inputs to the HERS rating software. The level of detail shall be similar to the CF-1R report specified in the *2008 Residential ACM Approval Manual*.

~~2.5~~ 2.6 Post-Retrofit Utility Bill Analysis (Optional)

~~In the event that~~ If the homeowner implements the recommendations provided in the rating, the post-retrofit utility bill analysis would ~~verify these savings by comparing~~ compare the post-retrofit utility bills to estimates from the pre-retrofit ~~inverse model~~Inverse Model. See Figure 6 on Page 43 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

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

where

TDV_{Rated} The TDV energy of the rated home, excluding ancillary energy use outside the boundaries of the building envelope (kBtu/year).

TDV_{PV} The TDV energy produced by on-site PV systems or other renewable energy systems (kBtu/year).

$TDV_{Reference}$ The TDV energy of the reference home (kBtu/year).

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 or other on-site renewable generation, the California HERS Index shall be calculated both with and without the ~~PV system~~ on-site generation. The HERS Index without including the on-site generation shall be calculated using Equation 1 and setting the TDV_{PV} value to zero.

If the conditioned floor area of the rated home is larger than 2,500 square feet (ft^2), the TDV energy of the reference home shall be based on a 2,500 ft^2 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 2.

Equation 2

$$TDV_{Reference,ScaledBack} = \frac{2{,}500\ ft^2}{Area_{RatedHome}} \times TDV_{Reference,FullSize}$$

Table 2 – 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 *2008 Residential ACM Approval Manual*, and the rated home shall be identical to the proposed design specification in the *2008 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 Building ~~e~~Energy ~~e~~Efficiency ~~s~~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, the number of bedrooms, the number and types of lighting fixtures, appliances, and ancillary energy-consuming items outside of the home but on the same utility meters that serve the home, such as swimming pools. 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 rating 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 ~~C~~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~~ *2008 Building Energy Efficiency Standards*. Defining the reference~~rated~~ home involves ~~two~~ three 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.
- Third, the lighting and appliances for the reference home are determined based on the default assumptions in this Technical Manual and the presence or absence of certain types of appliances in the rated home.

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*~~*HERS reference home* shall be the same as the *standard design* home as defined in the *2008 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 *2008 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 home~~newly-constructed 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 ceiling surfaces exposed to unconditioned space 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 Slab~~s~~-on-Grade Modeling Rules

ACM Section	Applicability
3.6.1 Inputs for ~~Proposed Design~~Rated Home and ~~Standard Design~~Reference Home	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~~Rated Home	No changes from Residential ACM
3.10.2 ~~Standard Design~~Reference Home	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~~Rated Home	No changes from Residential ACM
3.11.2 ~~Standard Design~~Reference Home	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 home~~newly constructed homes that are rated~~.~~
3.11.6 Fan Energy	Not applicable for existing systems but could be applicable for equipment replacements or ~~new home~~newly constructed homes that are rated~~.~~
3.11.7 Cooling System Calculations	Not applicable for existing systems but could be applicable for equipment replacements or ~~new home~~newly constructed 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 DesignRated Home	Mechanical ventilation is assumed for existing homes even when they do not have it. See 4.10
3.13.2 Standard DesignReference Home.	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 swing seasonsshoulder). Most utility rates only use the summer and winter seasons.
- 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 or demand.
- Demand charges: a fixed or seasonally variable charge that scales with peak demand for the month or billing period..
- Time-of-use charges: a different price per unit of consumption applies depending on the time of day that the consumption occurs. Typically there are three time of use periods: on-peak,

off-peak and shoulder. The on-peak period typically occurs on weekday afternoons and early evenings during the summer. The shoulder period typically occurs on weekday mornings and sometimes on weekends. The off-peak period typically occurs at night. In the future, California will be moving towards critical peak pricing, real time pricing, and peak time rebate approaches. HERS rating software shall be capable of modeling these approaches also.

- ~~Ratcheted rates.~~

The Energy Consumption Analysis Report (see Chapter 2), which is required for all HERS rating software, shall report energy consumption in the bins or categories defined above. For instance, if the home is on a time-of-use rate, energy consumption shall be reported for each of the time periods defined for the utility rate, for example, on-peak, off-peak, and shoulder. If the home is on a tiered rate, energy consumption shall be reported for each of the tiers.

4.4 Schedules for Lights, Appliances, People, and Equipment

The hourly schedules shown in Table 3 shall be used.

Table 3 – Hourly Schedules for Lighting and Appliances Model (Percent of Daily Total)

Time	Refrigerators	People	Equipment	Interior Lighting	Exterior Lighting
1	4.2%	~~5.9~~3.5%	~~3.1~~3.7%	2.3%	0%
2	4.2%	~~5.9~~3.5%	~~3.1~~3.5%	1.9%	0%
3	4.2%	~~5.9~~3.5%	~~3.2~~3.4%	1.5%	0%
4	4.2%	~~5.9~~3.5%	~~3.3~~3.4%	1.7%	0%
5	4.2%	~~5.9~~3.5%	~~3.6~~3.2%	2.1%	0%
6	4.2%	5.9%	~~3.9~~3.6%	3.1%	0%
7	4.2%	~~5.9~~8.2%	~~4.0~~4.2%	4.2%	0%
8	4.2%	~~4.6~~5.5%	~~4.0~~4.4%	4.1%	0%
9	4.2%	~~1.9~~2.7%	~~4.2~~3.7%	3.4%	0%
10	4.2%	~~1.9~~1.4%	~~4.2~~3.2%	2.9%	0%
11	4.2%	~~1.9~~1.4%	~~4.2~~3.3%	2.7%	0%
12	4.2%	~~1.9~~1.4%	~~4.3~~3.3%	2.5%	0%
13	4.2%	~~1.9~~1.4%	~~4.4~~3.2%	2.1%	0%
14	4.2%	~~1.9~~1.4%	~~4.4~~3.3%	2.1%	0%
15	4.2%	1.9%	~~4.6~~3.5%	2.1%	0%
16	4.2%	~~1.9~~2.7%	~~4.9~~3.7%	2.6%	0%
17	4.2%	~~3.7~~4.1%	~~5.4~~4.4%	3.1%	0%
18	4.2%	~~4.3~~5.5%	~~5.9~~5.3%	4.4%	0%
19	4.2%	~~4.9~~6.8%	~~5.5~~5.8%	8.4%	0%
20	4.2%	~~4.9~~8.2%	~~4.7~~6.0%	11.7%	0%
21	4.2%	~~4.9~~8.2%	~~4.3~~6.2%	11.3%	25%
22	4.2%	~~5.2~~7.0%	~~3.8~~6.0%	9.6%	25%
23	4.2%	~~5.6~~5.3%	~~3.6~~5.2%	6.3%	25%
24	4.2%	~~5.9~~3.5%	~~3.3~~4.5%	3.8%	25%

Seasonal adjustments shall be made to the energy use and internal loads for interior lighting, interior equipment, and occupants based on the multipliers in Table 4.

Table 4 – Seasonal Internal Gain Multipliers

Month	Multiplier	Month	Multiplier	Month	Multiplier
Jan	1.19	May	0.84	Sep	0.98
Feb	1.11	Jun	0.80	Oct	1.07
Mar	1.02	Jul	0.82	Nov	1.16
Apr	0.93	Aug	0.88	Dec	1.21

4.5 Appliances and Miscellaneous Energy Use

HERS rating software shall include an estimate of TDV energy use for lighting and appliances using the procedures in this section. The software shall also provide hourly estimates of gas and electricity use.

4.5.1 Refrigerator/Freezer

The refrigerator[1] in the reference home shall use 775669 kWh/year. The reference home shall not have a second refrigerator or standalone freezer. 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 775 kWh/yearthe 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 1,013 kWh/year for each additional refrigeratorthe energy of the second refrigerator using Equation 3.

Equation 3

$$Electricity_{SecondRefrig} = -50 + 0.717 * CFA$$

where

$Electricity_{SecondRefrig}$ Annual electricity use of the second refrigerator (kWh/year)

CFA Conditioned floor area of the rated home

In those instances when the rater observes the presence of a standalone freezer, the rated home shall include 929 kWh/year for each standalone freezer.

The refrigerator(s) and freezer in both the rated house and the reference house shall use the *Refrigerator* schedule from Table 3.

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:

---

[1] The refrigerator is assumed to be a combined refrigerator/freezer with the freezer integrated into the appliance (top-mount, bottom-mount, or side-by-side).

Equation 3

$$Electricity_{Dishwasher} = 0.27 \times \frac{Cycles/year}{EnergyFactor}$$

Where

$Electricity_{Dishwasher}$	The annual electricity use of the dishwasher in kWh/year.
Cycles/year	The cycles per year of dishwasher use from Table 5. The number of occupants shall be rounded before using this table.
Energy Factor	The energy factor of the dishwasher taken from the EnergyGuide label or from the EPA EnergySTAR database.

Table 5 – Dishwasher Use Assumptions

OccupantsBedrooms	Cycles/year	Reference Dishwasher kWh/year
21	154	90
32	214	126
43	247	145
54	296	174
65 or more	345	203

The dishwasher in both the rated house and the reference house shall use the *Equipment* schedule from Table 3.

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 be calculated for both the rated home and the reference home using the following equations. Use Equation 4 for an electric dryer or hookup and Equation 5 for a gas dryer or hookup. 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 3. 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. Use Equation 5 if the rated home has no clothes dryer and has both electric and gas hookups.

Equation 4

$$Electricity_{Dryer} = 263 + 0.254 \times CFA$$

Equation 5

$$Gas_{Dryer} = 13 + 0.010 \times CFA$$

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 be calculated for both the rated home and the reference home using Equation 6. 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 3. 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 6

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

4.5.5 ~~Oven/~~Range/Oven

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 7. 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 8 when the equipment has continuously burning pilot lights or when the equipment is not present. Use Equation 9 when the equipment has electronic ignition. Gas use for the reference home shall be calculated using Equation 9.

In the event that the rated home has both an electric and gas range oven or hookups, ~~then both Equation 7 and~~ use Equation 8 ~~shall be used~~ for ~~both~~ the rated home when the equipment has continuously burning pilot lights or when the equipment is not present. Use Equation 9 when the equipment has electronic ignition. Equation 9 shall be used for the reference home. Both the rated home and the reference home shall use the *Equipment* schedule from Table 3.

Equation 7

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

Equation 8

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

Equation 9

$$\text{Gas}_{\text{Range/Oven}} = (31 + 0.008 \times \text{CFA}) \times 0.43$$

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 ~~e~~*Equipment* schedule from Table 3.

Equation 10

$$\text{Electricity}_{Misc} = 723 + 0.706 \times \text{CFA}$$

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

$$\text{Electricity}_{InteriorLights} = (214 + 0.601 \times \text{CFA}) \times (\text{Fract}_{Portable} + (1 - \text{Fract}_{Portable}) \times \text{PAM}_{Interior})$$

where

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

CFA Conditioned floor area (ft^2).

$\text{Fract}_{Portable}$ 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.

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

Equation 12

$$\text{PAM}_{Interior} = \frac{\sum \text{PAM}_{Fixture,i} \times \text{PAM}_{Control,i} \times \text{DailyHours}_i \times \text{Count}_i}{\sum \text{DailyHours}_i \times \text{Count}_i}$$

where

$\text{PAM}_{Fixture,i}$ 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 *2008* ~~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 8 for permanently installed luminaire types.

$\text{PAM}_{Control,i}$ 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 6).

$Count_i$ The number of fixtures of this type. The count is determined following the rules in Table 7.

Equation 13

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

where

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

F Number of hardwired fixtures for rated house

CFA Conditioned floor area (ft^2)

Table 6 – Daily Lighting Hours – Interior

Location	$DailyHours_i$
Small Closet	0.5
Bedroom/WICWalk In Closet	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 7 – 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' foot 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 foot length, rounded up to 3 foot multiple.
Chandeliers with non-medium based sockets	Chandeliers with candelabra or pin-based sockets	Count = 1 for luminaries with one lamp or one socket Count = 1 luminaire for every ten sockets, rounded up to the nearest whole number, for luminaires with multiple lamps or sockets
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 8 – Permanently Installed Luminaire Types

Classification	Definition
Permanently Installed High eEfficacy	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 screw-based incandescent lamps, but that has medium screw-based track head with screw-in CFL, CFL track heads with factory installed ballast, or LED track heads

4.6.2 Exterior Lighting

Equation 14

$$Electricity_{OutdoorLights} = (-81 + 0.152 \times CFA) \times PAM_{Exterior}$$

where

$Electricity_{OutdoorLights}$ 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 2008 ~~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 9).

$DailyHours_i$ The average daily hours of lighting operation based on the location of the luminaire (see Table 10).

$Count_i$ The number of fixtures of this type. The count is determined following the -rules in Table 7.

Table 9 – 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 10 – 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, interior appliances, and miscellaneous electricity, as calculated in the previous sections. The rater shall determine if the clothes washer, dryer, additional refrigerator, or standalone freezer are located in conditioned space. Appliances located in unconditioned space shall not contribute to internal gain. 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 located in conditioned space 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 3.

Table 11 – 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%

The number of occupants for the rated and reference home shall be based on the number of bedrooms using:

Equation 16

$$\text{Occupants} = 1.75 + 0.4 \times \text{Bedrooms}$$

In addition to the heat generated by lights and appliances, an additional 3,900~~4,140~~ Btu per day ~~(230 Btu per occupant times 18 hours per day per occupant)~~ shall be included for each occupant~~bedroom~~ in the rated house and the reference house. The “people” heat gain shall follow the People schedule in Table 3.

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 newly constructed and existing homes is specified in Table 12. The values for newly constructed homes are identical to the values from 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 12 – Default Infiltration Rates (SLA)

Case	New HomeNewly Constructed Homes	Existing Homes
Unsealed ducts	4.3	4.9
Sealed ducts (see Note 1)	3.8Reduction of 0.5	4.4Reduction of 0.5 (see Note 1)
Air retarding building wrap (see Note 2)	Reduction of 0.5	Reduction of 0.5
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

Notes

1:. To use the 4.4 reduced SLA value for existing ducts, the ductsy shall be tested to a leakage of 6%.

2: The air retarding wrap shall be tested and labeled by the manufacturer to comply with ASTM E1677-95, Standard Specification for an Air Retarder (AR) Material or system for Low-Rise Framed Building Walls and have a minimum perm rating of 10.

4.10 Mechanical Ventilation

Mechanical ventilation became a mandatory feature for homes constructed in compliance with the *2008 Title 24 Building eEnergy eEfficiency sStandards*, 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 inspectorrater 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 to calculate the fan energy for the rated home. The mechanical ventilation system in the standard design reference house shall be as specified in the RACM *2008 Residential ACM Approval Manual* for newnewly constructed homes.[2]

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 outside the building envelope 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 that are on the same energy meters as the house.

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 13 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 produced by the HERS rating software, and these uses shall assume the time pattern of the schedules in Table 14 when required by the utility rate depends on the time of day.

[2] 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.

Table 13 – Average Energy Consumption Data for Ancillary Energy Uses

End Use	Features	Electricity (kWh/year)	Gas (therms/year)
Swimming Pool	Gas heated with cover	2,671	352
	Gas heated with no cover	2,671	703
	Solar heated or not heated	2,671	0
	Electric heated with cover	4,169	0
	Electric heated with no cover	5,667	0
Spa	Gas heated with cover	467	81
	Solar/gas heated with cover	467	20
	Electric heated with cover	2,186	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-Xenergy 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 14 – Schedules for Ancillary Energy Uses

Time of Day	Pools	Spas	Well Pumps	Grinder Pumps
1	0%	0%	Use *Equipment* schedule from Table 3	Use *Equipment* schedule from Table 3
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 rating software shall have the capability to perform a statistical analysis of utility bill data and to establish a relationship in the form of equations between monthly and annual energy consumption and provide a correlation against outdoor temperature datafor the same period as the utility data. The equations enable the comparison of estimated energy use from building energy simulations to the energy bills and enable the estimation of post-retrofit energy savings.

