6. Optional Capabilities Tests

6.1 Overview

This chapter of the Manual explains the tests that must be performed in order for residential ACMs to be approved for optional capabilities. See the Overview section of Chapter 5 for details. There are two sets of optional capabilities. The first are for space conditioning and include hydronic heating systems, combined (with the water heater) hydronic heating, zonal control of space temperatures, sunspaces, side fins and exterior mass walls. The second set of capabilities relate to solar systems used for water heating applications. At this time, photovoltaic systems are not an optional capability.

6.2 Optional Space Conditioning Capabilities

6.2.1 Summary of Tests

The optional capabilities tests for space conditioning are summarized in Table R6-1. These tests use the same labeling scheme, test procedures, and prototypes as the minimum modeling capabilities (see Chapter 5).

Table R6-1 – Summary of the Optional Space Conditioning Tests

Type	*Test*	*Prototypes*	*Climates*	*Optional Capability (Discrete Modification(s))*	*Continuous Variable*
OC	1	A	3, 9, 12, 14, 16	**Dedicated Hydronic.** Replace the gas furnace and air distribution system with a gas boiler with hydronic baseboards and fan coils. See detailed description below. Produces a positive compliance margin.	**Fenestration U-factor**. Increase the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.
OC	2	A	3, 9, 12, 14, 16	**Combined Hydronic, Gas Water Heater**. A 75 gallon storage gas water heater is used for both space conditioning and water heating. Hot water baseboards are used for heat distribution. Insulated pipes are used in unconditioned space.	**Fenestration U-factor**. Vary the U-factor of the fenestration to find the passing solution and the failing solution.
OC	3	A	3, 9, 12, 14, 16	**Combined Hydronic, Electric Resistance Water Heater**. An electric water heater is used for both space conditioning and water heating and air is distributed through a fan coil system that delivers air to ducts located in an attic.	**Fenestration U-factor**. Vary the U-factor of the fenestration to find the passing solution and the failing solution.
OC	4	A	3, 9, 12, 14, 16	**Combined Hydronic, Heat Pump Water Heater**. An electric heat pump is used for both space conditioning and water heating. Distribution is provided through hot water baseboards. All pipes are located within conditioned space.	**Fenestration U-factor**. Vary the U-factor of the fenestration to find the passing solution and the failing solution.
OC	5	B	3, 9, 12, 14, 16	**Control Vent Crawlspace**. See detailed description below. Produces a positive compliance margin.	**AFUE**. Reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
OC	6	A	3, 9, 12, 14, 16	**Zonal Control**. See detailed description below. Produces a positive compliance margin.	**AFUE**. Reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
OC	7	A	3, 9, 12, 14, 16	**Attached Sunspace**. See detailed description below. Produces a positive compliance margin.	**AFUE**. Reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
OC	8	A	3, 9, 12, 14, 16	**Exterior Mass Walls**. See detailed description below. Produces a negative compliance margin.	**Wall R-value**. Increase the interior wall R-value to find the Passing Solution and the Failing Solution.
~~OC~~	~~9~~	~~A~~	~~3, 9, 12, 14, 16~~	~~**Gas Engine Driven Cooling**. Replace the basecase cooling system with an engine driven gas fired cooling system with a COP of 2.27. Produces a positive compliance margin.~~	~~**Fenestration U-factor**. Increase the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.~~
OC	9 ~~10~~	A	3, 9, 12, 14, 16	**Gas Absorption Cooling.** Replace the basecase cooling system with an absorption gas cooling system with a COP of 3.3. Produces a positive compliance margin	**Fenestration U-factor**. Increase the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.

6.2.2 Dedicated Hydronic Systems

Measure Description

Dedicated hydronic systems have boilers or other heating devices which produce hot water that is distributed through the building for heating. The system is commonly used in other areas of the country. Its use in California is limited. Heat is transferred through the building by water instead of air. Terminal heating units include fan coils, baseboards, radiant floors, or radiant ceilings. If large fan coils are used that distribute warm air through a conventional air distribution system, then the losses of the duct system must be accounted for in the same manner as gas furnaces.

Algorithms and Modeling Assumptions

Dedicated hydronic systems are modeled in a manner similar to a gas furnace, but the AFUE of the boiler is adjusted to account for pipes located outside the conditioned space. The ACM vendor shall include inputs for pipes located in unconditioned spaces. Inputs shall include the pipe length, diameter and insulation, as described in Chapter 2.

Equation R6-1

$$AFUE_{eff} = AFUE - \frac{PL}{RI}$$

Where

$AFUE_{eff}$ = The effective AFUE of the gas boiler that is providing space heat (unitless).

AFUE = The rated AFUE of the boiler (unitless).

PL = Annual Pipe losses (kBtu/h). This may be assumed to be zero when less than 10 feet of the piping (plan view) is located in unconditioned space. Pipe losses are calculated using the procedures described below.

RI = The rated input of the gas water heater (kBtu/h). This is available from the CEC appliance directory and other sources.

If heat is distributed with a fan coil, then the energy of the fan shall be accounted for in the same manner as for furnaces. The default fan energy is 0.005 Wh/Btu of heat delivered by the fan coil (not the entire heating system).

Hydronic systems are permitted when the AFUE is known and can be entered. When water heaters are used in hydronic systems for space heating alone (a separate water heater for domestic service), the water heater functions as a boiler and is required by NAECA to have a minimum AFUE of 0.80. The AFUE of a water heater if tested as a boiler would be approximately equal to the average of the EF and the RE, and will generally not meet the minimum NAECA requirement. Water heaters proposed for use in hydronic systems for space heating only must be tested as a boiler using the DOE AFUE and appropriate safety standard test procedures.

Test Description

For prototype A, the basecase heating system, consisting of a gas furnace and a forced air distribution system, is replaced with a dedicated hydronic system. The boiler has an AFUE of 85%. Twenty (20) ft of insulated pipe are located in unconditioned space. Heat is distributed with combination of fan coils (20 kBtu/h) and hydronic baseboards (40 kBtu/h). Water is circulated through the hydronic loop by a 1/8 hp pump. The pump motor meets the minimum efficiency requirements of the California appliance efficiency standards. Substituting this system will produce a positive compliance margin. The fenestration U-factor is then reduced to find the passing solution and the failing solution, according to the procedures described in Chapter 5. The CEC reference method must pass the passing solution and fail the failing solution.

The ACM vendor must also demonstrate that the software correctly produces the standard design. This requires that the vendor create a standard design equivalent building that matches the standard design for the system described above. When the standard design equivalent building is entered into the candidate ACM, the proposed design and standard design TDV energy must equal each other. The standard design equivalent energy must also equal the standard design energy for the test case.