The utility bill analysis serves several purposes:

1. The energy bills may shall 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[3]

The utility bill analysis shall be consistent with ASHRAE Research Paper 1050, *Inverse Modeling Toolkit: Numerical Algorithms*.[4] 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 use 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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[3] 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.

[4] 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).

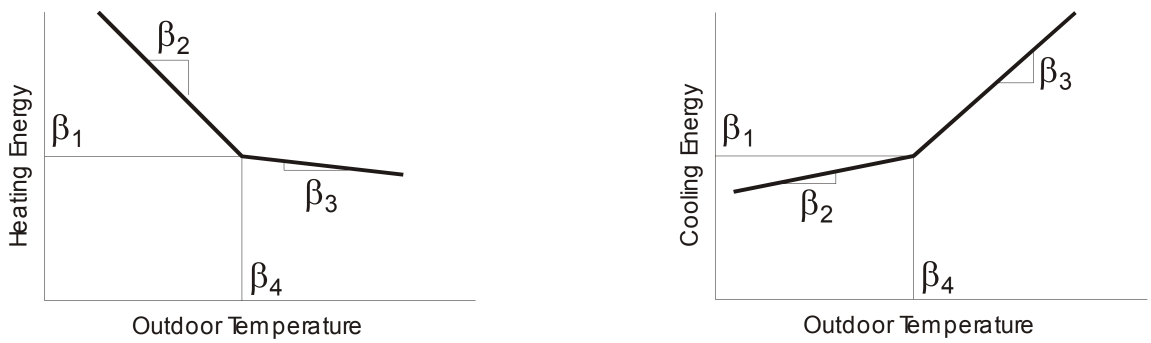
5.1.1 Four-Parameter Model

The four-parameter model has two modes~~forms~~ as shown in Figure 4. The model results in separate equations, one for heating and one for cooling if both are present. The form of the equations is shown in Equation 17. 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 from the weather station most appropriate for the home using procedures described in the *Inverse Model Toolkit*.[5]

Equation 17

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

Figure 4 – Four-Parameter Regression Model



Source: Inverse Model Toolkit (1050RP)

5.1.2 Five-Parameter Model

The five-parameter model is shown in Figure 5 and Equation 18. 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*.[6]

Equation 18

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

Figure 5 – Five-Parameter Regression Model

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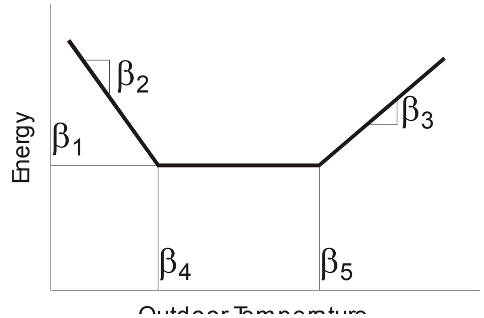
[5] Ibid.

[6] Ibid.



Source: ~~Inverse Model~~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 manual data input.

Table 15 – Standard Text Format for Climate Data

Sample Data			
1	1	1995	43.0
1	2	1995	40.6
1	3	1995	47.5
1	4	1995	49.2
1	5	1995	48.6
1	6	1995	48.0
1	7	1995	51.9
1	8	1995	52.9
1	9	1995	58.4
1	10	1995	56.3
1	11	1995	53.5
1	12	1995	53.9
1	13	1995	56.1
1	14	1995	57.5
1	15	1995	50.1
1	16	1995	46.7
1	17	1995	41.2
1	18	1995	46.1
1	19	1995	45.3
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
1	27	1995	49.7

Notes

Columns:

1 Month

2 Day

3 Year

4 Average Daily Temperature

Columns (data fields) shall be separated by tabs, spaces, or commas.

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 16 below)

Data for many~~several~~ California cities is available at ftp://ftp.ncdc.noaa.gov/pub/data/gsod/

~~http://www.engr.udayton.edu/weather/~~.

Table 16 – Standard Text Format for Utility Bill Data

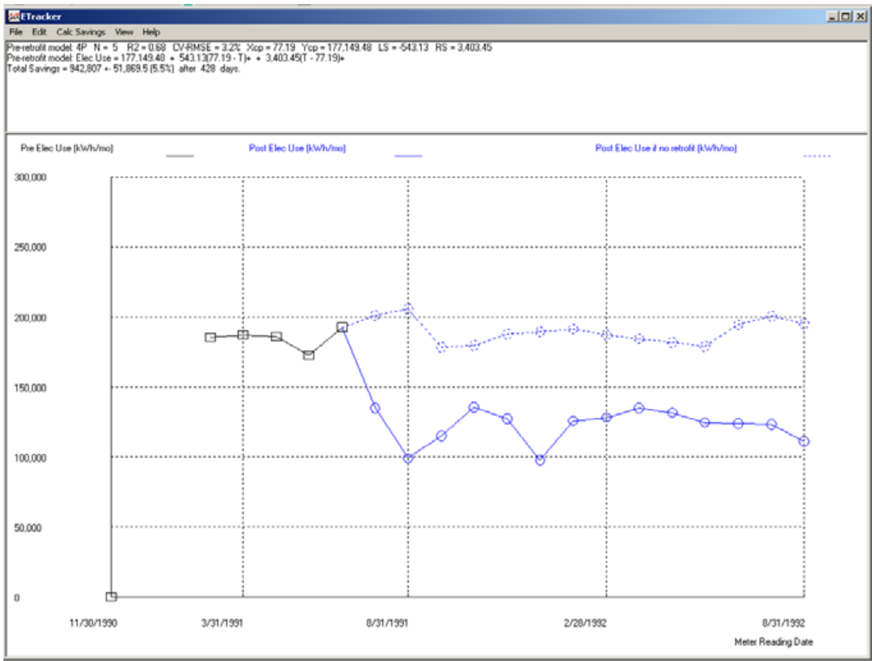
Sample Data								Notes
10	31	1990	-99	722	527	1	1	Columns
11	30	1990	-99	1409	1126	1	1	1. meter reading month
12	31	1990	-99	1093	1443	1	1	2. meter reading day
1	31	1991	-99	809	1301	1	1	3. meter reading year
2	28	1991	185200	1180	1392	1	1	4. electricity consumption (kWh/month)
3	31	1991	187000	1461	1351	1	1	5. peak electrical demand (kW)
4	30	1991	185700	1690	872	1	1	6. thermal energy consumption (units/month)
5	31	1991	172300	2021	914	1	1	7. pre/post indicator for electricity use
6	30	1991	192500	2420	770	1	1	8. pre/post indicator for thermal energy use
7	31	1991	134700	1747	701	2	2	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 retrofitpost-retrofit periods. Enter "1" to represent data from before the retrofit, and "2" to represent data from after the retrofit.
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	

5.3 Post-Retrofit Evaluation

Energy savings from improvements may be verified through an optional post-retrofit analysis. The HERS rating software and utility bill analysis feature shall have the capability to evaluate post-retrofit energy consumption through inverse modelInverse Modeling (described above) and to compare it to what the home would have used had there been no retrofit. HERS providers and raters shall offer this service to their customers when the HERS generated recommendations are implemented in the rated home. Figure 6 is an example produced by the ETracker software, which implements the recommended procedure.[7]

[7] 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 6 – Example Post-Retrofit Utility Bill Analysis



~~Source: ETracker Software, University of Dayton~~

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 rating 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:

- **Simulated Energy Bills~~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 shall beis always required, even when energy bills are not available.

- **Raw Energy BillsBilling 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, fFor example, if the billing period was 40 days and the month has 30 days, then the consumption for the month would be scaled by the ratio of 30/40 or 0.75.
- **Billing History Normalized Energy Billsto Standard Weather Files.** The Inverse Modeling equation(s) determined using the raw energy bills and concurrent weather data shall be applied to the outdoor temperature data used in the building simulation model to calculate 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. The HERS provider shall provide raters with the common gas and/or electric utility rate for each geographic area.

The utility bill analysis is required for several reasons:

- The normalized energy bills may be more reasonably compared to the simulation results, since variations in results due to temperature differences between the data used for the simulations and the actual temperature data are removed.
- The procedure also effectively averages occupancy variations, again making it easier to compare the normalized energy bills to the simulation results.
- The procedure enables seasonally dependent energy uses (heating and cooling) to be disaggregated from baseline energy, and this information helps the rater identify possible adjustments to the modeling assumptions for the Custom Approach to developing recommendations.

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 modelInverse Modeling procedures.

6. Recommendations for Energy Efficiency Improvements

As part of the rating process, California home energy rating systems shall produce a list of cost-effective recommendations ~~which~~ that 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 ~~a~~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 ~~a~~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 in some cases 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.~~

Use of the Custom Approach is recommended when the normalized utility bill data (from Inverse Modeling) is significantly different from the energy consumption estimated using the Standard Approach. In these instances, the rater should interview the homeowner to understand how their use patterns may vary from the standard assumptions. Use patterns that would result in significantly different energy consumption than that estimated using the Standard Approach may be used to change the simulation for the Custom Approach.

The two Approaches are summarized and contrasted in the following table.

Table 17 – 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. • *Homeowner Identified Measures.* With this strategy, homeowners may skip over measures that they do not wish to consider and/or specify that other measures be included in the Custom Approach.
Determining Cost-Effectiveness of Energy Efficiency Measures	Determine cost-effectiveness of measures using the method used for the *2008 ~~Title 24~~ Building ~~e~~Energy ~~e~~Efficiency ~~s~~Standards*.[8]	Determine ~~Consider~~ cost-effectiveness based on net zero cash flow from the perspective of the homeowner or investor, using available financial instruments or programs available to 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 such as thermal comfort, indoor air quality, and acoustics may be considered in identifying measures for consideration, but the net zero cash flow method shall not consider the monetary benefits of such measures.~~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 used for ~~of energy costs are incorporated in Title 24 method of~~ determining cost-effectiveness for the *2008 Building Energy Efficiency Standards*.	Use the utility rates in effect for each home that is rated.

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

	Path A – Standard Approach	Path B - Custom Approach
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.~~ Miscellaneous electricity consumption • ~~Life-style patterns~~Hot water consumption • Building shade from trees or adjacent buildings
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. Stable incentives may be factored into the cost premiums, as long as the same incentives are used by all HERS providers. (The Standard Approach should result in the same recommendations, independent of the rater or the provider.)	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~~ can be directly modeled using the approved HERS modeling tool. • Cost reductions from incentive programs may be considered. 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.
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. See Appendix B.	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 model~~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. This process shall be continued until adding another measure increases the life cycle cost compared to the basecase. The basecase for an existing home shall be the existing measures in the home. The basecase for a newly constructed home shall be the measures that are used to show compliance with the *2008 Building Energy Efficiency Standards*.

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[9] 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~~ a discount rate of 3 percent 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~~until the next measure increases the life-cycle cost above the original basecase. ~~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.~~ Note that some of the measures at the end of the process will have a benefit cost ratio of less than one. 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.

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9 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.

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 home buyer 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 example, 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 want certain measures to always be included in the recommendations, regardless of cost-effectiveness. Homeowners may also eliminate measures from consideration if they wish.one or more measures they prefer in combination with other measures that are determined to be cost-effective as a whole. This approach allows the homeowner to consider thermal comfort, amenity, property appreciation and other non-energy factors in the selection of a package of measures.

Homeowners may want specific energy efficiency measures or renewable energy systems to be included as a recommendation even though they may not be included in the package of measures determined to be cost-effective using the Standard Approach.

The Custom Approach can evaluate these strategies while varying all of the assumptions and parameters identified in Table 17 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 change in life-cycle cost method used for of the *2008 Title 24Building Eenergy Eefficiency Sstandards*.[10] 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

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

equation. If the change in 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 19

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

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

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 ($/(kBtu/year))
ΔTDV	reduction in TDV energy from implementation of the measure (kBtu/year)

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

6.3.2 Custom Approach

With the Custom Approach, a net zero cash flow method shall be used to determine cost-effectiveness of measures. 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. Measure cost-effectiveness is determined when the first year energy savings is equal to or greater than the additional mortgage payments with consideration of tax benefits and other factors relevant to the homeowner.

The following factors are used in the Custom Approach analysis and are constrained as follows:

- **Mortgage Rate and Term**. If the improvements are being financed, the actual interest rate and term of the financing shall be used to determine the incremental payment. The actual financial instrument may include utility funding programs or green financing programs. If the improvements are not being financed or actual financing terms have not been determined, a 30-year fixed term mortgage shall be assumed and the prevailing interest rate at the time of the rating shall be used. The HERS provider shall determine the prevailing interest rate and provide this information to the rater.
- **Homeowner Tax Bracket**. Since interest on mortgage payments could be a deductible expense, it reduces the federal and California taxable income of the homeowner, and this benefit shall be taken into account in the analysis, if known. If the identity of the homeowner or purchaser is known, the actual tax bracket of the homeowner or purchaser shall be used in

the analysis. If the rated home is new, or unoccupied, then the average income and tax bracket of California homeowners shall be used in the analysis. The HERS provider shall determine the average tax bracket and provide this information to the rater.

Institutional lenders may have programs to finance home energy efficiency improvements with terms or requirements that vary from the approach described in this section. HERS providers may use the rules and requirements of these lenders to establish the cost-effectiveness of measures, provided the same cost-effectiveness rules are used for all providers and raters.

~~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~~ or for other reasons, no utility rate is in effect, then the most common rate for homes in the area shall ~~may~~ be used. HERS providers shall determine the most common rate for the areas they serve and provide this information to the rater. ~~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~~ shall 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~~,~~. ~~f~~For example, no cooling measures would be included in the list of measures for homes that are not air-conditioned. The rater shall determine if the rated home is air-conditioned. If any air-conditioning equipment is observed by the rater, including window units, the rated home shall be assumed to be 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 the difference between the model results and the normalized energy consumption (from Inverse Modeling) is more than 30 percent, it is recommended that the rater interview the occupants to determine if life-style issues might explain the differences. Alternative modeling assumptions shall be based on information obtained through these interviews. 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 18 – 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~~Miscellaneous electricity consumption	The homeowner runs a catering operation from the kitchen.
~~Lifestyle patterns~~Hot water consumption	The home is occupied by an extended family. The family has a large number of teenagers.
Building shade	The home may be located in a dense urban setting where neighboring buildings shade the home or the home is beneath a mature and dense tree canopy.

6.6 Determining ~~Measures and~~ Costs for Measures 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 in consultation with the Energy Commission, 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 Rebates and/or Incentives

HERS providers may adjust measure costs to account for rebates or incentives provided by utilities or others, when the providers determine that the rebates or incentives will be stable for the period of time that the costs will be used, (for example, if the incentive is scheduled to phase out in a shorter period of time (such as three months), then the incentive or rebate would not be available for all homes). Such adjustments shall be consistent for all providers and raters.

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

The following database fields are required:

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

Replacement and Maintenance Costs

Measures costs 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 and Energy Commission staff 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.
- The cost of measures may be adjusted to consider rebates, product discounts, or other available financial incentives.

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~~ Recommendations for Measures That Do Not Affect the California HERS Index

6.7.1 Standard Approach

The process of determining cost-effectiveness described in the previous sections does not apply to measures that do not directly affect the California HERS Index.

Standard (non-customized) recommendations shall be provided for miscellaneous indoor energy uses, including major appliances other than refrigerators and dishwashers, and for ancillary energy uses outside the home, ~~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.~~ See Appendix B for the standard recommendations. These standard recommendations are based on good practice and/or low or no cost measures.

6.7.2 Customi~~zed~~ 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 ancillary energy uses not considered in the California HERS Index.

6.8 Energy Bill History

6.8.1 Standard Approach

The r~~R~~ater 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~~Energy Consumption Analysis report (see Chapter 2).

6.8.2 Custom Approach

The Custom Approach shall have the same~~Same~~ requirements as the Standard Approach, except that results of the Inverse Modeling may be used to "calibrate" the model (see Modeling Assumptions above).

6.9 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 shall~~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~~the *2008 Building Energy Efficiency Standards*. A California ~~Whole House~~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 the ~~Title 24, Part 6~~*2008 Building Energy Efficiency Standards*, 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~~Whole-House Home Energy Rater

A rater certified as a California ~~Whole House~~Whole-House Home Energy Rater may collect any data used to produce a California Home Energy Audit or a California ~~Whole House~~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 19. Only a person who is certified~~,~~ by a HERS provider~~,~~ as a California Home Energy Auditor or a California ~~Whole House~~Whole-House Home Energy Rater is permitted to collect this data to develop a California Home Energy Audit or a California ~~Whole House~~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 the ~~Title 24, Part 6~~*2008 Building Energy Efficiency Standards*, field verification and diagnostic testing measures as a HERS rater.

Table 19 – Data That May Only Be Field-Collected by a California Home Energy Auditor, California ~~Whole House~~Whole-House Home Energy Rater, or a California Field Verification and Diagnostic Testing Rater

ACM Section	ACM Title	Data to ~~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 Eneregy 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.~~

The HERS regulations recognize two types of raters: the Field Verification and Diagnostic Testing Rater and the California Whole-House Home Energy Rater. These raters perform entirely separate functions. The Field Verification ~~A~~and Diagnostic Testing Rater is involved in field verification and diagnostic testing for compliance with the *2008 Building Energy Efficiency Standards*. This rater function was established by the first phase of the HERS regulations. The California Whole-House Home Rater collects data on existing and newly constructed homes, analyzes this data and generates recommendations for improvements.

A California Home Energy Auditor is essentially the same as a California Whole-House Home Energy Rater. They both are required to meet the same training and certification requirements from the HERS provider and are subject to the same quality assurance procedures. A California Home Energy Audit is expected to be requested by people who may not wish to have a formal rating but want recommendations for cost-effective energy efficiency improvements. It is also anticipated that the certified auditor shall pay greater attention to occupant behavior when performing a California Home Energy Audit and making recommendations on energy efficiency measures. Any requirements and authority that apply to a California Whole-House Home Energy Rater also apply to a California Home Energy Auditor even when only the term California Whole-House Home Energy Rater is used.

A Building Performance Contractor is a California Whole-House Home Energy Rater who is also authorized to serve as a general or specialty contractor for performing energy efficiency improvements on the homes they rate, subject to the exception to Section 1673(i)(3) and the additional quality assurance requirements described in this Technical Manual and the HERS regulations.

Two specialized certifications apply to roles that are subordinate to the California Whole-House Home Energy Rater. Individuals with these certifications are not raters~~,~~, but can perform specific tasks that are a subset of the functions of a California Whole-House Home Energy Rater. The

California Home Energy Inspector can collect data on existing homes under the supervision of a California Whole-House Home Energy Rater. The California Home Energy Analyst can process data and analyze the performance of homes, also under the supervision of a California Whole-House Home Energy Rater.

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~~G) and (~~M~~P) of Section 1673(a)(1) of the HERS regulations with special emphasis on elements (H)~~-~~ and (K)-(M) 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 *2008 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 *2008 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 Whole-House Home Energy Rater

To be certified as a California Whole-House Home Energy Rater, an applicant shall demonstrate competence in all areas of Section 1673(a)(1) of the HERS regulations.

A California Whole-House Home Energy Rater is certified to gather information on the energy consuming features of a home, perform diagnostic testing at the home, evaluate the validity of that information, simulate and perform analysis for a Whole-House Home Energy Rating or a California Home Energy Audit using an Energy Commission-approved HERS rating software program to estimate the energy consumption of a home using the information gathered on site, and complete all of the cost-effectiveness evaluations described in Section 1672(d) of the HERS regulations. The California Whole-House Home Energy Rater can produce the Rating Certificate, or~~,~~ if acting as a California Home Energy Auditor, can produce a California Home Energy Audit Certificate. See Figure 1 and Figure 2.

8.1.3 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~~L) and (~~M~~P) of Section 1673(a)(1) of the HERS regulations.

A California Home Energy Inspector shall be directly supervised by a California ~~Whole House~~Whole-House Home Energy Rater ~~may~~ to collect on-site data used for the production of a California ~~Whole House~~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 19Table 18.

8.1.38.1.4 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 (JL)-(NP) of Section 1673(a)(1) of the HERS regulations. A California Home Energy Analyst shall also demonstrate in-depth competence in elements (G), (H), (I), and (LJ) of Section 1673(a)(1) of the HERS regulations.

Persons certified as a California Home Energy Analyst shall be directly supervised by a California Whole-House Home Energy Rater to use may complete a California Home Energy Audit or a California Whole House Home Energy Rating using Energy Commission-approved HERS rating software as long as they to complete the analysis of data used to determine the cost-effectiveness of improvements and/or a HERS Index scoreunder the direct supervision of a California Whole House Home Energy Rater. The analysis audit or rating shall be based either upon data collected from drawings and field verification and diagnostic testing report for a newly constructed home or collected at the site by either a California Whole HouseWhole-House Home Energy Rater, a California Home Energy Auditor, or a California Home Energy Inspector directly supervised by a California Whole HouseWhole-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 bBuilding pPerformance cContractor exception to Section 1673(i)(3) of the HERS regulations, 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) of the HERS regulations. 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~~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) of the HERS regulations. 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~~Whole-House Home Energy Rating. However, the Building Performance Contractor shall meet the requirements of Subsections 8.3.1 through 8.3.7specified herein.

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~~Whole-House Home Energy Rating. The ~~b~~Building ~~p~~Performance ~~c~~Contractor shall only issue an official California ~~Whole House~~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 ~~t~~Technical ~~m~~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 ~~b~~Building ~~p~~Performance ~~c~~Contractor.

8.3.2 Package of Improvements

The objective of the ~~b~~Building ~~p~~Performance ~~c~~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 ~~b~~Building ~~p~~Performance ~~c~~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 the ~~Title 24, Part 6~~*2008 Building Energy Efficiency Standards*. See Table 20 for examples.

Table 20 – Example Field Verification and Diagnostic Testing Required of the Building Performance Contractor (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~~Whole-House Home Energy Rating

Once the improvements are completed, the Building Performance Contractor shall perform an official California ~~Whole House~~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's package of improvements. Any work performed by the Building Performance Contractor that is normally subject to verification by a HERS rater under the ~~Title 24, Part 6~~*2008 Building Energy Efficiency Standards*, 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 the ~~these~~ HERS 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 Technical mManual.

8.3.7 Post RetrofitPost-Retrofit Utility Bill Analysis

Twelve months following implementation of the improvements, the Building Performance Contractor shall conduct a post retrofitpost-retrofit utility bill analysis as described in Chapter 5 of this Technical mManual. 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.

The purpose of this requirement is to estimate what the energy consumption would have been without the improvements (using the Inverse Model developed from pre-retrofit energy bills) and to compare these estimates to the actual post-retrofit energy consumption. In those instances where at least 12 months of data are not available for the rated house, before the improvements, this requirement is waived.

APPENDIX A

A. Data Input Requirements and On-Site Inspection Procedures for California HERS Ratings

A.1 Summary of HERS Model Data Inputs and Notes

3.2 General

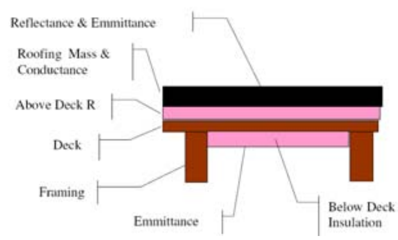
ACM Section	Data to Collect	Notes
3.2.1 Weather Data	**Climate Zone**	**Climate zone will be determined based on the city or zip code of the rated house**
3.2.2 Ground Reflectivity	**None**	**This is defaulted. No need for data input**
3.2.3 Building Physical Configuration	**None**	**See A.2 for guidelines on how to determine the different classes of exterior surfaces: wall adjacent to garage, floor over crawlspace, ceiling at attic, etc.**
Building Vintage	**Year of Construction**	**Title or deed document**
3.2.4 Thermostats	**Thermostat type**	**Rater should record the type of thermostat for information purposes only.**
3.2.5 Internal Gains	**None**	**No direct inputs; data is derived from the lighting and appliances model, the number of bedrooms and the floor area.**
3.2.6 Joint Appendix 4	**None**	**No direct inputs; data is derived from other inputs. Uninsulated wood framed walls and ceilings are modeled with a U factor of 0.25.**
3.2.7 Quality Insulation Installation	**None**	**Not generally applicable for existing insulation but could be applicable for major renovations, insulation retrofits, or newly constructed homes that are rated.**

3.3 Zone Level Data

ACM Section	Data to Collect	Notes
3.3.1 Building Zone Information	**Number of Stories** **Number of Bedrooms** **Conditioned floor area** **Conditioned volume**	**See Section A.2 for notes on determining conditioned floor area and volume**
	Free ventilation area **Ventilation height difference**	**Free ventilation area is determined from the types and sizes of windows specified and does not require direct input.** **Ventilation height difference is defaulted from the number of stories, but can be entered for special situations**
3.3.2 Thermal Mass	**Exposed slab area (%)**	**For floor surfaces, this will be determined from inputs to Section 3.6.1 (slab-on-grade).** **See A.2 for guidelines on determining exposed and covered slab areas.**
	UIMC and areas if high mass	**See A.2 for guidelines on determining the UIMC and area for non-slab mass surfaces.**
3.3.3 Infiltration	**Default**	**The default SLA depends on the presence of air distribution ducts.**
	Air retarding wrap	**See A.2 for procedures to determine the presence of a house wrap.**
	Reduced infiltration due to duct sealing	**See RA3 for a test protocol for sealing ducts.**
	Diagnostic testing for reduced infiltration – leakage rate in CFM	**See A.2 for a test protocol for measuring house leakage and SLA.**

3.4 Attics

ACM Section	Data to Collect	Notes
3.4.1 Roof Pitch and Attic Height	**Roof pitch (rise to run) of the dominant roof area**	**See A.2.**
3.4.2 Ceiling/Framing Assembly	**Choose an assembly from Joint Appendix 4**	**See A.2.**
3.4.3 Attic Ventilation	**Free ventilation area** **Fraction located high in attic**	**See A.2.**
3.4.4 Roof Deck	**Solar reflectance and emittance**	**See A.2.**
	Roofing type	
	Above deck insulation	
	Above deck mass	
	Framing members below deck insulation	
	Insulation below deck	
	Radiant barrier	



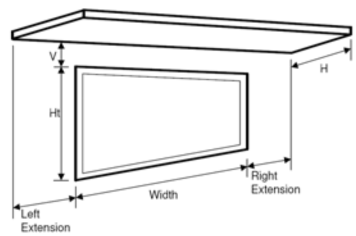
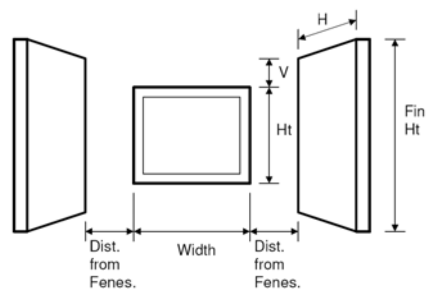
3.5 Exterior Surfaces Other Than Attics

ACM Section	Data to Collect	Notes
3.5.1 Non-Attic Ceiling and Roof Constructions	**Surface area, orientation and tilt** **Choose an assembly from Joint Appendix 4** **Quality insulation installation (Yes/No)**	**See A.2.**
3.5.2 Exterior Walls	**Surface area and orientation** **Choose an assembly from Joint Appendix 4** **Quality insulation installation (Yes/No)**	**See A.2.**
3.5.3 Basement Walls and Floors	**Surface area 0-2 ft below grade** **Surface area 2-6 ft** **Surface area >6 ft** **Choose an assembly from Joint Appendix 4**	**See A.2.**
3.5.4 Raised Floors	**Surface area over crawlspace/basement** **Surface area over exterior** **Surface area over garage** **Choose an assembly from Joint Appendix 4** **Quality insulation installation (Yes/No)**	**See A.2.**

3.6 Slabs-on-Grade

ACM Section	Data to Collect	Notes
3.6.1 Inputs for Proposed Design and Standard Design	**Area slab perimeter, carpeted** **Area slab perimeter, exposed** **Area slab interior, carpeted** **Area slab interior, exposed** **Perimeter insulation R-value and depth**	**See A.2.**

3.7 Fenestration and Doors

ACM Section	Data to Collect	Notes
3.7.1 Doors	**Area** **Orientation** **NFRC U factor if available or** **Choice from Joint Appendix 4**	**See A.2.**
3.7.2 Fenestration Types and Areas	**Area** **Orientation (or parent surface)**	**See A.2.**
	U-factor **SHGC**	**See A.2.**
3.7.3 Overhangs and Sidefins	**Overhang (see Figure R3-4)** • **Window height** • **Window width** • **Distance above window** • **Right extension** • **Left extension**	**See A.2.** 
	Sidefin (see Figure R3-5) • **Window height** • **Distance from fenestration** • **Fin height** • **Fin projection** • **Distance from window top to fin top**	**See A.2.** 
3.7.4 Interior Shading Devices	**None**	**Use default**
3.7.5 Exterior Shading Devices	**Default or choice from Table R3-28**	

3.8 Inter-Zone Transfer

ACM Section	Data to Collect	Notes
3.8.1 Inter-Zone Surfaces Reporting Requirements for CF-1R	**Surface type** **Surface area** **Choice from Joint Appendix 4**	
3.8.2 Inter-Zone Ventilation	**Natural** • **inlet and outlet areas** • **inlet/outlet height difference** **Fan** • **fan W and** • **fan cfm**	

3.9 HVAC System Overview

ACM Section	Data to Collect	Notes
3.9.1 System Type	**Data is needed to establish the reference building system. This will likely be available from other inputs.**	**See A.2.**
3.9.2 Multiple System Types	**The user will need to either create a separate zone for each system or assign floor area to each system so that loads may be prorated.**	**See A.2.**

3.10 Heating Systems

ACM Section	Data to Collect	Notes
3.10.1 Proposed Design	**Choose from R3-32**	**See A.2.**
3.10.3 Heating System Calculations	**AFUE or HSPF for heat pump**	**See A.2.**

3.11 Cooling Systems

ACM Section	Data to Collect	Notes
3.11.1 Proposed Design	**Choose from R3-33**	**See A.2.**
3.11.3 Refrigerant Charge or Charge Indicator Light	**For split systems only, choose none, charge or light**	**See A.2 and RA3.**
3.11.4 Maximum Cooling Capacity Credit	**Choose yes or no**	**See A.2 and RA3. Applies only to new systems and to new homes.**
3.11.5 Adequate Airflow	**Choose yes or no if not measured**	**See A.2.**
3.11.6 Fan Energy	**Default or measured fan Watt draw and airflow W/cfm <0.80**	**See A.2 and RA3.**
3.11.7 Cooling System Calculations	**SEER or EER if available**	**See 3.11.4.**