6.2.3 Combined Hydronic Space/Water Heating

Measure Description

Combined hydronic space/water heating is a system whereby a water heater is used to provide both space heating and water heating. Dedicated hydronic space heating systems are also an optional capability covered in Section 6.2.2. Space heating terminals may include fan coils, baseboards, and radiant surfaces (floors, walls or ceilings).

Algorithms and Modeling Assumptions

For combined hydronic systems, the water heating portion is modeled in the normal manner. For space heating, an effective AFUE is calculated for gas water heaters. For electric water heaters or heat pumps, an effective HSPF is calculated. The procedures for calculating the effective AFUE or HSPF are described below.

When a fan coil is used to distribute heat, the fan energy and the heat contribution of the fan motor must be considered. The algorithms for fans used in combined hydronic systems are the same as those used for gas furnaces and are described in Chapter 4.

If a large fan coil is used and air distribution ducts are located in the attic, crawlspace or other unconditioned space, then the efficiency of the air distribution system must be determined using methods consistent with those described in Chapter 4. Duct efficiency is accounted for when the distribution type is "ducts."

Storage Gas Water Heater

When storage gas water heaters are used in combined hydronic applications, then the effective AFUE is given by the following equation.

Equation R6-2 $$AFUE_{eff} = RE - \frac{PL}{RI}$$

Where

$AFUE_{eff}$ = The effective AFUE of the gas water heater in satisfying the space heating load.

RE = The recovery efficiency of the gas water heater. A default value of 0.76 may be assumed if the recovery efficiency is unknown. However, this value is generally available from the CEC appliance directory.

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements is located in unconditioned space (see Equation R6-6).

RI = The rated input of the gas water heater (kBtu/h). This is available from the CEC appliance directory.

Storage Electric Water Heater

The HSPF of storage water heaters used for space heating in a combined hydronic system is given by the following equations.

Equation R6-3 $$HSPF_{eff} = 3.413\left[1 - \frac{PL}{3.413\,kWi}\right]$$

Where:

$HSPF_{eff}$ = The effective HSPF of the electric water heater in satisfying the space heating load.

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements are located in unconditioned space (see Equation R6-6).

kWI = The kilowatts of input to the water heater.

Heat Pump Water Heater

The HSPF of heat pump water heaters used for space heating in a combined hydronic system is given by the following equations. If the system has a fan coil, the $HSPF_{eff}$ is used. $HSPF_{w/o\_fan}$ is used if there is no fan coil.

Equation R6-4

$$HSPF_{eff} = 3.413\left(\frac{RE_{hp}}{CZ_{adj}} - \frac{PL}{3.413kWi}\right)$$

where

$HSPF_{eff}$ = The effective HSPF of the heat pump water heater in satisfying the space heating load.

CZ_{adj} = The climate zone adjustment (see ~~water heating calculation method) (see~~Table RG-7~~Table R 4-9~~).

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements is located in unconditioned space (see Equation R6-6).

kWI = The kilowatts of input.

RE_{hp} = The recovery efficiency of the heat pump water heater. Equation R6-5 may be used as a default if the recovery efficiency is not known.

Equation R6-5

$$RE_{hp} = \frac{1}{\frac{1}{EF_{DOE}} - 0.1175}$$

where

EF_{DOE} = The energy factor of the heat pump water heater when tested according to the DOE test procedure.

Pipe Losses

Pipe losses must be considered when pipes between the water heater storage tank and the fan coil or other heating element are located in unconditioned space. To simplify compliance, pipe losses can be ignored when no more than ten feet of pipe (in plan view) is located in unconditioned space. Hourly pipe loss rates (PLR) are given either from Equation R6-7 or from Table R6-2.

Equation R6-6

$$PL = \sum_{i=1}^{n} \frac{FT_i \times PLR_i}{8760}$$

PL = Hourly pipe loss (kBtu/h).

PLR_i = The annual pipe loss rate per foot of length for the i^{th} pipe (kBtu/y-ft).

FT_i = The length in feet of the i^{th} pipe located within unconditioned space. Can be assumed to be zero if less than ten feet in plan view.

n = The number of unique pipe size or insulation conditions.

The annual pipe loss rate per foot of length (PLRi) is calculated from the following equation

Equation R6-7

$$PLR_i = 8.76 \left(\frac{T_s - T_a}{\frac{\ln\left(\frac{D_{io}}{D_{po}}\right)}{2 \pi Ki} + \frac{1}{\pi\, ha\, D_{io}}} \right)$$

where

8.76 = Conversion factor from Btu/h to kBtu/y

T_s = Supply Temperature. This is assumed to be a constant 135 F.

T_a = Ambient Temperature. This is assumed to be 60.3 in all California climate zones.

D_{io} = Outside diameter of insulation. ft (actual not nominal).

D_{po} = Outside diameter of pipe, ft (actual not nominal).

Ki = Insulation conductivity, constant 0.023 Btu/h-ft-F

ha = Air film coefficient, constant 1.65 Btu/h-ft²-F

Table R6-2 – Annual Pipe Loss Rates (kBtu/y-ft)

	Insulation Thickness		
Nominal Pipe Size	1/2 inch	¾ inch	1 inch
1/2 inch	71.6	60.9	54.2
3/4 inch	91.1	75.8	66.6
1 inch	109.9	90.1	78.1
1 - 1/2 inch	146.7	117.5	100.3
2 inch	182.9	144.3	121.7

Test Description

The tests for combined hydronic systems are based on modifications to prototype A. Three different systems are added as discrete modifications. The test systems are described in Table R6-3

Table R6-3 – Combined Hydronic System Specifications

		Test Number		
		OC2A	OC3A	OC4A
Water Heater Type		SG	SE	HP
Recovery Efficiency	Unitless	0.76	n.a.	n.a.
Rated Input	Btu/h	60,000	n.a.	n.a.
Rated Input	KW	n.a.	5.00	n.a.
Wpump	W	n.a.	60.0	n.a.
EF	Unitless	n.a.	n.a.	2.00
Pipe Length in Unconditioned Space	Ft	100.0	n.a.	n.a.
Annual Pipe Loss Rate	kBtu/y-ft	71.6	n.a.	n.a.

For this series of tests, only the TDV energy for space conditioning is considered. The combined hydronic systems described above are added to the Prototype A building to replace the gas furnace. The ACM vendor shall change the fenestration U-factor on all orientations of the prototype to find the passing solution and the failing solution. The CEC reference method shall pass the passing solution and fail the failing solution.

In addition, the ACM vendor shall demonstrate that the software correctly defines the standard design for combined hydronic. This is achieved by creating and running the standard design equivalent building. For the standard design equivalent building, the TDV energy for the proposed design and the standard design must be equal. The standard design equivalent TDV energy must also equal the TDV energy for the standard design case of this test.

6.2.4 Controlled Ventilation Crawl Spaces (CVC)

Measure Description

A controlled ventilation crawlspace has insulation installed in the side walls of the crawlspace, instead of in the floor that separates conditioned space from the crawlspace. In addition, special dampers are used to provide the required ventilation for the crawlspace which open in the summer and close in the winter.