3.12 Air Distribution Systems

ACM Section	Data to Collect	Notes
3.12.1 Air Distribution Ducts.	**Choice from ACM Table R-3.34.**	**See A.2.**
3.12.3 Special Credit	**Duct location** **Return duct location** **Supply duct location** **Duct surface area**	**See A.2 and RA3.**
3.12.4 Duct System Insulation	**Effective R-value** **Buried attic ducts** **Buried ducts on the ceiling** **Deeply buried ducts**	**See A.2 and RA3.**
3.12.5 Duct/Air Handler Leakage	**Low leakage air handler – Yes/No** **Verified low leakage ducts in conditioned space – Yes/No** **Verified sealed and tested ducts**	**See A.2 and RA3.**
3.12.9 Calculation of Duct Zone Temperatures for Multiple Locations	**Duct surface area at each location**	**See A.2 and RA3.**

3.13 Mechanical Ventilation

ACM Section	Data to Collect	Notes
3.13.1 Proposed Design	**None** **Continuous air flow (CFM)** **Stand-alone IAQ fan power (Watts)** **Central air handler air flow in ventilation mode (CFM) and fan power in ventilation mode (Watts)**	**See A.2.**

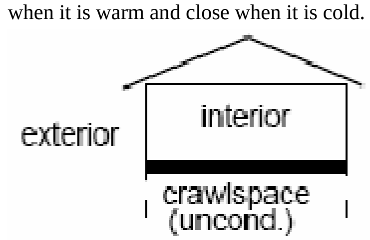
3.14 Special Systems

ACM Section	Data to Collect	Notes
3.14 - Hydronic Distribution Systems and Terminals	**Pipe run** **Nominal pipe size** **Insulation thickness or R-value**	**See A.2.**

3.15 Water Heating

ACM Section	Data to Collect	Notes
3.15.1 Water Heating	**For most systems** • **Water heater type** • **Energy factor** • **Distribution system and characteristics**	**See A.2.**
	For less common systems, additional inputs would be required for: • **Solar system** • **Large storage water heaters** • **Circulation pumps and controls**	**See A.2 and RACM Appendix E.**

A.2 On-Site Inspection Protocols[1]

ACM Section	Task	On-Site Inspection Protocol
3.3.1 Building Zone Information	Determine number of stories and bedrooms	Record the number of stories of the house as defined by the *California Building Code*.
	Determine number of bedrooms	Record the number of bedrooms in the house. Bedroom: any space in the conditioned area of a dwelling unit or accessory structure which is 70 square feet and greater in size and which is located along an exterior wall, but not including the following: hall; bathroom; kitchen; living room (maximum of one per dwelling unit); dining room (in proximity to kitchen, maximum of one per dwelling unit); family room (maximum of one per dwelling unit), laundry room, closet/dressing room opening off of a bedroom. A bedroom must have a window with minimum dimensions for egress and a door that closes.
	Measure floor dimensions	Measure floor dimensions in accordance with ANSI Z765-2003. For conditioned basements and crawl spaces, find dimensions of basement walls and floor. Divide walls into above and below grade sections. Measure the floor to the nearest inch, and record the square footage to the nearest square foot. Use exterior measurements; those measurements should start at the exterior finished surface of the outside wall. Openings to the floor below should not be included in the square footage calculation, with the exception of stairways; stairways and associated landings are counted as square footage on both the starting and ending levels. Do not include the "footprint" of protruding chimneys or bay windows. Do include the "footprint" of other protrusions like a cantilever when it includes finished floor area. Do include the square footage of separate finished areas that are connected to the main body of the house by conditioned hallways or stairways.
	Determine conditioned volume of space	Determine conditioned and indirectly conditioned volume of space by multiplying conditioned floor area by ceiling height. The house may need to be split into different spaces with different ceiling heights and added to each other for both conditioned and indirectly conditioned spaces. For areas with vaulted ceilings, volume must be calculated geometrically.
	Identify Crawlspaces	A crawl space is typically defined as a foundation condition with a clear vertical dimension 4 feet high or less. Crawl spaces are either vented or have controlled ventilation as described in the 2008 Residential ACM Manual.. **Vented crawl spaces** have some form of vent or louver in the crawl space walls, or are constructed in such a manner so that air moves freely from outside the walls to inside the crawl space. **Controlled ventilation crawl** spaces have insulation installed in the side walls of the crawlspace, instead of in the floor, which separates conditioned space from the crawlspace. In addition, special dampers in the foundation vents are installed that are used to provide the required ventilation for the crawlspace, which automatically open when it is warm and close when it is cold. 

[1] Adapted from National Home Energy Rating Technical Guidelines, December 28, 2005, Appendix A, On-Site Inspection Procedures for Minimum Rated Features, which was excerpted from: Guidelines for Uniformity: Voluntary Procedures for Home Energy Ratings, Version 2.0, Home Energy Rating Systems Council (HERSC), August 1996.

ACM Section	Task	On-Site Inspection Protocol
	Determine whether basement is unconditioned or directly or indirectly conditioned.	A full basement has characteristics similar to an unvented crawl space, except that the clear vertical dimension is typically greater than 4 feet. Stairs that lead from the main floor to a below grade space are an indication of a basement in a house. To determine whether a basement is conditioned, assess the insulation placement in the walls or floor/ceiling assembly. A basement may be considered either unconditioned or directly or indirectly conditioned based on the following criteria: • **Unconditioned** -The basement is not intentionally heated or cooled and the floor/ceiling assembly between the basement and the conditioned space above is insulated, Typically, any heating or plumbing distribution systems in the space is insulated. • **Conditioned, directly or indirectly** – Either the basement is intentionally heated and/or cooled or the floor/ceiling assembly between the basement and the conditioned space above is uninsulated. Foundation walls are insulated or uninsulated. If the basement is either directly or indirectly conditioned, then it shall be considered part of the conditioned floor area and volume of the house.
3.3.2 Thermal Mass	General	Thermal mass systems consist of solar-exposed heavyweight materials with high heat capacitance and relatively high conductance (high thermal diffusivity) such as masonry, brick, concrete, tile, stone. These elements may be integral with the building or distinct elements within the building. “Heavy” mass includes elements such as concrete slab floors, masonry walls, double gypsum board, Trombé walls and other special mass elements. A building is considered to have a high thermal mass if it: has mass equivalent to 30% of the conditioned slab floor area being exposed slab and 70% slab covered by carpet or casework, and 15% of the conditioned non-slab floor area being exposed with two inch thick concrete with the remainder low-mass wood construction.
	Determine the inside surface condition of slab on grade floors (exposed or covered)	For slabs on grade, determine the percentage that is exposed and covered. Exposed slabs provide more effective thermal mass. • **Covered** -If floor is covered with wall-to-wall carpet, consider it covered. Floors with only area rugs are not considered covered. The default is 80% covered. • **Exposed** -If the floor has tile, linoleum or wood, consider it exposed. The default is 20% exposed. In special circumstances, the determination may be made separately for the perimeter portion of the slab and the interior portion. The perimeter is that portion within 2 ft from the exterior wall.
	Determine the Interior Mass Capacity for other (non-slab) mass elements	Other features or components of the home can increase the thermal mass. These include concrete toppings on raised floors, double drywall or thick plaster finishes, tile set in mortar, and interior mass walls. The mass contribution of these additional mass elements may be accounted for using Interior Mass Capacity method from Standards Reference Appendix RA5. Using this approach, identify the surface area of all qualifying mass elements from RA5. The interior mass capacity (IMC) is the sum of the product of the assembly areas and UIMC.
3.3.3 Natural Ventilation and Infiltration	Determine Natural Ventilation Area	The default assumption is that all windows are sliders and that they have a free ventilation area equal to 10% of their total rough opening area. If a large fraction of hinged windows are used, then the areas of the three basic window types, slider, fixed, and hinged should be determined and entered into the HERS software tool to account for larger free ventilation area and take advantage of the natural ventilation cooling calculated in the software.
	Determine Ventilation Height Difference	The default assumption for the proposed design is 2 ft for one story buildings and 8 ft for two or more stories. Greater height differences may be used with special ventilation features such as high, operable clerestory windows. In this case, the height difference entered by the user is the height between the average center height of the lower operable windows and the average center height of the upper operable windows.
	Determine presence of air retarding wrap	For newly constructed buildings, determine whether or not an air retarding wrap is present. An air retarding wrap must meet specifications of ASTM E1677-95, Standard Specification for an Air Retarder (AR) Material or system for Low-Rise Framed Building Walls, and have a minimum perm rating of 10. Polymer-based housewraps are available that meet the minimum perm requirement. Building paper that is used as a weather resistive barrier will not meet this requirement. For recently constructed buildings, the presence of an air retarding wrap should be documented on the special features section of the CF-1R form.
	Determine presence of sealed ducts	A credit for reduced infiltration may also be taken for sealed and tested ducts for ducted systems. Refer to the test procedure in Reference Appendix RA3-2008 for measurement of duct leakage. For reduced infiltration credit for existing duct systems, duct leakage must be tested and be at or below 6% of total fan flow. This credit may also be taken for recently sealed duct systems if the documentation for the duct sealing by a HERS rater indicates that the duct leakage is 6% or less of total fan flow.

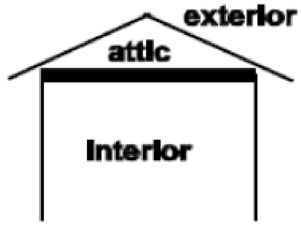
<table>
<tr><th>ACM Section</th><th>Task</th><th>On-Site Inspection Protocol</th></tr>
<tr><td></td><td>Determine specific leakage area from a blower door test</td><td>Credit for reduced air infiltration may be taken by using the testing protocol described in ASTM E 779-03, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization</td></tr>
<tr><td>3.4.1 Roof Pitch and Attic Geometry</td><td>Determine roof pitch</td><td>Roof pitch: rise over run (as in 4:12). One approximate method of measuring the pitch is with a level. The measurements are taken from on top of the roof. Simply mark a level at 12", hold it perfectly level and measure from the roof surface to your 12" mark, this will give you the rise. Be careful with this method as a roof with many layers of shingles, or any type of roofing that is irregular can give you less than precise results.

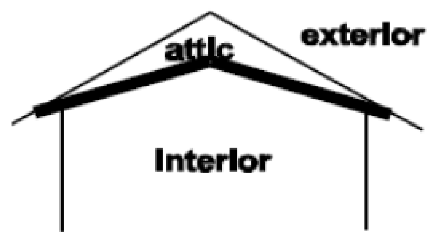
A more accurate method is to measure the pitch from the underside of the rafters. To use this method there are 3 possible places to take your measurements: the underside of a barge rafter on a gable end, the underside of a rafter on an overhang at the bottom of the roof, or the underside of a rafter in the attic.

Another alternative is to use a framing square. Point the long end of the L towards the roof and the short end towards the ground. Position the framing square so that the long end hits the roof at the 12 inch mark. Level the square horizontally and measure the vertical rise (the short leg) in inches.

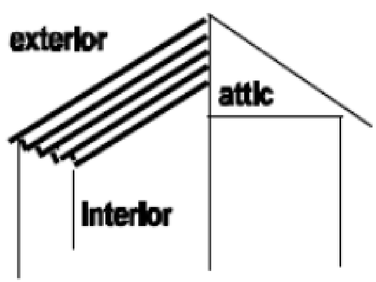
A carpenter's "square" has a first member with a level so it can be held horizontal with one end elevated above a pitched roof, while the opposite end rests on the roof exactly 12 inches from the inside edge of a vertically movable member supported in the first member, and clamped to it by a thumb screw. This inside edge is graduated inches to read out roof pitch directly in "inches per foot".</td></tr>
<tr><td>3.4.2 Ceiling/Framing Assembly</td><td>Measure the area of all ceiling surfaces</td><td>Measure the linear perimeter dimensions of the ceiling area to the nearest ½ foot and use these measurements to calculate surface area of the ceiling. If a ceiling area is vaulted, it may be necessary to calculate dimensions geometrically. Identify the ceiling as: next to attic, exposed beams or rafters, or finished framed ceiling. See the descriptions below:

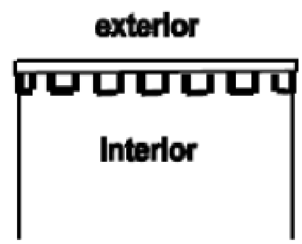
Ceiling next to attic - If the ceiling has attic space above (even if the ceiling is vaulted, as in a scissor truss) it is considered a ceiling next to attic. If there is a vaulted ceiling check its angle against the angle of the roof -- if the ceiling angle is gentler there is attic space above the ceiling. Also check for an attic access, either separate or from an attic over another part of the house.



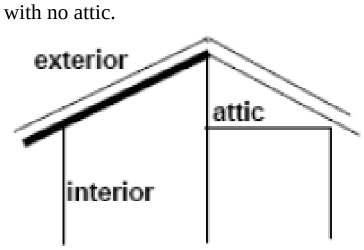


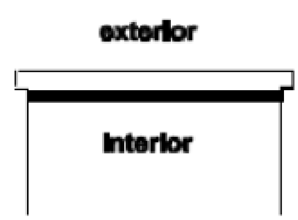
Exposed beams or rafters - when you look up from inside the room, you will see exposed beams or rafters.





Finished framed ceiling with no attic -if the ceiling is framed (has no attic space above it, but you cannot see the rafters because the ceiling is finished with drywall, plaster, paneling, etc.) consider it a finished framed ceiling with no attic.





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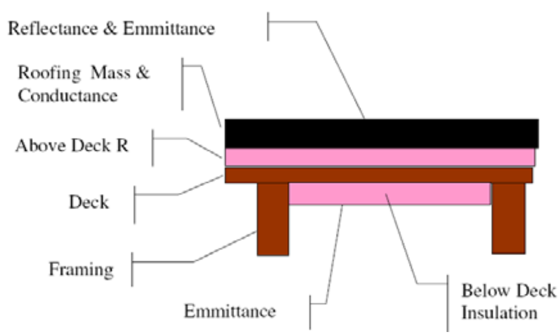
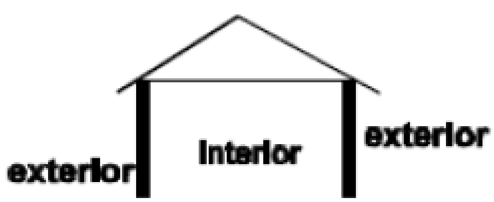
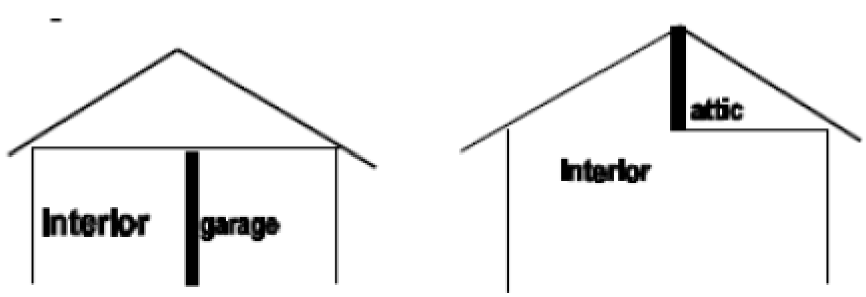
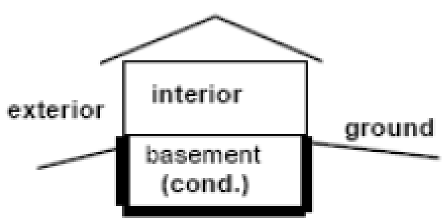
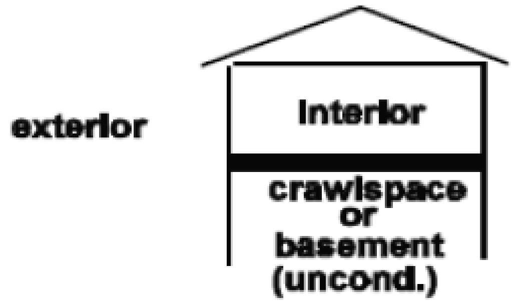
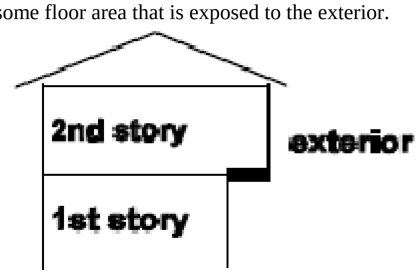
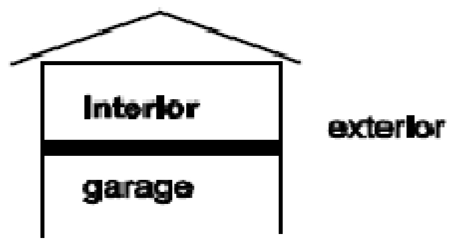
</table>

ACM Section	Task	On-Site Inspection Protocol
3.4.2 Ceiling/Framing Assembly	Determine R-value of the ceiling insulation	To determine the insulation R-value which exists in the ceiling area (cavity): • Measure the depth of the insulation in four places and take the average; if the depth in one section of the attic is different by 2 inches or more than other areas, measure the depth for the areas separately or use the least depth for the whole attic; • Determine the type of ceiling insulation present (may be a combination of more than one type); • Multiply the R-value per inch of the material by the depth of the insulation; Use an R-value per inch of 3.85 for fiberglass blankets or batts, 3.41 for loose-fill cellulose, 2.13 for vermiculite, 3.85 for expanded polystyrene (EPS) rigid boards. Use R-11 for 3.75-5 inches of mineral fiber (rock, slag or glass), R-19 for 6.5 to 8.75 inches of mineral fiber, R-22 for 7.5 to 10 inches, and R-30 for 10.25 inches or greater.
	Determine the type and spacing of the framing	Determine the framing member type and spacing for framed ceilings exposed to unconditioned spaces. Check the framing by looking from the attic access or by looking at the rafters from the outside where they protrude from the eave.
	Select Construction from Joint Appendix 4	Select the U-factor from the Table 4.2.1 or Table 4.2.4 of Reference Appendix JA4 that corresponds to the framing size and spacing and insulation level in the attic. In most cases, a value will be chosen from column A of the table. If there is no access to the framed ceiling, ask the customer for documentation of insulation or use a default value based on age based on Table 3-50 of the Residential ACM Manual.
	Determine Insulation Quality	A credit is offered in the HERS software for ceiling, wall, and floor assemblies that meet the insulation quality standards. Determine the insulation installation quality meets the requirements of Reference Appendix RA3-2008, section 3.5. To qualify for the Insulation Quality Standards credit ALL insulation in ceilings, walls, and raised floors must meet the insulation quality requirements. Generally this credit cannot be taken separately for walls, ceilings, or raised floors nor for parts of walls, ceilings, or raised floors.
3.4.3 Attic Ventilation	Determine the free ventilation area	Ventilation area: free ventilation area / attic floor area (ex: 1/300). Measure the area of each ventilation grille and assume that 60% of the area of the grille is free ventilation area for 3/8ths inch mesh. Note that newly installed soffit vents must meet California Fire Code requirements in Wildland Urban Interface areas and will have smaller free ventilation area factors. Divide the total free ventilation area by the floor area of the attic.
	Determine the percent of ventilation area located high	Fraction ventilation high – the fraction of the free ventilation area that is located high in the attic due to the presence of ridge, roof or gable end mounted vents. Ventilation is considered high if it is within 2 feet of the highest point in the attic. Soffit vents are considered low ventilation.
3.4.4 Roof Deck above Attic		
	Determine solar reflectance and emittance	For asphalt shingles or composition shingles, the default aged solar reflectance is 0.08. The default aged solar reflectance for other roofing materials is 0.10. The default emittance for all materials except unpainted metal roofing is 0.85. For products rated by the CRRC, the aged reflectance and emittance shall be used. If the aged reflectance is not available from the CRRC, it shall be estimated by multiplying the initial reflectance by 0.70 and adding 0.06. The aged emittance shall be equal to the initial emittance. For existing homes, the solar reflectance is assumed to be one of the default values unless it is measured. The solar reflectance can be measured for low-sloped surfaces using a pyranometer, following the ASTM E1918-06 Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field.
	Determine the roof type	Identify the type of roofing surface. The user chooses from: concrete or clay tile; metal tile or wood shakes; other high slope roofing types (including asphalt and composite shingles and tapered cedar shingles); or low slope membranes (a rise to run ratio of 2:12 or less).

ACM Section	Task	On-Site Inspection Protocol
	Determine above deck insulation	Above deck R-value – R-value of insulation above the roof deck (the default is no insulation) Use the R-value per inch times the thickness of the rigid insulation installed.
	Determine roof mass	Roofing mass – choose from: normal gravel, concrete tile, heavy ballast or pavers, very heavy ballast or pavers, or all other roofing.
	Determine depth of framing	Frame depth – depth of framing attached to the roof deck
	Check for radiant barrier	Radiant barrier – whether or not a radiant barrier is present (Yes/No)
	Determine below deck insulation	Below deck R – R-value of the insulation at the bottom of the roof deck between the framing
	Determine roof deck framing spacing	The roof deck framing is either 24” o.c. or 16” o.c.
	Check insulation installation quality	Insulation installation quality – determine if the ceiling insulation meets the quality installation requirements in Reference Appendix RA3, section RA3.5. To qualify for the Insulation Quality Standards credit, ALL insulation in ceilings, walls, and raised floors must meet the insulation quality requirements. Generally this credit cannot be taken separately for walls, ceilings, or raised floors nor for parts of walls, ceilings, or raised floors.
	Check ceiling framing	The ceiling framing is either 24” o.c. or 16” o.c.
3.5.1 Non-Attic Ceiling and Roof Constructions	Determine surface area	Determine the surface area of the ceiling in the same manner as in section 3.4.2.
	Determine orientation and tilt	Determine the orientation by taking a compass reading (adjusted for magnetic deviation) in the direction toward which the roof surface faces. Determine the roof pitch (such as 4:12) by the procedures in section 3.4.1.
	Determine the assembly U-factor	Determine the assembly U-factor by measuring the depth of the insulation and the framing thickness. Assume an R-value per inch of 3.85 for fiberglass, 3.41 for cellulose, 3.85 for rigid expanded polystyrene (EPS), 6.25 for rigid polyisocyanurate insulation, 2.13 for vermiculite. Lookup the assembly U-factor in Table 4.2.2 of Reference Appendix JA4 for wood-framed rafter roofs, Table 4.2.3 for SIP (foam core panel) roofs, Table 4.2.5 for metal framed rafter roofs.
	Check insulation installation quality	Insulation installation quality – determine if the insulation meets the quality installation requirements in Reference Appendix RA3, section RA3.5 or JA7 for foam installation. To qualify for the Insulation Quality Standards credit, ALL insulation in ceilings, walls, and raised floors must meet the insulation quality requirements. Generally this credit cannot be taken separately for walls, ceilings, or raised floors nor for parts of walls, ceilings, or raised floors.
3.5.2 Exterior Walls	Determine whether walls border exterior space, attic, garage or crawl space	Wall to exterior -Walls border exterior space.  Wall to enclosed unconditioned space -Walls that border unconditioned attics, garages and crawl spaces. 

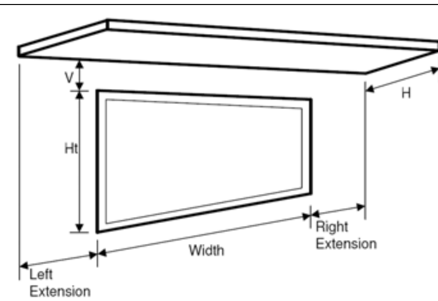
ACM Section	Task	On-Site Inspection Protocol
	Determine wall orientation	Determine the orientation of each exterior wall using a compass adjusted for magnetic deviation.
	Determine surface area of all walls exposed to unconditioned space	Measure linear perimeter of the walls to the nearest ½ foot. Measure the interior wall height of the walls to the nearest 1/4 foot. Use these measurements to calculate surface area. Exclude surface area of any windows (including the window frame) when making the wall area measurement.
	Determine the structural system of walls	Wood framing -is very common in residential construction. Wood studs are located 16" or 24" on center all along the wall. Knocking on the wall will give a "hollow" sound in the cavities between the studs and a "solid" sound at the stud locations. Metal framing -can be found in some newer residential construction. A strong magnet slid against the wall will hold to metal framing. Also check inside the attic at the edges for evidence of metal wall framing. Masonry walls - include walls constructed of concrete or brick. A wood framed wall with brick veneer would not be considered a masonry wall. Also note insulated siding or insulated finish materials on the wall. Foam core walls (SIPs) - are a sandwich panel consisting of a foam center with outer layers of structural sheathing, gypsum board or outer finish materials. Foam core panels may be structural (load bearing) or non-structural. Non-structural panels are frequently used in post and beam construction. Log walls - are typically solid wood walls, using either milled or rough logs or solid timbers. Some homes may have the appearance of solid log walls, yet may actually be wood frame walls with siding that looks like solid logs inside and out. Some log walls are manufactured with insulated cores. Unless manufacturer's documentation is available or visual inspection of insulation type and thickness can be made, assume no added insulation exists in a log wall.
	Determine framing member size for all framed walls exposed to unconditioned space	To determine whether 2x4 or 2x6 framing exists: Measure the depth of the window jambs; Subtract the thicknesses of the wall coverings and sheathing materials (approximately .25" to 1.0" for stucco, .5" to .6" for interior sheetrock, and .5" to .75" for other exterior siding materials); Compare the remaining width to 3.5" for a 2x4 wall or 5.5" for a 2x6 wall; If exposed garage walls exist, examine them for reference (although they will not always be the same as other walls); If a wall does not come close to the framing width of a 2x4 or 2x6, inspect for foam sheathing on the inside or outside of the walls. In super-insulated construction, "double stud," or "strapped" walls may account for thickness greater than 5.5 inches. For brick veneer walls, assume 4.5" - 5" for brick, airspace and sheathing material. Check the framing member size on all sides of the house. If an addition has been added, be sure to check the walls of the addition separately. If the house has more than one story, check the framing member size for each floor.
	Determine type and thickness of existing insulation and resultant U-factor	**Framed Walls** Check at plumbing outlet under sink or, in order of preference, remove cable outlet plate, telephone plate, electrical switch plates and/or electrical outlet plates on exterior walls. Probe the cavity around the exposed plate with a non-metal device (such as a plastic crochet hook or wooden skewer). Determine type of insulation (fiberglass, cellulose insulation, foam, etc.). Inspect outlets/switch plates on each side of the house to verify that all walls are insulated. For wood framed walls, determine the U-factor based on the insulation level (batt or foamed) and the presence of insulated sheathing, as documented in Table 4.3.1 of Reference Appendix JA4. In most cases, a value will be chosen from column A of this table. For metal framed walls, select a U-factor corresponding to the assembly framing thickness, cavity and continuous insulation levels and framing spacing from Table 4.3.4 of Reference Appendix JA4. For foam core walls (SIPs), select a U-factor corresponding to the appropriate assembly in Table 4.3.2 of Reference Appendix JA4. The value is chosen based on the insulation level of the core. Values are presented for both EPS (expanded polystyrene panels) and polyiso (polyisocyanurate) panels. (Assume an insulation R-value per inch of 3.85 for EPS. For polyiso core panels, insulation R-values of R-26 and R-40 are present for 4.5” and 6.5” panels, respectively.) For log walls, select a U-factor based on the log thickness from Table 4.3.11 of Reference Appendix JA4. Parts of the house that were added later must be checked separately from the original walls. **Sheathing** Insulated sheathing may exist on walls, but can be difficult to verify. Walls with insulated sheathing may be thicker than walls without insulated sheathing. Visual verification of insulated sheathing may be found in the attic at the top of the wall, exterior wall penetrations, and at the connection between the foundation and the wall. Determine the thickness of the sheathing and resulting R-value, and use this with the cavity insulation R-value to determine the assembly U-factor from the Tables in Reference Appendix JA4.

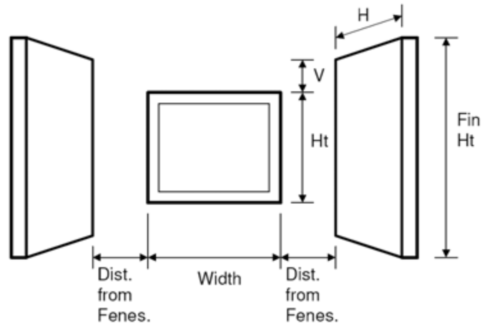
ACM Section	Task	On-Site Inspection Protocol
	Determine insulation value	The rim joist is installed around the perimeter of the floor joists over a basement or crawl space, or between 2 stories of a house. **Crawl space or Basement** From the basement or crawl space, visually identify and measure the depth of insulation at the rim joist. The insulation used is generally fiberglass batts, often folded in an L-shape and attached to the rim joist. Rigid board insulation may also be found. Insulation value **Between Stories** Look for access to the area from a garage or a utility access trap door. Visually identify and measure insulation if it exists. If no access can be found, assume insulation exists at the rim joist between stories if insulation was found at the rim joist at the top of the crawl space or basement in the same house. Otherwise, assume no rim joist insulation exists.
	Check insulation installation quality	Insulation installation quality – determine if the insulation meets the quality installation requirements in Reference Appendix RA3, section RA3.5 or JA7 for foam insulation. To qualify for the Insulation Quality Standards credit, ALL insulation in ceilings, walls, and raised floors must meet the insulation quality requirements. Generally this credit cannot be taken separately for walls, ceilings, or raised floors nor for parts of walls, ceilings, or raised floors.
	Determine type and thickness of all mass walls	If the dwelling's walls are constructed of concrete, masonry or brick, determine their type and thickness. Solid concrete walls (poured) – Determine the U-factor based on Table 4.3.6, row 5 of Reference Appendix JA4. Measure the thickness of the poured concrete wall in inches. Concrete Masonry Unit – Determine the U-factor based on the wall thickness and the density (105 lb/ft^3 for lightweight CMU, 115 lb/ft^3 for medium-weight CMU and 125 lb/ft^3 for heavyweight CMU) from Table 4.3.6 of Reference Appendix JA4. Cinder block or uninsulated concrete wall - hollow in the middle. Determine the U-factor based on Table 4.3.5 of Reference Appendix JA4. Check for additional insulation (interior furring, foam board, foam fill). Since grouting cells affects thermal performance, data is provided for three cases: where every cell is grouted (Column A), where the cells are partially grouted and the remaining cells are left empty (Column B), and where the cells are partially grouted and the remaining cells are filled with perlite or some other insulating material (Column C). Measure the thickness of the wall in inches. If interior furring insulation is present, look up the effective R value from Table 4.3.13 of Reference Appendix JA4. Use the equation 4-1 from JA4 to add the effective R-value of the interior/exterior furring to the U-factor.
3.5.3 Basement Walls and Floors	Determine area of basement walls	Portions of basement walls above grade shall be considered conventional above-grade walls. For below-grade basement walls, measure the area at each of three depth ranges: from zero to 2 feet below grade (shallow), greater than 2 feet to 6 feet below grade (medium), and greater than 6 feet below grade (deep).
	Determine insulation in walls and floor of conditioned basement or crawl space	If basement or crawl space is determined to be conditioned, its walls and floor are considered part of the building envelope. (The floor between the house's ground floor and the basement or crawl space is considered an interior boundary with no associated heat transfer calculated.)  Determine insulation type, thickness and R-value in walls. Wall insulation may be located inside foundation wall (studs and batts, foam under drywall, etc.), integral with foundation wall (insulated cores of block wall, insulating concrete block such as insulating formwork) or outside the foundation wall (rigid foam insulation). Choose a U-factor for the basement floor from Reference Appendix JA4. Select a U-factor that is appropriate for the basement wall construction from Tables 4.3.5 or 4.3.6, and noting any additional interior or exterior insulation. If exterior insulation is added to the foundation wall, equation 4-4 and 4-5 from Reference Appendix JA4 are used to determine the total U-factor and C-factor.