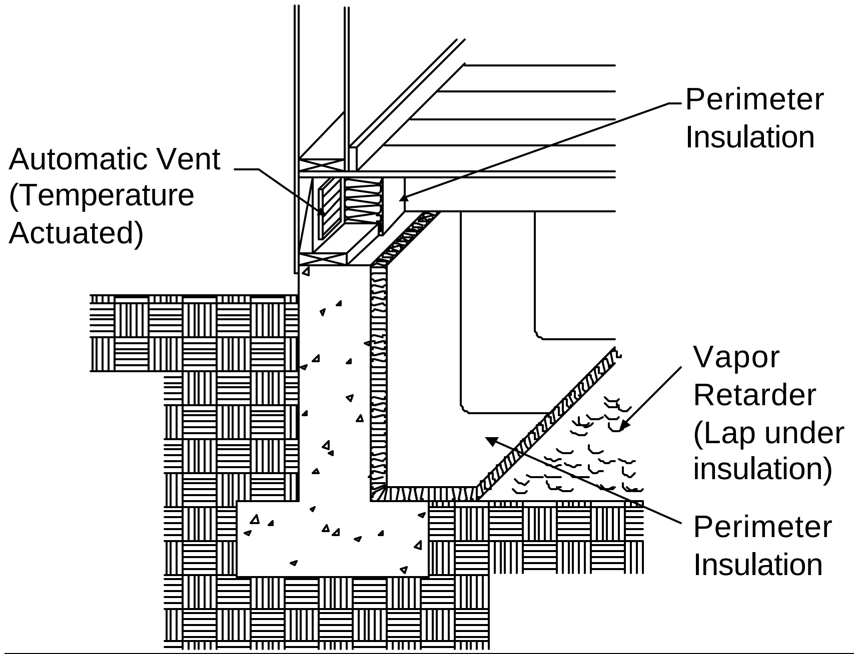


Figure R6-1 – Section at Crawlspace Perimeter

Algorithms and Modeling Assumptions

CVC requires that the ACM have the capability of modeling two thermal zones. The house itself if modeled as a conditioned zone and the crawlspace is modeled as an unconditioned zone.

Test Description

To test this optional capability the ACM vendor shall model prototype B in climate zones 3, 9, 12, 14, and 16. The CVC to be modeled shall have the following features:

- The CVC unconditioned zone has an exterior perimeter length and floor area (i.e., the ground area) equal to the prototype building B. Crawlspace volume is 3,467 ft^3.
- CVC infiltration is modeled using the air changes per hour method and uses 0.22 air changes per hour.
- The floor separating the crawl space from conditioned space is an inter-zone boundary. 400 ft^2 of this floor has a U-value of 0.342, representing an uninsulated, uncarpeted floor, and the remainder has a U-value of 0.199, representing an uninsulated, carpeted floor.
- Insulation that meets the floor insulation requirements used for compliance is placed in the perimeter walls of the crawl space.
- The crawl space vents are modeled with automatic seasonally operated louvers to minimize ambient conditions within the crawl space. When the building is in a heating mode, the vents are closed (inlet and outlet are zero). When the building is in a cooling mode, the vents are open and the total vent area is 1/150 of the crawlspace floor area or 10.67 ft^2. Half of this is inlet and half outlet.
- The ventilation height difference is zero. Only wind effects apply. Wind speed is reduced to 25% of that on the weather tape to account for ground level conditions.
- Heat capacity in the crawlspace is 1.4 Btu/F-ft^2.

This system is expected to produce a positive compliance margin. The heating equipment AFUE is then reduced to find the passing solution and the failing solution. The CEC reference method must pass the passing solution and fail the failing solution. Several eligibility criteria apply for CVC.

In addition, the vendor shall demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. The vendor shall create and run the standard design equivalent building for climate zone 12. The proposed design and standard design TDV energy for the be equal. The TDV energy from the standard design equivalent must also equal the standard design TDV energy for this test.

Eligibility Criteria

Drainage. Proper enforcement of site engineering and drainage, and emphasis on the importance of proper landscaping techniques in maintaining adequate site drainage, is critical.

Ground Water And Soils. Local ground water tables at maximum winter recharge elevation should be below the lowest excavated site foundation elevations. Sites that are well drained and that do not have surface water problems are generally good candidates for this stem-wall insulation strategy. However, the eligibility of this alternative insulating technique is entirely at the building officials' discretion. Where disagreements exist, it is incumbent upon the applicant to provide sufficient proof that site drainage strategies (e.g., perimeter drainage techniques) will prevent potential problems.

Ventilation. All crawl space vents must have automatic vent dampers to receive this credit. Automatic vent dampers must be shown on the building plans and installed. The dampers should be temperature actuated to be fully closed at approximately 40°F and fully open at approximately 70°F. Cross ventilation consisting of the required vent area reasonably distributed between opposing foundation walls is required.

Foam Plastic Insulating Materials. Foam plastic insulating materials must be shown on the plans and installed when complying with the following requirements:

- Fire Safety—UBC Section 1712(b)2. Products shall be protected as specified. Certain products have been approved for exposed use in under floor areas by testing and/or listing.
- Direct Earth Contact—Foam plastic insulation used for crawl-space insulation having direct earth contact shall be a closed cell water resistant material and meet the slabedge insulation requirements for water absorption and water vapor transmission rate specified in the mandatory measures.

Mineral FiberWool Insulating Materials

- Fire Safety—UBC Section 1713(c). "All insulation including facings, such as vapor barriers or breather papers installed within ... crawl spaces ... shall have a flame-spread rating not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with UBC. Standard No. 42-1." In cases where the facing is also a vapor retarder, the facing shall be installed to the side that is warm in winter.
- Direct Earth Contact—Mineral fiberwool batts shall not be installed in direct earth contact unless protected by a vapor retarder/ground cover.

Vapor Barrier (Ground Cover). A ground cover of 6 mil (0.006 inch thick) polyethylene, or approved equal, shall be laid entirely over the ground area within crawl spaces.

- The vapor barrier shall be overlapped six inches minimum at joints and shall extend over the top of pier footings.
- The vapor barrier should be rated as 1.0 perm or less.
- The edges of the vapor barrier should be turned up a minimum of four inches at the stem wall.
- Penetrations in the vapor barrier should be no larger than necessary to fit piers, beam supports, plumbing and other penetrations.
- The vapor barrier must be shown on the plans and installed.

Studies show that moisture conditions found in crawl spaces that have minimal ventilation do not appear to be a significant problem for most building sites provided that the crawl-space floors are covered by an appropriate vapor barrier and other precautions are taken. The Energy Commission urges building officials to carefully evaluate each application of this insulating technique in conjunction with reduced ventilation because of the potential for adverse effects of surface water on crawl-space insulation that could negate the energy savings predicted by the procedure.

6.2.5 Zonal Control

Measure Description

Zonal control is one of the optional capabilities based on the ability of an ACM to model more than one conditioned thermal zone at the same time. With zonal control, the sleeping and living areas are modeled separately, each with its own separate thermostat schedule and internal gain assumptions. The specifications for zonal control are detailed in Chapter 4. Key features are discussed below.

Algorithms and Modeling Assumptions

The thermostat schedules are in Chapter 4 Table R4-1 . An alternate set of internal gain schedules is used: one for the living areas of the house and one for the sleeping areas. Both standard schedules and schedules for zonal control are shown in Chapter 4.

Test Description

For this test, prototype A is divided into living and sleeping zones as shown in Figure R6-2. The boundary between the zones consists of a wall with U-value of 0.29 and net area of 360 ft^2. The wall contains an uncloseable opening of 40 ft^2, modeled with a U-value of 20.0 Btu/h-ºF-ft².

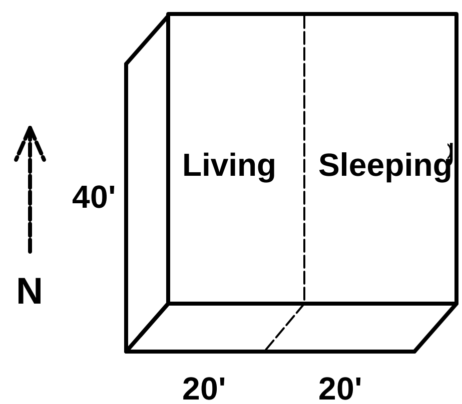


Figure R6-2 – Zoning the Prototype Building

Zonal control is added to prototype A as the discrete modification. The heating equipment AFUE is then reduced to find the passing solution and the failing solution as defined in Chapter 5. This test is performed in climate zones 3, 9, 12, 14, and 16. The CEC reference method must pass the passing solution and fail the failing solution.

The vendor shall also demonstrate that the ACM correctly defines the standard design building and calculates the custom budget correctly. The vendor shall create and run a standard design equivalent building in climate zone 12. In the standard design equivalent building, the proposed design and standard design TDV energy must equal each other. The standard design equivalent TDV energy must also equal the standard design energy for this test.

6.2.6 Sunspaces

Measure Description

A sunspace is a passive solar system consisting of an unconditioned space facing south or near south. The sunspace has a great deal of fenestration that collects solar energy and stores the energy in thermal mass elements such as a slab floor. The ACM must be capable of modeling two thermal zones in order for the sunspace feature to be approved.

Algorithms and Modeling Assumptions

Sunspaces shall be modeled as a separate, unconditioned thermal zone. An interzone vent separating the house from the sunspace is controlled to open only when temperature (T) conditions are $T_{house} < T_{desired}$ and $T_{sunspace} > T_{house}$ (in heating mode).

Assumptions for infiltration, heat capacity, solar gain targeting, and zone thermostat temperature settings vary from the conditioned zone. Internal gains in the sunspace are assumed to be zero. Sunspace zone infiltration is modeled using the air changes per hour method and the same infiltration of 0.50 air changes per hour. There are no restrictions on targeting solar gains that enter unconditioned spaces such as sunspaces.

Test Description

For this test, an unconditioned sunspace is added to the south side of Prototype A as illustrated in Figure R6-3 and Figure R6-4. The wall and window separating the sunspace and the house remain the same as in the base case, but the surfaces and vent openings of this wall are changed from exterior types to interzone types. The performance characteristics of sunspace envelope components are the same as for the basecase prototype. Total vent area is assumed to be 40 ft^2 with an eight foot height difference

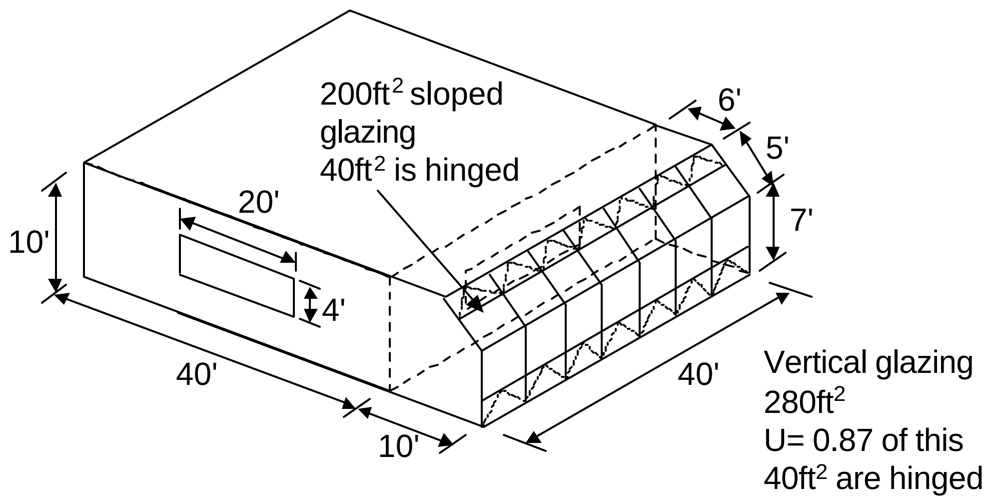


Figure R6-3 – Sunspace Prototype

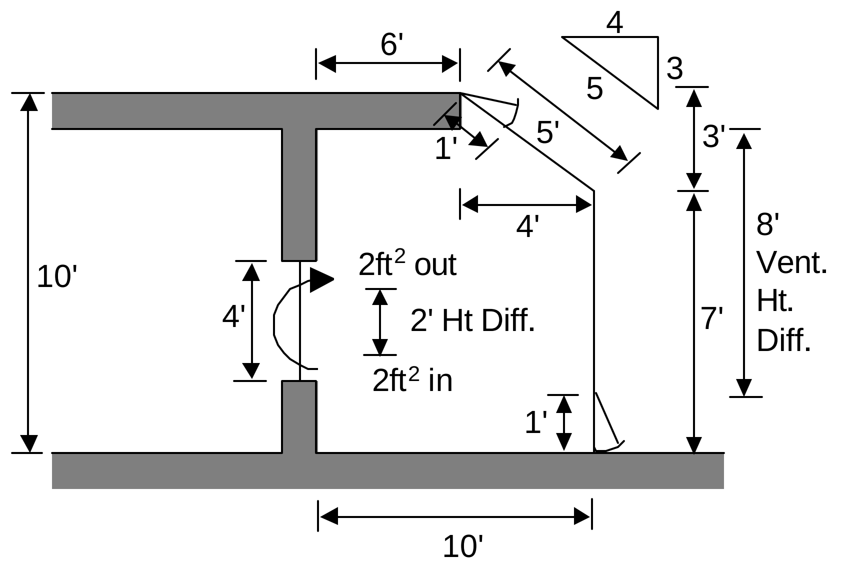


Figure R6-4 – Sunspace Section

The vendor must find the passing solution and failing solution in climates 3, 9, 12, 14, and 16 by varying the heating equipment AFUE. The CEC reference method shall pass the passing solution and fail the failing solution.