<table>
<tr><th>ACM Section</th><th>Task</th><th>On-Site Inspection Protocol</th></tr>
<tr><td>3.5.4 Raised Floors</td><td>Measure floor area over crawlspace</td><td>Measure the floor area over a crawlspace or basement to the nearest square foot.

</td></tr>
<tr><td></td><td>Measure floor area over exterior space</td><td>Measure the floor area that borders exterior unenclosed space above grade which is considered floor to exterior. For example, in a two story house, the second story may extend horizontally further than the first story, creating some floor area that is exposed to the exterior.

</td></tr>
<tr><td></td><td>Measure floor area over unconditioned garage</td><td>Measure floor area over an unconditioned garage.

</td></tr>
<tr><td></td><td>Determine floor insulation level and U-factor</td><td>For loose fill applications, multiply the thickness of the insulation (in inches) by the R-value per inch based on the insulation type in order to calculate the total existing floor insulation R-value. Also note if any exterior sheathing insulation exists. For raised floors over an unconditioned crawlspace, choose a U-factor from Table 4.4.1 of Reference Appendix JA4 based on the insulation R-value and framing thickness. For framed floors without a crawlspace, choose a U-factor from Table 4.4.2 of JA4.</td></tr>
<tr><td></td><td>Check insulation installation quality</td><td>Insulation installation quality – determine if the insulation meets the quality installation requirements in Reference Appendix RA3, section RA3.5 or JA7 for foam installation. To qualify for the Insulation Quality Standards credit ALL insulation in ceilings, walls, and raised floors must meet the insulation quality requirements. Generally this credit cannot be taken separately for walls, ceilings, or raised floors nor for parts of walls, ceilings, or raised floors.</td></tr>
<tr><td>3.6 Slabs-on-Grade</td><td>Identify slab on grade foundation</td><td>A slab on grade is constructed by pouring a concrete slab directly on the ground as the floor for the house.

</td></tr>
</table>

ACM Section	Task	On-Site Inspection Protocol
	Identify walkout basement	A walkout basement, if fully conditioned, is typically considered partially slab on grade construction (where the floor level is above grade) and partially a basement (where the floor level is below grade). The area of the floor that is below grade is considered to be basement floor area and the area of the floor that is on grade is considered to be slab on grade floor area. The walls over the basement portion of the floor shall be considered basement walls and the walls above the slab on grade portion shall be considered ordinary exterior walls exposed to ambient air.
	Determine perimeter of slab foundation	Determine the perimeter of the slab foundation by measuring each dimension to the nearest ½ foot and adding them together. Note that in the case above the boundary between the slab on grade portion and the basement floor portion is NOT part of the slab on grade perimeter.
	Determine perimeter and interior areas that are exposed	Determine the area near the slab perimeter (within two feet of the exterior wall) that is carpeted and the area near the slab perimeter that is exposed. Determine the area of the interior that is carpeted and the area that is exposed slab. If no measurements are taken, the default assumption is that 80% of the perimeter and interior slab areas are carpeted or covered by casework and 20% of the area is exposed.
	Determine if slab perimeter insulation exists and determine insulation depth and R-value	If present, slab perimeter insulation is usually installed on the outside of the slab and extends both above and below grade. To identify slab perimeter insulation, look for a protective coating above grade as opposed to the usual exposed slab edge at any conditioned space(s). Determine the R-value of the insulation by multiplying the insulation thickness times the R-value per inch. For newly-constructed buildings, the insulation R-value that is stamped on the slab insulation may be visible. This will usually be listed as R-value per inch thickness. If the R-value is not shown, the installation contractor should provide verification of the insulation R-value. If the insulation is to be installed as part of the foundation form, the R-value should be verified prior to pouring concrete. If the R-value is not visible from the insulation, use 4.0 per inch for extruded polystyrene rigid boards and 6.8 per inch for rigid polyisocyanurate foam insulation (closed cell is assumed for slab edge insulation). For existing buildings, move a little bit of dirt away from an edge of the slab where conditioned space is located. If present, the rigid insulation around the perimeter of the slab may be seen. However, it may be difficult to visually verify the existence of slab perimeter insulation because of the protective covering which may be installed over the rigid insulation. Determine the slab insulation depth. Perimeter insulation should extend downwards from the top of the slab to the top of the footing, and then may extend horizontally either inwards or outwards. Under slab insulation cannot be assumed to exist unless visually verified by a photograph of construction, at chase way, at sump opening or at plumbing penetrations.
3.7.1 Doors	Determine construction type of doors	Determine if the exterior door(s) is fiberglass, metal, or wood by making a close inspection of its texture, distinguishing the sound produced when knocking on it, and checking its side view.
	Determine orientation of doors	Measure the door orientation of each door with a compass (adjusted for magnetic deviation).
	Determine surface area of doors	Measure the surface area of the door(s) to the nearest ½ square foot. For doors with glass panes, measure the glass area including framing, and record the door opaque surface area as the total door area minus the glass area. For newly-constructed buildings, look for NFRC label values for U-factor and SHGC ratings for the entire door. If NFRC labels are not present use the values from Joint Appendix JA4, Table 4.5.1.
	Determine whether doors are insulated	Determine whether the exterior door(s) is insulated (or not) by its sound, temperature transfer, labeling, or thermal break. Sound - Insulated/solid door will sound dull when knocked on. An uninsulated/hollow door will sound hollow. Heat transfer - Feel the inside and outside of the door with flat palms. Insulated/solid door will less readily transfer heat. The inside will feel warmer in cold outside weather and cooler in hot outside weather than an uninsulated/hollow door. Labeling - Check the side view of the door at the hinges for a descriptive label.
	Determine door U-factor	Based on construction type and insulation, select a door U-factor from Table 4.5.1 of Reference Appendix JA4. For newly constructed buildings use values from NFRC labels or Table 4.5.1 of Reference Appendix JA4.
3.7.2 Fenestration Types and Areas	Determine area of windows	Measure the area of the window openings using width times height to the nearest inch. Estimate the width and height to represent the rough frame opening of the window. Typically this will be the outside dimensions of the frame plus an approximate ½ in. perimeter band.
	Determine orientation of windows	Use a compass (adjusting for magnetic deviation) to determine orientation of all windows. If a parcel map or site plan is available, orientations may be determined from the plans. Also specify the tilt of windows for windows that are not vertical.

ACM Section	Task	On-Site Inspection Protocol
	Determine window framing type	Examine each window frame in order to determine the type of material used. Open the window and examine it to see whether the frame is made of metal, wood, or vinyl. Tap the frame with fingernail or knuckle to test if it's vinyl or metal. Wood frames are usually thicker than metal. If the window is dual-pane or multiple-pane and is metal framed, determine if a thermal break is present by looking for two separated metal extrusions connected by a non-metallic (plastic, wood, or rubber) spacer. Ask the customer for documentation if you can't tell.
	Determine window glazing characteristics	Check all windows in the house for number of panes (single, double, or glass block) and existence of tint. To determine whether the windows are single-paned or multiple-paned: • Look at frame width and spacers; • Look at reflections; • Look at edge thickness. Determine the window type: • Operable • Fixed • Greenhouse/garden window Determine if the window has dividers between the panes of double pane glass or penetrating through the glass (true divided lites). Only dividers that are outside the glazing need not be assessed.
	Determine solar heat gain coefficient of glazing	Check product information and consult NFRC guide. If NFRC product information is not available, select a representative SHGC from Table 116-B of the Title 24 Standards based on the number of panes and the existence of a tint.
	Determine window U-factor	Look for an NFRC label on new windows (it will display the U-factor of the window including the frame). If no label can be found but customer has documentation, look up product information in NFRC Certified Products Directory to determine U-factor. If the product information cannot be found in the NFRC Certified Products Directory, select the U-factor from Table 116-A of the Title 24 Standards.
	Determine area of skylights	For skylights with a curb, measure the length and width of the skylight to the outside dimensions of the curb. For skylights without a curb, estimate the dimensions of the rough frame opening.
	Determine framing and glazing characteristics of skylights	See windows.
	Determine orientation of skylights.	Determine the orientation of the lower edge of the skylight. Use the outward horizontal direction perpendicular to the lower edge of the skylight as the orientation of the skylight.
	Determine tilt of skylights	Measure the tilt of the skylight relative to horizontal. This can be done with a level and angle finder instrument or geometrically with a protractor or assume the same tilt as the pitch of the roof where the skylight is installed.
	Determine skylight U-factor	See windows
	Determine solar heat gain coefficient of skylights	See windows
3.7.3 Overhangs and Sidefins	Determine overhang dimensions	• Window height (H) – the height of the window • Window width – the width of the window • Distance above window(V) – the vertical distance between the top of the window and the bottom edge of the overhang • Right extension – the horizontal distance between the right edge of the window and the edge of the overhang • Left extension – the horizontal distance between the left edge of the window and the edge of the overhang 

ACM Section	Task	On-Site Inspection Protocol
	Determine sidefin dimensions (including walls at right angles to the window)	• Window height (Ht)– the height of the window • Distance from fenestration – the distance from the edge of the window to the sidefin or sidewall • Fin height (Fin Ht) – the vertical height of the sidefin or sidewall • Fin projection (H)– the horizontal projection of the fin or sidewall out from the wall in which the window is installed • Distance from window top to fin or sideall top (V) 
	Determine external shading device type	Identify the type of exterior shading device from Table R3-28 of the Residential ACM Manual (standard bug screens, woven sunscreens, louvered sunscreens, low sun angle louvered sunscreens, roll-down awnings, or roll-down blinds or slats).The most common screen is an insect screen that covers some or all of the window. If it is a full-coverage type screen and has a dense weave, assume it is a shade screen.

3.9.1 System Type		Determine the System Type for heating and for cooling from the list below:
3.9.2 Multiple System Types	Determine the floor area served by each system.	If a central system serves the area (supply registers) then the central system type should be used. Otherwise estimate the area served by each system.
3.9.3 Multiple System Types Serving the Same Area		If an area is served by more than one heating system or more than one cooling system, note the system types and the area (room or rooms) that they serve.
3.9.4 No Cooling	Determine if the rated home has air conditioning	Note the areas of the house that have no air-conditioning or evaporative cooling.
3.10.1 Heating System Type	Determine fuels used for heating and cooling	Heating systems may use natural gas, propane, oil, or electricity. • Oil - look for a large storage tank (typically oblong-shaped) or fill pipes which would indicate a buried tank. Oil is typically supplied to the heating equipment via a 1/4" - 3/8" copper line. A fuel filter may be evident in the line. • Natural gas - look for a meter connected to piping on the exterior of the home. Piping to the heating equipment is typically done with ½" - 1" iron piping. • Propane - look for storage tank(s) (typically cylindrical-shaped). Large tanks may be buried with a 12" - 18" cap exposed above grade. Fuel is typically supplied to equipment through 1/4" - 3/8" diameter copper piping. • Electric - look for large gauge cables running to a central piece of equipment or look at circuit breaker panel for circuits marked for resistance heat circuits (electric resistance or electric radiant systems).

ACM Section	Task	On-Site Inspection Protocol
	Identify type(s) of equipment for heating	For heating systems, choose from one of the following: • CntrlFurnace - comprised of a combustion chamber and heat exchanger (natural gas, propane or oil) or an electric resistance element (electric) and a fan which forces air across the heat exchanger or resistance element to provide heat in a forced air system. Gas fan-type central furnaces have a minimum AFUE=78%. • Boiler - Gas or oil boilers. Distribution systems can be Radiant, Baseboard or any of the ducted systems. Boiler may be specified for dedicated hydronic systems. • Heater - Non-central gas- or oil-fired space heaters, such as wall heaters floor heaters or unit heater. Equipment has varying efficiency requirements. Distribution is ductless and may be gravity flow or fan-forced.. • SplitHeatPump - Split system central air source heat pump. These systems move energy from one location to another using the vapor compression cycle. They are electrically driven, and can provide heating in winter and cooling in summer by reversing the direction of heat flow. Split system heat pumps consist of an outdoor unit and an indoor air handling unit, resembling a furnace. These systems require ductwork for air distribution. This descriptor is for both the heating and cooling system. • PkgHeatPump - Single package central air source heat pump. A single package central heat pump is similar to a split system, except it combines the functions of the indoor and outdoor units into one cabinet, usually mounted on the roof or on the ground. It also requires a separate distribution system. These are sometimes found in multi-family dwellings. This descriptor is for both the heating and cooling system. • LrgPkgHeatPump –large packaged units rated at or above 65,000 Btu/hr (heating mode). Distribution system shall be one of the ducted systems. These include water source and ground source heat pumps. • RoomHeatPump - non-central room air conditioning systems. These include small ductless split system heat pump units and packaged terminal (commonly called “through-the-wall”) units. This descriptor is for both the heating system and cooling system. • Non-ducted Electric - All electric heating systems other than space conditioning heat pumps. Included are electric resistance heaters (convective or radiant), electric boilers and storage water heat pumps (air-water) (StoHP). Distribution system can be Radiant, Baseboard or any of the ducted systems. • CombHydro - Water heating system can be storage gas (StoGas, LgStoGas), storage electric (StoElec) or heat pump water heaters (StoHP). Distribution systems can be Radiant, Baseboard, or any of the ducted systems and can be used with any of the terminal units (FanCoil, RadiantFlr, Baseboard, and FanConv).
	Determine the location of the distribution system for heating	Identify the location of the distribution system for heating. Common choices are attic, basement, garage or ventilated closet.
	Identify the control system for the heating	Determine the type of control systems. There may be separate controls for the heating and cooling systems. Thermostat controls may be programmable.
	Determine heating system efficiency	Identify the model number from the nameplate and review CEC appliance directories or historical GAMA product directories to determine the efficiency. If the efficiency cannot be found, use the default value from Table R3-50 of the Residential ACM Manual based on the estimated age of the equipment. • AFUE is used to measure the efficiency of furnaces and boilers. • HSPF is used to measure the heating performance of heat pumps. If a HSPF rating is not available, look for a COP rating and use Equation R3-32 in the Residential ACM Manual to convert to HSPF.