The vendor shall also demonstrate that the ACM correctly defines the standard design building and calculates the space conditioning custom budget. The vendor shall create and run a standard design equivalent building for climate zone 12. The standard design equivalent proposed design TDV energy must equal the standard design equivalent standard design TDV energy. These values shall also equal the standard design TDV energy for this test.

6.2.7 Exterior Mass Walls

Measure Description

Exterior mass walls are walls that are built with a heavy material that absorbs heat as the sun strikes it and releases the heat into the conditioned space after a period of time. Thermal mass has the effect of both dampening and delaying heat transfer.

Algorithms and Modeling Assumptions

The ACM must have the capability to model heat storage in exterior walls. The ACM must accept inputs on the thermal storage capacity of walls. For the CEC reference method, this input is heat capacity (HC) which is entered as Btu/ºF-ft². However, ACMs may take the input in other ways acceptable to the CEC.

Test Description

The test for exterior mass walls is made using prototype A in five climate zones: 3, 9, 12, 14, and 16. All of the exterior walls of the building are assumed to be of mass construction: The mass is assumed to be 12 inches thick with a volumetric heat capacity of 10 Btu/F-ft³ and a conductivity of 1.064. The outside surface of the mass wall is modeled with a U-value of 2.63 (R = 0.38) to approximate the effect of an air film. Insulation is assumed to be on the inside surface of the wall. The ACM vendor shall find the passing solution and the failing solution by varying the R-value of the interior insulation. The CEC reference method must pass the passing solution and fail the failing solution.

The ACM vendor shall also demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. The ACM vendor shall create and run a standard design equivalent building for climate zone 12. For the standard design equivalent building, the TDV energy for both the standard design and proposed design cases must be equal. They must also equal the TDV energy for the standard design case in this test.

6.2.8 Gas ~~Fired~~ Cooling

Measure Description

Gas ~~Fired~~ cooling provides an opportunity to reduce peak electric demand. ~~Two types of systems are available for residential applications: engine driven and absorption. With gas engine driven cooling the electric motor that would normally power the compressor is replaced by a gas reciprocating engine.~~ With gas absorption, a chemical process is used to provide cooling.

As a minimum capability, ACMs must be able to accept a COP input, and report the use of gas ~~fired~~ cooling in the *Special Features and Modeling Assumptions* section of the reports. The ACM user shall ~~must~~ also attach manufacturer's equipment specifications showing the COP95, CAP95 and PPC of the equipment ~~supporting calculations or worksheets of Commission approved methods~~.

Algorithms and Modeling Assumptions

Test Description

To determine the accuracy of modeling cooling ~~fired heat pumps~~ the ACM vendor shall perform the test listed in Table R6-1. ~~One test is for engine driven gas cooling and the other for absorption. In both cases, t~~The passing and failing solutions are determined by varying the fenestration U-factor.

6.3 Solar Thermal Water Heating

6.3.1 Overview

This section describes the acceptable methods for calculating the solar savings multiplier (SSM). Two methods are provided here and ACMs can become certified for one or both.

- The first method has limited scope. It may only be used for water heating systems serving individual dwelling units. In addition the solar system has to be rated by the Solar Rating and Certification Corporation (SRCC) with the OG 300 method.
- The second method is more general in scope and may be used for any active solar water heating systems in single family or multi-family buildings.

Energy benefits of solar water heating systems shall be calculated using the procedures described in ACM RG-2005. When a credit is taken for nondepletable energy, the ACM standard input reports must flag this and include a statement in the *Special Features and Modeling Assumptions* section of the reports. The ACM user must also attach SRCC documentation for the system or collectors used and either ~~supporting calculations or~~ Commission approved worksheets if the OG 300 method is used or an F-Chart computer run printout if the second method is used~~methods~~.

6.3.2 Integration in ACMs

Solar water heating calculation procedures may be integrated in residential ACMs or they may be stand-alone calculation procedures. The descriptions, algorithms, and test procedures described in this section apply to either case. Contact the CEC for information on how to obtain approval of a stand-alone solar water heating calculation procedure.

6.3.3 Water Heating Systems for Individual Dwellings Rated with the OG 300 Procedure

Measure Description

Residential solar systems can include many types of systems. The simplest system is the integrated collector storage (ICS) system which is basically a dark colored tank mounted behind glazing. Thermosyphon systems have a storage tank mounted above the collectors so that the fluid (usually water) can circulate naturally as it is heated in the collectors. Forced circulation systems use a pump to circulate a fluid from the storage tank to the collector. For forced circulation systems, the collectors may be located remotely from the storage tank.

All of these residential scale solar systems are rated by the Solar Rating and Certification Corporation (SRCC). The SRCC OG 300 procedure tests a complete system put together by the manufacturer, including the collectors, the pumps, controls, storage tanks and backup system (SRCC refers to the backup system as the auxiliary system). The OG 300 procedure uses the TRNSYS computer program to calculate the rating for the system as a whole and produces a Solar Energy Factor (SEF). The SEF is a unitless term and is meant to be compared to the energy factor (EF) published for conventional water heaters. Since the rated system includes the backup water heater, the SEF depends on whether the system was rated with electric or gas backup. It also accounts for the efficiency of the backup system. The SRCC publishes data on all systems and collectors hat have been rated.

Algorithms and Modeling Assumptions

Modeling assumptions and algorithms are documented in ACM RG-2005.

Eligibility Criteria

In order to use the OG-300 method, the system must satisfy the following eligibility criteria:

- The collectors must face within 35 degrees of south and be tilted at a slope of at least 3:12.
- The system must be installed in the exact configuration for which it was rated, e.g. the system must have the same collectors, pumps, controls, storage tank and backup water heater fuel type as the rated condition.
- The system must be installed according to manufacturer’s instructions .
- The collectors shall be located in a position that is not shaded by adjacent buildings or trees between 9:00 AM and 3:00 PM (solar time) on December 21.

Test Description

To determine the accuracy of modeling solar systems using the OG 300 method the ACM vendor shall perform the test listed in table R6-4. The ACM vendor modifies the gas water heating base case and reports the solar savings fraction (SSF) for both the proposed design and the standard design. The CEC reference method shall predict a SSF energy within 5% of the candidate ACM.

Table R6-4 – OG-300 Solar Systems Tests

Type	*Test*	*Prototypes*	*Climates*	*Optional Capability (Discrete Modification(s))*
SS	1	A	3, 9, 12, 14, 16	**Solar System with Electric Backup.** Add a solar system with electric backup that has a SEF of 2.0.
SS	2	A	3, 9, 12, 14, 16	**Solar System with Gas Backup.** Add a solar system with gas backup that has a SEF of 1.0

6.3.4 Water heating Systems for Individual Dwellings or Multi-Family Buildings Based on Collector Tested Using the OG-100 Procedure

Measure Description

The solar thermal systems described in this section have general applicability for water heating applications. They may be used for multi-family or single family water heating systems. Any solar water heating system that uses forced circulation, and collectors rated under the SRCC OG-100 method can use this approach. Situations where this approach might be used are: a single family residences with large hot water demand, solar water heating systems for multi-family buildings, and where a single family system cannot meet the eligibility criteria for OG 300 rated systems.Minimum Reports

A report shall be created that includes the parameters listed in Table R6-5 and Table R6-6.

Prototype

For this series of tests thermal loads and water heating budget shall be based on water heating prototype E (see chapter 5).

Table R6-5 – Prototype Solar System

Parameter	Value
Collector Slope	4:12
Collector Azimuth	180 º (due south)
Collector Area	Four collectors as described below.
Collector Performance (OG 100)	SRCC Certification Number 100-1998-0018 Yint = 0.530, Slope = -0.250 Btu/h-ft²-ºF, A = 32.9 ft²
Storage Tank Size	500 gallons
Pumping	¼ hp pump between collectors and storage tank
Freeze Control	Drain-down
Add more as needed	<Rob>

Algorithms and Modeling Assumptions

The CEC reference method is based on the F-Chart procedure, which is available from multiple sources. Modeling inputs and limits for the F-Chart reference method are defined in ACM RG-2005.

Test Description

To determine the accuracy of modeling solar systems using the SRCC OG100 method, the vendor of the integrated ACM or stand-alone solar application shall perform the test listed in Table R6-6. The integrated ACM or stand-alone solar application shall predict a solar savings fraction (SSF) for the cases in Table R6-6 within plus or minus 3% of the SSF predicted by the CEC reference method.

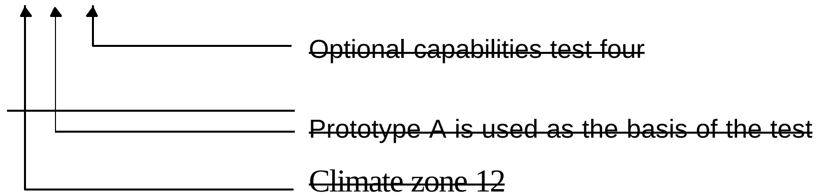
Table R6-6 – OG 100 Solar System Tests

Type	Test	Prototypes	Climates	Optional Capability (Discrete Modification(s))
SS	3	ºF	All	**Basecase.** The basecase solar system with the schedule of loads shall be simulated in all climate zones.
SS	4	ºF	3, 9, 12, 14, 16	**Collector Orientation.** Vary the orientation of the collectors from due south (the basecase) to 45 degrees east of south.
SS	5	ºF	3, 9, 12, 14, 16	**Collector Slope.** Change the collector slope from the 4:12 pitch in the basecase to 12:12.
SS	6	ºF	3, 9, 12, 14, 16	**Collector Performance. Substitute the following collector.** SRCC Certification Number 100-1981-0085A Yint = 0.737, Slope = -0.805 Btu/h-ft²-ºF, A = 32.3 ft²
SS	7	ºF	3, 9, 12, 14, 16	**Collector Area.** Double the number of collectors
SS	8	ºF	3, 9, 12, 14, 16	**Storage Tank Size.** Reduce the storage tank size To 200 gallons.
SS	10	ºF	3, 9, 12, 14, 16	**Circulation Pump.** Increase the size of the circulation pump from ¼ hp to ½ hp.
SS	11	ºF	3, 9, 12, 14, 16	**Freeze Control.** Change the freeze control from drain-down to glycol.

Optional Capabilities Tests

This section of the Manual explains the tests that must be performed in order for residential ACMs to be approved for optional capabilities. Most of the tests are performed relative to one of the prototype buildings identified in the previous section. Each computer run used to test the minimum space conditioning capabilities is given a precise designation to make it easier to keep track of the runs and to facilitate analysis. Optional capabilities tests begin with the test number "51". The following scheme is used:

12 E 51



~~*6.1Controlled Ventilation Crawl Spaces (CVC)*~~

~~Controlled ventilation crawl spaces is an optional capability based on the ability of an ACM to model more than one thermal zone. The crawl space of the building is modeled as a separate, unconditioned thermal zone. Details of the test model are provided in Appendix C, test file 12B51. Some key features are summarized below.~~

~~The CVC zone has an exterior perimeter length and floor area (i.e., the ground area) equal to the prototype building B perimeter and floor area. Crawlspace volume is 3467 ft~~^{3}~~. CVC infiltration is modeled using the air changes per hour method and uses 0.22 air changes per hour.~~

~~The floor separating the crawl space from conditioned space becomes an interzone boundary. 400 ft2 of this floor has a U-value of 0.342, representing an uninsulated, uncarpeted floor, and the remainder has a U-value of 0.199, representing an uninsulated, carpeted floor.~~

~~Insulation is placed in the perimeter walls of the crawl space, and the crawl space vents are modeled with automatic seasonally operated louvers to minimize ambient conditions within the crawl space. When the building is in a heating mode, the vents are closed (inlet and outlet are zero). When the building is in a cooling mode, the vents are open and the total vent area is 1/150 of the crawlspace floor area or 10.67 ft2. Half of this is inlet and half outlet. The ventilation height difference is zero. Only wind effects apply. Wind speed is reduced to 25% of that on the weather tape to account for ground level conditions. Heat capacity in the crawlspace is 1.4 Btu/F-ft2.~~

~~When insulation is placed in the perimeter walls of the crawl space in lieu of the floor assembly, other requirements are triggered for builders. The definition of "controlled ventilation crawlspace", in the glossary of the *Residential Manual*, should be consulted for more details.~~