ACM Section	Task	On-Site Inspection Protocol
3.11.1 Cooling System Type	Determine the type of cooling system.	For cooling systems, choose from one of the following systems listed in Table R3-33: • No Cooling - Entered when the proposed building is not air conditioned. • SplitAirCond - Split system air conditioner, - similar to a split system air source heat pump. Consists of an outdoor unit and a coil in the forced air distribution system, usually in a fossil fuel furnace. • PkgAirCond - Central packaged air conditioning systems less than 65,000 Btuh cooling capacity. • LrgPkgAirCond - Large packaged air conditioning systems rated at or above 65,000 Btu/hr (cooling capacity). • RoomAirCond - Non-central room air conditioning cooling systems. These include small ductless split-system air conditioning units and packaged terminal (commonly called through-the-wall) air conditioning units. • SplitHeatPump - Split system central air source heat pump. • PkgHeatPump - Single package central air source heat pump. • LrgPkgHeatPump –large packaged units rated at or above 65,000 Btu/hr (heating mode). • RoomHeatPump - non-central room air conditioning systems. • GasCooling – gas absorption cooling. Look for a cooling tower, an exhaust pipe, a gas burner to evaporate refrigerant and a heat exchanger similar to an electric air conditioner. • EvapDirect - Direct evaporative cooler. Evaporative coolers work by blowing air over a damp pad or by spraying a fine mist of water into the air. • EvapIndirect - Indirect evaporative cooler - evaporation takes place on only one side of a heat exchanger so that additional moisture is not added to the cooled air. • EvapIndirDirect – Indirect-direct evaporative cooler. • Evap/CC - Evaporatively Cooled Condensers. A split mechanical system, with a water-cooled condenser coil. • IceSAC - Ice Storage Air Conditioning. Split air conditioner condensing coil in combination with ice storage.
	Identify the control system for the heating and cooling system(s)	Determine the type of control systems. There may be separate controls for the heating and cooling systems. Thermostat controls may be programmable.
3.11.3 Refrigerant Charge or Charge Indicator Light	Verify refrigerant charge or Charge Indicator Light	To take a credit for proper refrigerant charge, verify refrigerant charge according to the procedures in Reference Appendix RA3, section 3.2. The air handler airflow must also be verified for this test see section 3.3 of RA3). If a charge indicator light is present, verify its functionality by the procedure in Reference Appendix RA3, section 3.2.2. The refrigerant charge test applies to split system air conditioners and heat pumps.
3.11.4 Maximum Cooling Capacity Credit	Maximum Cooling Capacity Credit	Credit is available for new systems if the installed cooling capacity is less than or equal to the cooling capacity determined by sizing procedures in Reference Appendix RA1. The system must have verified cooling coil airflow and sealed and tested ducts to claim this credit.
3.11.5 Adequate Airflow	Verify Airflow over Central Cooling Coil	To receive credit for adequate airflow, follow the procedures in Reference Appendix RA3, section 3.3. If the airflow is not measured by the rater, a default value shall be assumed.
3.11.6 Fan Energy	Verify fan Watt draw	To receive credit for verified fan Watt draw, follow the procedures in Reference Appendix RA3, section 3.3. Airflow must be measured simultaneously to obtain a Watt draw in Watt/cfm. If no measurement is taken, a fan Watt draw of 0.8 W/cfm is assumed.

ACM Section	Task	On-Site Inspection Protocol	
3.11.7 Cooling System Calculations	Determine the cooling equipment efficiency	Check nameplate for the model number and use this number to determine the efficiency from CEC appliance directories or ARI directories. If the efficiency cannot be determined, use the default value from Table R3-50 of the Residential ACM Manual based on the estimated age of the equipment. • SEER is used to measure the seasonal efficiency of central air conditioners and air source heat pumps that have single phase power and a capacity of 65,000 Btuh or less. Credit is also available for high EER central air conditioners and air source heat pumps that have SEER ratings. To verify high EER efficiency ratings use the procedures in Reference Appendix RA3, Section 3.4. • EER is used to determine the efficiency of electric air conditioners and air conditioners older than 1988. • For indirect and indirect-direct evaporative cooling units an SEER and EER of 13 is assumed for energy calculations, For direct systems a fixed SEER of 13 is assumed. Since efficiencies for evaporative cooling systems are assumed, only the system type needs to be identified. • For evaporatively cooled condensing units, EER at 75 degrees wet-bulb and at 65 degrees wet-bulb is used. The eligibility requirements of Reference Appendix RA4, Section 4.3.2 shall be met. • For gas absorption cooling three descriptors, COP95, the rated COP for the gas portion, CAP95, the rated capacity, and PPC, the parasitic electric energy at rated conditions in Watts shall be determined. • For ice storage air conditioning systems, eligibility requirements of Reference Appendix RA4, Section 4.3.1 shall be met. The model number from the nameplate must be determined.	
3.12 Air Distribution	Identify type of distribution system used to provide space heating and cooling	Determine how the HVAC system distributes heating or cooling to the interior of the home. The most common types of distribution systems use air or water to distribute heating or cooling through ducts or pipes. Some systems rely on natural means to distribute heating or cooling without pipes or ducts..	
	Air Distribution Systems	Determine if an air distribution system is used. Fan-powered, ducted distribution systems are used with most heating or cooling systems. When ducted systems are used with furnaces, boilers, or combined hydronic/water heating systems the electricity used by the fan shall be calculated using the methods described later in this manual. R-value shall be specified in "Duct R-value" column when a ducted system is specified	
		DuctsAttic	Determine if the ducts are located overhead in the unconditioned attic space
		DuctsCrawl	Determine if the ducts are located underfloor in the unconditioned crawl space
		DuctsCVC	Determine if the ducts are located underfloor in a controlled ventilation crawl space
		DuctsGarage	Determine if the ducts are located in an unconditioned garage space.
		DuctsBasemt	Determine if the ducts are located in an unconditioned basement space
		DuctsInEx12	Determine if the ducts located within the conditioned floor space except for less than 12 lineal feet of duct, typically an HVAC unit in the garage mounted on return box with all other ducts in conditioned space.
		DuctsInAll	Determine if the HVAC unit or systems and all HVAC ducts are located within the conditioned floor space. Location of ducts in conditioned space eliminates conduction losses but does not change losses due to leakage. Leakage from either ducts that are not tested for leakage or from sealed ducts that are modeled as leakage to outside the conditioned space.
		DuctsOutdoor	Determine if the ducts are located in exposed locations outdoors.
		DuctsNone	Deternmine if the air distribution systems has no ducts such as ductless split system air conditioners and heat pumps, window air conditioners, through-the-wall heat pumps, etc.
	Ductless Systems	Ductless radiant or warm/cold air systems using fan-forced or natural air convection and hydronic systems relying upon circulation pumps and fan-forced or natural air convection and	
		Furnaces	Determine if heating equipment such as wall and floor furnaces are present and used
		Radiant	Determine if radiant electric panels or fanless systems are used with a boiler, electric or heat pump water heater, or combined hydronic heating equipment.
		Baseboard	Determine if electric baseboards or hydronic baseboard finned-tube natural convection systems are present and used
	Special Credits for Air Distribution Systems	LowLlCod	Verified Low Leakage Ducts in Conditioned Space – To claim credit for this measure, a rater shall diagnostically test the ducts to verify that air leakage to outside conditions is equal to or less than 25 cfm when measured in accordance with Section RA4-4.3.3, steps 1 through 9.
		LowLkAH	Low Leakage Air Handlers – Determine if the model number of the air handling unit is one that is a factory sealed air handler unit that has been tested by the manufacturer and certified to the Commission to have achieved a 2 percent or less leakage rate at 1-inch water gage – as prescribed in RA4-4.3.9.

ACM Section	Task	On-Site Inspection Protocol
3.12.3 Special Credits (Duct Location and Area)	Determine the location of ducts	Air ducts may be located in the attic, crawl space, a controlled ventilated crawlspace, unconditioned area (basement or garage) or in a conditioned area. You must locate and differentiate between supply and return ducts. Ducts may be located in more than one area (for example, some return ducts in attic and some in conditioned space). See Table R3-34 of the Residential ACM Manual for a list of duct locations.
	Determine the surface area of ducts in unconditioned space	A credit is available for duct systems for HVAC systems with air handlers located outside the conditioned space but with less than 12 lineal feet of duct located outside the conditioned space (including air handler and plenum). This is an alternative to recording the surface areas of individual duct segments in the unconditioned space. If this does not apply, then the duct lengths and inside dimensions must be measured to determine duct surface area. The inside surface dimensions of duct segments in unconditioned spaces (attic, crawlspace, basement or other) and the duct segment lengths are taken to determine duct surface areas. This measurement is required if the credit for verified low leakage ducts is taken. The area of ducts in the conditioned space is not included. The area of ducts in floor cavities or vertical chases that are surrounded by conditioned space and separated from unconditioned space with draft stops are also not included. If no measurement is taken a default surface area is assumed.
	Determine presence of attic radiant barrier	See 3.4.4.
3.12.4 Duct System Insulation	Determine the value of distribution system insulation	Air ducts may be insulated with insulation blankets or rigid insulation board. Inspect the duct or pipe insulation for R-value labeling (printed on the insulation by the manufacturer). If the insulation is not marked with the R-value, identify type and measure the thickness of the insulation to determine R-value. Check for internal insulation by tapping on the exterior and listening to the sound. For ducts buried in attic insulation, effective insulation R-values shall be taken from Table R3-38 of the Residential ACM Manual. The portions of duct runs directly on or within 3.5 inches of the ceiling gypsum board and surrounded with blown attic insulation of R-30 or greater may take credit for increased effective duct insulation as shown in Table R3-38. Credit shall be allowed for buried ducts on the ceiling only in areas where the ceiling is level and there is at least 6 inches of space between the outer jacket of the installed duct and the roof sheathing above. Deeply buried ducts may take credit for an effective R-25 for fiberglass and R-31 for cellulose insulation when Residential ACM requirements are met.
	Determine presence of ducts buried in attic insulation	Ducts partly or completely buried in blown attic insulation in dwelling units meeting the requirements for High Insulation Quality (Residential Appendix RA3-2008, section 3.5) and Procedures for Field Verification and Diagnostic Testing of Air Distribution Systems (Residential Appendix RA3-2008, section 3.1) may take credit for increased effective duct insulation. For each duct segment buried in attic insulation, indicate the duct diameter, attic insulation value and insulation type (fiberglass or cellulose).
3.12.5 Duct/Air Handler Leakage	Determine air leakage from ducts	Follow the test procedures in section 3.1 of Reference Appendix RA3. a) Duct Leakage for new ducts – air leakage in ducts is tested according to procedures in RA3.1.4.3 of Reference Appendix RA3. The duct leakage factors for sealed and tested new duct systems correspond to sealed duct requirements in newly constructed dwelling units, to entirely new duct systems in existing dwelling units, and to duct systems in alterations and additions that have been sealed to meet the duct leakage requirements of procedures in RA3, section 3.3. b) Duct Leakage for existing ducts – air leakage for existing ducts is tested according to procedures in section 3.1 of Reference Appendix RA3. The duct leakage factors for sealed and tested duct systems in existing dwelling units apply only to sealed duct requirements for alterations to existing dwelling units and to extensions of existing duct systems to serve additions. The total fan system airflow must also be measured according to procedures in RA3, section 3.3. c) Verified Low leakage ducts in Conditioned space – this credit is available for ducts entirely in conditioned space that have been tested to have an air leakage to the outside less than 25 cfm according to the test procedures in RA3, section 3.1.4.3. d) Sealed Existing Duct Systems – the objective of this test is to show a 60% reduction in leakage rate after sealing all the ducts. Existing duct systems that fail to pass the duct leakage tests may be tested after sealing all accessible leaks. A smoke test must then be performed according to procedure RA3.1.4.3.5 or RA3.1.4.3.6 of Reference Appendix RA3 to visually verify duct leakage improvement. If no duct leakage testing is performed a default leakage is assumed.
	Determine if low leakage air handler is present	A verified low leakage air handler credit is available for an air handler cabinet that has been certified to leak no more than 2 percent of its nominal airflow when pressurized to 1” w.g. Look for an indication of air leakage testing on the air handler label. To obtain this credit, ducts must be sealed and tested according to the procedures in Reference Appendix RA3.

ACM Section	Task	On-Site Inspection Protocol
3.13 Mechanical Ventilation	Measure fan Watt draw for mechanical ventilation systems	There are two ways of providing mechanical ventilation to provide IAQ: a standalone IAQ fan system and a central air handler fan system that can introduce outdoor air. A standalone indoor air quality fan system is a fan system (one or more ventilation fans) that provide at least the system airflow (Qfan) given by $Qfan = 0.01Afloor + 7.5(Nbr + 1)$ where Nbr is the number of bedrooms and Afloor is the conditioned floor area. For a standalone indoor air quality (IAQ) fan system is installed, determine the following data: 1. Fan W/cfm at expected operating conditions. Measure the fan Watt draw and airflow simultaneously and record the ratio as a decimal fraction. Use an exhaust fan flow meter to measure the CFM and a true power watt meter to measure the fan watts. 2. The fan system type shall be noted as “Unbalanced” for an exhaust or supply only system or “Balanced” for a system with both a supply and return fan. 3. If the stand alone ventilation system provides heat recovery, the sensible heat recovery effectiveness as a decimal fraction shall be obtained from product information. For Central Air handlers, the air handler airflow and fan Watt draw shall be measured according to procedures in Residential Appendix RA3-2008, section 3.3. A default value of 0.8 W/cfm is used if the airflow and fan Watt draw are not measured. Also determine whether or not the system: 1.directly introduces outdoor air into the central system ducts or 2. uses a central fan integrated ventilation system to automatically mix outdoor air provided by a separate ventilation fan not directly connected to the central system ductwork. A central fan integrated ventilation system automatically provides this mixing when the HVAC system is not already operating to provide heating or cooling.
3.15 Water Heating	Determine type and heat source of water heater	**Storage**. These water heaters are the most common type. Water is heated in an insulated tank that typically ranges in capacity from 30 to 75 gallons. Storage water heaters may use electric resistance, gas, propane, oil or electric heat pump. • Storage electric -look for rigid or flexible 240 A/C conduit, UL seal, no vent, no burner or pilot tubing. Thermostats are usually hidden behind metal access doors. Often there is both an upper and a lower thermostat. • Storage gas -look for a vent connection (top of tank), gas connector and line valve, thermostat, burner and pilot tubing, burner compartment doors, and "AGA" seal rating plate. Most gas water heaters have legs to lift the unit above the floor level to provide combustion air to the burner. • Storage propane -look for the same features as those listed for gas water heaters. Also, look for a rating plate or tag that states "For Use with LP Gas Only." • Large Storage gas – a storage gas heater with an input capacity greater than 75,000 Btu/hr. • Storage heat pump -water heaters remove heat from the air in the room where they are located and then release the heat to the water in the storage tank. Look for the same features as those found on electric water heating systems. In addition, there will be a fan, condenser and evaporator. Also, the system may be one single unit, or may be a split system. • Indirect Storage Gas – storage tank indirectly heated by gas or oil-fired source. In addition, oil systems are usually furnished with draft regulators which are attached to the vent pipe between the tank and chimney. Vent dampers may also be apparent on the vent pipe. • Boiler – boiler dedicated solely to hydronic space heating • Combination DHW/furnace system (CombHydro heating system) - natural gas combo systems use heat drawn from a hot water tank circulating through an air handling module to heat the space.
		Instantaneous. These water heaters heat water on demand, instead of storing pre-heated water in a large tank. They are usually small units, with storage of no more than 2 gallons, and are often attached to a wall close to the point of use. Instantaneous water heaters may be used in addition to a primary storage water heater to serve fixtures in a distant location of the house, so check for a main storage unit as well. Determine if the instantaneous heater uses gas or electricity. The CEC Appliance Efficiency Regulations define an instantaneous water heater as “a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water.” • Instantaneous gas - look for a connector and line valve, vent connection, thermostat, burner and pilot tubing, and AGA seal. Check whether unit has a pilot light or intermittent ignition device. • Instantaneous electric - look for the absence of a gas line, vent or pilot light. Look for a UL seal. Super-heater - check for this supplementary heat source.
	Determine location of storage tank	Determine whether water heater is located in conditioned or unconditioned space.

ACM Section	Task	On-Site Inspection Protocol
	Determine the capacity of the storage tank	Determine the size of the storage tank by referring to manufacturer's literature, the FTC label for new storage water heaters, or by using the model number and manufacturer's information.
	Determine the Energy Factor or Seasonal Efficiency of the water heater	Storage Water Heaters Determine the EF by examining the water heater's nameplate and product literature. Some water heaters will list their EF right on the nameplate. If the EF cannot be determined in this manner use the model number to find the EF from CEC appliance directories or manufacturer trade association directories. If the EF cannot be determined from the FTC label or from the model number and manufacturer's information use the equations below to determine the EF. Gas Water Heaters EF = 0.62 – (0.0019 x V) Electric Water Heaters EF = 0.93 – (0.00132 x V) Where V is the volume of the water heater in gallons. For older water heaters (manufactured before 2004), which are wrapped with R-12 insulation or better, add 0.05 to the EF. For large storage gas water heaters not covered by NAECA (greater than 75,000 Btu/hr input), look for an efficiency rating on the water heater, and the Tank R-value (hr-ft2-F/Btu), the total thermal resistance of the internally-insulated tank and the R-value of any external insulation wrap. The standby loss is taken from the Energy Commission database. Combined Hydronic Heating Systems For combined hydronic heating systems, determine the heat input in kBtu/h for gas (or kW for electric) and the recovery efficiency (%). For large storage gas or indirect gas water heaters in a combined hydronic heating system, determine the pump input in Watts. Instantaneous Water Heaters For large instantaneous water heaters (>10 gal storage), determine the unit's TE (Thermal Efficiency) from the nameplate or by using the model number and CEC or manufacturer's directories. For gas models, determine if there is a standing pilot light. Determine the pilot light energy consumption (Btu/hr) from the Energy Commission's database. Also record the standby loss in Btu/h and note the R-value of any external insulation wrap. For small instantaneous water heaters, determine the EF of the water heater.
	Determine type of distribution system	Determine if a point of use water heating system or a recirculation system is installed. To claim credit for a point of use system, all fixtures shall be within 8 feet of a water heater, as specified in Reference Appendix RA4. For single dwelling units with recirculation systems, determine the recirculation control type from Table R3-45 of the Residential ACM Manual.
	Determine the water distribution piping location and insulation	Determine if the water pipes are in the attic, a crawlspace, or under the slab. If they are under the slab, determine if they are insulated. If there is no documented evidence of pipe insulation under the slab assume that the pipes are uninsulated.
	Determine recirculation control for multiple dwelling units	If the system serves multiple dwelling units, determine the recirculation control type from Table R3-46 of the Residential ACM Manual.
	Determine pump motor size and efficiency for recirculating systems	Determine the pump motor size and efficiency rating from nameplate information or manufacturer's information.
	Recirculating system dwelling unit information	Determine the number of apartments and the number of stories served by the recirculation system.
	Recirculating system pipe location, length, and insulation thickness	Determine fraction of piping between dwelling units that is located (a) outdoors, (b) in conditioned or semi-conditioned space, (c) buried in ground. For each pipe segment, measure its length, note its location and indicate pipe insulation thickness in inches. Indicate the total lineal feet of all circulation piping.

ACM Section	Task	On-Site Inspection Protocol
	Determine type of solar systems	Determine whether a solar domestic hot water system exists. These systems collect and store solar thermal energy for domestic water heating applications. If a solar water heating system exists, determine system type. Identify as passive or active. Base your evaluation on these criteria: • Passive - No purchased electrical energy is required for recirculating water through a passive solar collector. Three types of passive systems are integrated collector storage (ICS), thermosiphon systems and self-pumped systems. • Integrated Collector Storage (ICS) - consists of a single unit which incorporates both collector and water storage. An example is the common "bread box" design. Storage is usually outside the conditioned space. • Thermosiphon - consists of a flat-plate solar collector and hot water storage tank. Instead of using a pump, circulation of the fluid is achieved by natural convection action. The storage tank must be located above the collector, and is usually outside the conditioned space. • Self-pumped - circulates fluid from storage to collectors without purchased electrical energy. Photovoltaic and percolating systems are examples of self-pumped systems. The storage tank is usually inside the conditioned space. • Active -Also known as pumped systems. • Pumped -purchased electrical energy input is required for operation of pumps or other components. The storage tank is usually inside the conditioned space. Determine the type of solar collector by checking for the SRCC label or manufacturer's information. Determine the parameters for solar performance from the OG-100 or OG-300 test procedures based upon information from the homeowner or from the model number, manufacturer's information, and SRCC directories.
	Determine efficiency of solar system	Look for SRCC label. Check for SRCC system and component name plates. Refer to the Directory of SRCC Certified Solar Collector and Water Heating System Ratings, or other SRCC literature for solar energy factor (SEF) and other performance data. For systems manufactured after Jan. 1, 1995, system type, solar energy factor (SEF), and other performance characteristics shall be determined from the SRCC label (usually affixed to the solar storage tank) and by referring to SRCC literature. For systems lacking an SRCC label, energy factor and other performance characteristics can be determined using a certified HERS modeling tool, or appropriate default values.

HTM Section	Task	On Site Inspection Protocols
4.5 Appliances and Miscellaneous Energy Use		
4.5.1 Refrigerator/Freezer	Determine the number, location, and energy consumption of refrigerators and freezers	Determine the approximate size (ft^3) and basic type of the primary refrigerator. Basic types are freezer inside, freezer above, freezer below, side-by-side, through the door water service, and through the door ice service. Determine if there are other refrigerators or independent freezers in the house, garage, or outside and note the location, particularly if they are or are not in conditioned space.
4.5.2 Dishwasher	Determine the presence or absence of dishwasher and efficiency	Determine if a dishwasher is present. If present, determine the energy factor for the dishwasher.
4.5.3 Clothes Dryer	Determine the presence and type of clothes dryer	Determine if there is a clothes dryer or hookup for a clothes dryer. If a dryer or hookup is present determine its type (gas or electric) and whether or not it is located in conditioned space. Determine if it is a gas dryer or an electric dryer.
4.5.4 Clothes Washer	Determine the presence and type of clothes washer	Determine if there is a clothes washer or hookups for a clothes washer. If one is present determine its type (gas or electric) and its location, particularly if it located in conditioned space or not.
4.5.5 Oven/Range	Determine the presence and type of oven/range	Determine if there is a range with a cooktop with or without an associated non-microwave oven. If one is present determine its type (gas or electric) and whether or not there are continuously burning pilot lights for the range cooktop or the oven if they are gas appliances. Note that a gas range cooktop with intermittent ignition devices (IIDs) and no continuously burning pilot lights should produce the characteristic electric sparking sound when first turning on one of the range burners. A continuously burning pilot light on the other hand will often produce one or more warm spots on the non burner portion of the cooktop.
4.5.6 Miscellaneous Electricity	Determine the presence or absence of other appliances	Determine the presence and number of any of the appliances or energy-consuming products listed in Appendix B of this manual.
4.6 Lighting	Determine the energy used for lighting inside and outside the home	
4.6.1 Interior Lighting	Determine the number and type of fixtures inside the home	Using the rules specified in Tables 6 and 7 of Section 4.6.1 of this manual, determine the number and type of luminaires that are inside the conditioned part of the house.
4.6.2 Outdoor Lighting	Determine the number and type of lighting fixtures attached to the outside of the home	Using the rules specified in Tables 6 and 7 of Section 4.6.1 of this manual, determine the number and type of luminaires that are attached to the outside of the house, garage, or any other ancillary buildings on the lot.
	Determine the number and type of lighting fixtures inside the garage and other buildings on the same lot.	Using the rules specified in Tables 6 and 7 of Section 4.6.1 of this manual, determine the number and type of luminaires that are inside of the garage (attached or detached) and on the inside of other buildings detached from the home but on the same lot.

APPENDIX B

Standard Recommendations

The standard approach provides a set of recommendations that are triggered by the presence of a pool, spa, pumps or internal plug loads. Recommendations are also provided for interior and exterior lighting.

Item	Condition	Recommendation
Pools	No cover	Install and use a pool cover.
	No time clock	Install a time clock for the pool pump to provide daily control of pump and heater operation.
	Replacement/new pool pump motor	Consider installing a pool pump with a two-speed or variable-speed motor. Controls can set the speed to low for filtration and high for cleaning.
		New motors should be type capacitor start capacitor run (also known as two-value capacitor). Single-phase capacitor start motors (also known as capacitor start induction run) have lower efficiencies and should not be used for new installations.
		All pool pump motors should have a service factor not exceeding that specified in NEMA standard MG-1, Table 39.
	Oversized pool pump	Make sure the pool pump motor is properly sized for the flow and head requirements. In many cases a 1 hp pump will be sufficient.
	Conventional heating system	Consider installing a solar pool heating system.
	Too little or too much filtration	The average pool requires 4 to 6 hours of filtration per day, enough to have 1 pool turnover a day. A smaller horsepower pump that operates longer will use much less energy than a larger pump.
	Improper filter maintenance	Backwash or clean the filter per manufacturer's recommendations to maintain the system's efficiency.
	Excessive automatic pool sweeps	Limit the amount of time used by pool sweeps. Generally, three to four hours of daily operation is sufficient. Remember to start the pool sweep one hour or more after the pump has started and stop the sweep one hour or more before shutting off the pump.
Spas	No cover	Make sure that the spa has a cover, and preferably one with closed-cell foam insulation.
	No wind protection	Creating a windbreak around the spa (such as with trees, shrubs or fencing) will reduce heat loss and save energy.
	High Setpoint	Keep the setpoint at 102˚F or lower.
	Aerator on	Limit the use of the spa aerator to reduce heat loss.
	Seasonal operation	Setback the thermostat when on vacation.
	Frequent filter maintenance	Clean spa filters with every water change (new spas can go 4 to 6 months between changes), and replace annually to maintain performance.
Well Pumps	Oversized pump	Make sure the pump is properly sized. In many cases the pump can be downsized from a ¾ hp to a ½ hp pump.
	Inefficient motor	Use a pump with a high efficiency motor. Typical motor efficiencies for 1 hp pumps are 57% to 62%. High efficiency motors are in the 70% efficiency range.
	Leaky faucets or hoses	Repair leaks in faucets and hoses, which can increase both energy use and water consumption.
	Maintenance	Perform regular pump maintenance to ensure that the pressure tank is not filled with too much water.
Grinder Pumps	New pump installation	Specify a pump with a high efficiency motor.

Item	Condition	Recommendation
Waterbed	Existing waterbed	Install rigid insulation underneath and on the sides of the waterbed mattress. Make sure that the heater is separated from the insulation by a non-combustible material and that the heater is in direct contact with the mattress.
		Install a foam pad on the top of the mattress underneath the mattress pad and sheets. This allows for a reduced thermostat temperature on the waterbed to maintain the same comfort level.
	New waterbed	Specify shallow fill (6 inch depth or less) mattresses which require smaller heaters (150 W).
Refrigerator	Inefficient or outdated appliance	Install an Energy Star refrigerator. Choose the lowest energy using refrigerator that meets your needs.
	Excessive energy use of existing refrigerator	Keep your refrigerator between 35 and 40 degrees Fahrenheit and your freezer at 0 to 5 degrees Fahrenheit. Leave a space between the refrigerator and the walls and cabinets and clean the condenser coils twice a year to maintain efficiency.
	Manual defrost	Defrost the freezer whenever ice buildup is thicker than ¼ inch.
	Improper door seals	Check the door seals or gaskets on your refrigerator/freezer. You can do this by putting a dollar bill in the door as you close it and see if it holds firmly in place. Or, place a bright flashlight inside the refrigerator and direct the light toward a section of the door seal. With the door closed and the room darkened, inspect for light through the crack.
	Has an energy saver (anti-sweat) switch	Set the switch on during the summer and off during the winter.
	Existing refrigerator	To keep your refrigerator from working too hard, let hot foods cool, cover foods, label items for quick identification, and keep your freezer full.
	Second Refrigerator or Separate Freezer	Properly dispose of second refrigerator or separate freezer if possible.
Dishwasher	Inefficient or outdated appliance	Purchase Energy Star appliances. Check for an Energy Factor of at least 0.65 on the yellow Energy Guide label. Also check manufacturer's literature on water use, which is not part of the Energy Star rating.
	Existing appliance	Turn down the water heater temperature to 120F. Modern dishwashers have a booster heating element to raise the water temperature to 140-145F. Also, be sure to wait for a full load to run the dishwasher. Use the energy saving cycle (no heat air dry) if it has one. Wait until an off-peak period to use appliance.
Microwave	Inefficient or outdated appliance	Install a newer, more efficient microwave. A microwave uses much less energy to cook food than the oven uses.
Home Office	Computer present	Use a power strip and turn off power to the strip when not in use to avoid standby losses.
	Replacing existing equipment	Specify Energy Star equipment for laptop or desktop PCs and computer monitors.
	New laptop	Purchase a laptop with an Energy Star external power supply. Products with qualified adaptors receive a special version of the Energy Star label.
	Other Office Equipment	Use a power strip and turn off power to the strip when not in use. Also use Energy Star certified equipment.
TV	New Television	Install an Energy Star TV.
	TV Standby power	Turn off power strip when not in use for an extended period of time to avoid standby power draw from TV and DVD player. (Note that TVs, cable/satellite boxes and DVDs may need to be reprogrammed after powering up.)
	Other Consumer Electronics	Use a power strip and turn off power to the strip when not in use. Also use Energy Star certified equipment.
Washer	New washing machine	Install an Energy Star front-loading clothes washer. Front-load washers use much less water than top-loading washers with an agitator. Choose a washer with a low Modified Energy Factor (MEF) and a low Water Factor (WF). If the washer does not have controls to automatically adjust the water level, choose a washer that lets you select lower water levels for smaller loads.
	Existing washing machine	Wash clothes in a cold or warm cycle only, with a cold rinse. Wait until an off-peak period to use appliance.
Dryer	Present	Use the permanent press setting to obtain energy benefit of cool-down cycle. If available use the moisture sensor control setting rather than a timed dry. Keep the dryer exhaust vent on the outside of the house clean. It should be clear of cobwebs and lint. The moveable shutters should move easily. Clean lint filter after each use. Wait until an off-peak period to use appliance. Consider air-drying clothes on sunny days.
Range/Oven	Electric Range	Keep drip pans under conventional coil burners clean.
	Gas Range	Electronic ignition will use less energy than a gas pilot light. Pilot light and burner flame on gas stoves should be blue. If flame is yellow, ports need to be unclogged or adjusted.

Item	Condition	Recommendation
Interior Lighting	New fixtures	Specify Energy Star certified fixtures.
	Incandescent fixtures	Replace incandescent lamps with Energy Star certified CFLs or other Energy Star high efficacy replacement lamps, or specify occupancy sensors to reduce energy use. Dimming switches also can save some energy. When using fluorescent lamps with dimming switches, be sure to use only dimmable fluorescents.
	Portable lighting	For existing lighting replace incandescent lamps with Energy Star certified CFLs or other Energy Star certified high efficacy lamps.
	Kitchens and living rooms	Use linear fluorescent lighting or other high efficacy lighting where the design permits.
	Permanent fixtures	Specify Energy Star fixtures that meet Title 24 high-efficacy requirements (40 lumens/Watt for <15W, 50 lumens per Watt for 15-40 Watts and 60 lumens per Watt for greater than 40 Watts).
Exterior Lighting	Incandescent lamps	Switch to Energy Star certified CFLs or other high efficacy lamps.
	New outdoor fixtures	Specify Energy Star certified fixtures. Install compact fluorescent, high-pressure sodium, or other high efficacy fixtures appropriate for outdoor use.
	No motion sensors	Use motion sensors and daylight controls (photocontrols) for exterior lighting.