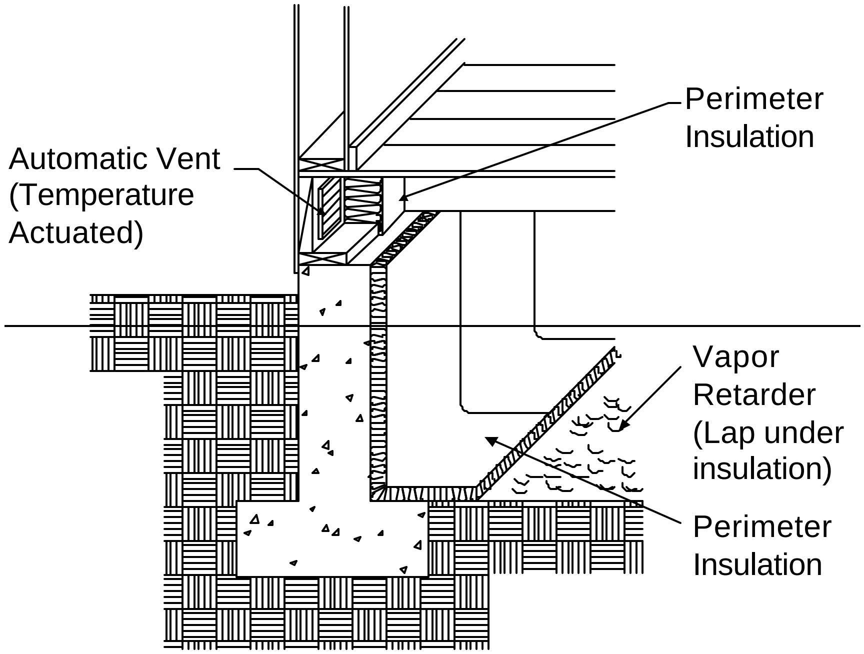


Figure 6-1 - Section at Crawlspace Perimeter

CVC is tested only for prototype building B in five climate zones: 3, 9, 12, 14 and 16. CVC is added and the heating efficiency is modified accordingly. Each computer run must result in greater energy use than the prototype B basecase building. The computer runs are summarized below. *Total of five runs.*

Table 6-1 - Controlled Ventilation Crawlspace Test Inputs

Run Label	CVC	Heating AFUE
03B51	yes	0.63
09B51	yes	0.43
12B51	yes	0.64
14B51	yes	0.69
16B51	yes	0.74

The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12B51" are equal. The standard design equivalent building is included in Appendix C and labeled "12B51C".

6.2 Zonal Control

Zonal control is one of the optional capabilities based on the ability of an ACM to model more than one thermal zone at the same time. With zonal control, the sleeping and living areas are modeled separately, each with its own separate thermostat schedule and internal gain assumptions. The specifications for the building with zonal control are detailed in CALRES input test file 12A52 available from the Commission on diskette. Further discussion is provided in the Residential Manual, in Section 8.9, and in the glossary under "zonal control". Key features are discussed below.

6.2.1 Prototype Zones

Figure 6-2 depicts the prototype building separated into living and sleeping zones. The boundary between the zones consists of a wall with U-value of 0.29 and net area of 360 square feet. The wall contains an uncloseable opening of 40 square feet, modeled with a U-value of 20.0.

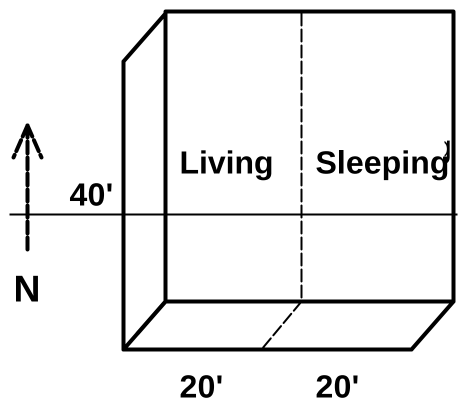


Figure 6-2 - Zoning the Prototype Building

6.2.2 Thermostats

The thermostat schedule for the living area is the same as the standard assumptions except that the cooling setpoint is 83°F between 11:00 pm and 7:00 am.

The thermostat schedule for the sleeping area has two heating setback periods: between 11:00 pm and 7:00 am and between 8:00 am and 9:00 pm. The cooling thermostat has one setup period to 83°F, between 8:00 am and 9:00 pm. The thermostat schedules for zonal control are shown in Table 6-1 below.

Table 6-2 - Zonal Control Thermostat Set Points

Hour	Heating	Cooling	Hour	Heating	Cooling	Hour	Heating	Cooling
Living Areas								
1	60	83	9	68	78	17	68	78
2	60	83	10	68	78	18	68	78
3	60	83	11	68	78	19	68	78
4	60	83	12	68	78	20	68	78
5	60	83	13	68	78	21	68	78
6	60	83	14	68	78	22	68	78
7	60	83	15	68	78	23	68	78
8	68	78	16	68	78	24	60	83
Sleeping Areas								
1	60	78	9	60	83	17	60	83
2	60	78	10	60	83	18	60	83
3	60	78	11	60	83	19	60	83
4	60	78	12	60	83	20	60	83
5	60	78	13	60	83	21	60	83
6	60	78	14	60	83	22	68	78
7	60	78	15	60	83	23	68	78
8	68	83	16	60	83	24	60	78

6.2.3 Internal Gains

Total internal gains are split between the living areas and the sleeping areas as indicated in the following equations.

Equation 6-1

$$Int\text{-}Gain_{living} = (20{,}000) + (15 \times CFA_{living})$$

Equation 6-2

$$Int\text{-}Gain_{sleeping} = 15 \times CFA_{sleeping}$$

An alternate set of internal gain schedules are used: one for the living areas of the house and one for the sleeping areas. These alternate schedules are shown in Table 6-3.

Table 6-3 - Internal Gain Schedules for Zonal Control

Hour	Percent	Hour	Percent	Hour	Percent
Living Areas					
1	1.61	9	6.33	17	6.19
2	1.48	10	6.86	18	7.18
3	1.14	11	6.38	19	7.24
4	1.13	12	5.00	20	5.96
5	1.21	13	4.84	21	5.49
6	1.46	14	3.15	22	6.20
7	2.77	15	2.94	23	4.38
8	5.30	16	3.41	24	2.35
Sleeping Areas					
1	4.38	9	3.76	17	4.47
2	4.02	10	3.85	18	4.45
3	4.50	11	4.70	19	4.29
4	4.50	12	3.61	20	3.30
5	4.32	13	3.65	21	3.75
6	5.46	14	2.63	22	3.75
7	6.39	15	2.46	23	4.45
8	7.40	16	2.32	24	3.59

6.2.4 Tests

The zonal control feature is tested only for prototype A in five climate zones: 3, 9, 12, 14 and 16. Zonal control is added and the heating efficiency is modified accordingly. Each computer run must result in greater energy use than prototype A. The computer runs are summarized in Table 6-4 below. *Total of five runs.*

Table 6-4 - Zonal Control Test Inputs

Run Label	Zonal Control	Heating AFUE
03A52	yes	0.74
09A52	yes	0.55
12A52	yes	0.68
14A52	yes	0.68
16A52	yes	0.73

The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12A52" are equal. The standard design equivalent building is included in Appendix C and labeled "12A52C".

6.3Sunspaces

Sunspace modeling is one of the optional capabilities based on the ability of an ACM to model more than one thermal zone at the same time. The sunspace of the building is modeled as a separate, unconditioned thermal zone. The specifications for the test building are detailed in the CALRES input test file 12A53 available from the Commission on diskette, and key features are highlighted below.

An unconditioned sunspace is added to the south side of Prototype A as illustrated inFigure 6-3 and Figure 6-4. The wall and window separating the sunspace and the house remains the same as in the base case, but the surfaces and vent openings of this wall are changed from exterior types to interzone types. The interzone vent is controlled to open only when temperature (T) conditions are $T_{house} < T_{desired}$ and $T_{sunspace} > T_{house}$ (in heating mode).

The performance characteristics of sunspace envelope components are the same as for the basecase prototype, except slab F2-value is 0.90; fenestration shading coefficient is 0.90, no internal shading device is assumed. Total vent area is assumed to be 40 ft2 with an eight foot height difference

In the sunspace zone, assumptions for infiltration, heat capacity, solar gain targeting, and zone thermostat temperature settings vary from the conditioned zone. Sunspace zone infiltration is modeled using the air changes per hour method and the same infiltration factors as used in the 1988 ACM manual, 0.50 air changes per hour. There are no restrictions on targeting solar gains that enter unconditioned spaces such as sunspaces.

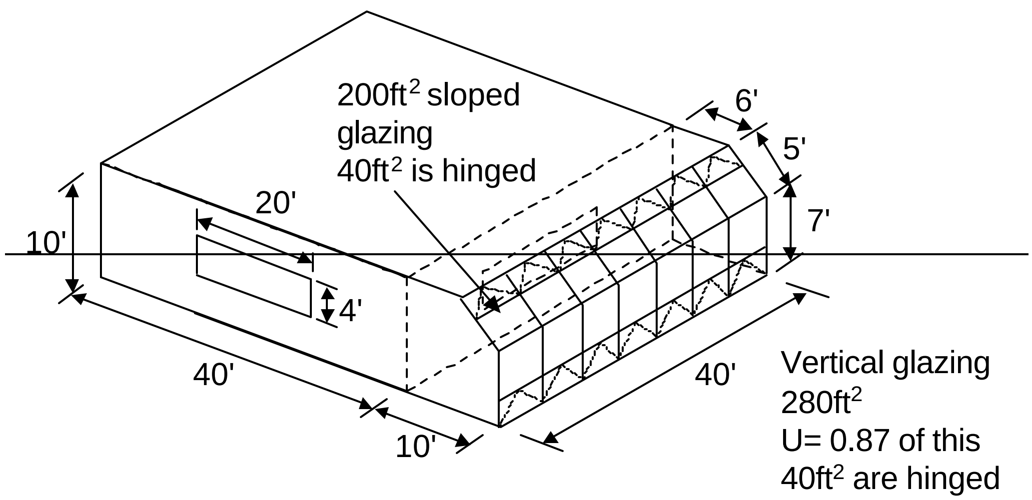


Figure 6-3 -- Sunspace Prototype

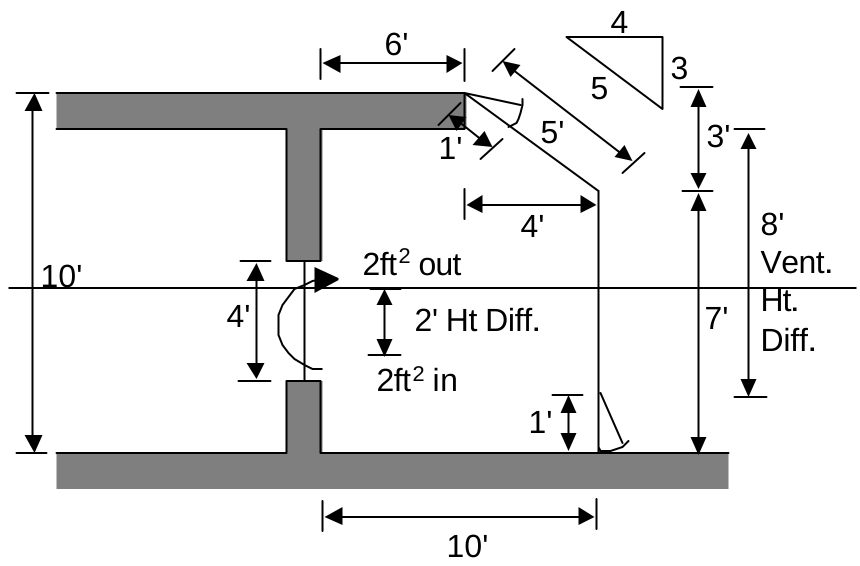


Figure 6-4 - Sunspace Section

Sunspaces are tested only for prototype A in five climate zones: 3, 9, 12, 14 and 16. A sunspace is added and the heating efficiency is modified accordingly. Each computer run must result in greater energy use than prototype A. The computer runs are summarized below. *Total of five runs.*

Table 6-5 – Sunspace Test Inputs

Run Label	Sunspace	Heating AFUE
03A53	Yes	0.55
09A53	Yes	0.29
12A53	Yes	0.54
14A53	Yes	0.54
16A53	Yes	0.64

The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12A53" are equal.

6.4Side Fin Shading

Testing for side fins is performed relative to a modification of prototype A; the base building is rotated 30 degrees to the west. The test is performed in five climate zones: 3, 9, 12, 14 and 16. The specifications for the side fins are provided on the Commission's CALRES input file diskette as , test file 12A54. Key features are covered below.

The side fins extend 40 feet from the surface of a window that is assumed to be 10 feet wide. The fins are 5 feet from the edge of the window. The top of the side fins are 20 feet above the top of the window. Side fins are separately added to the east and west sides of the building and the heating efficiency is modified accordingly. Each computer run must result in greater energy use than prototype A. *Total of five runs.*

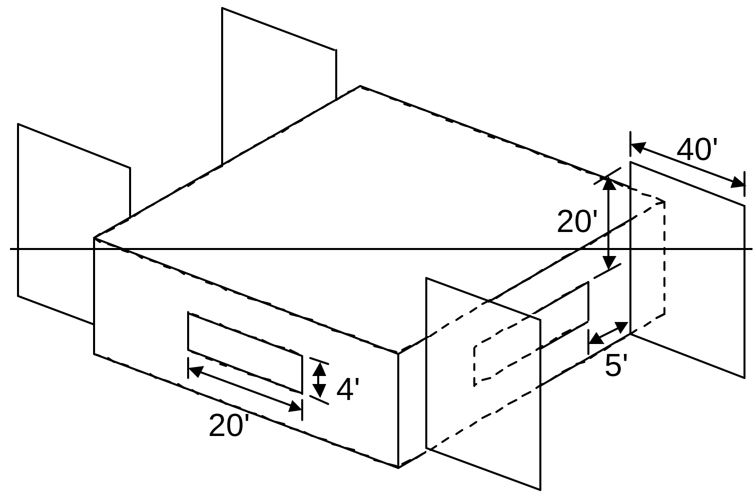


Figure 6-5 - Side Fins for Optional Capabilities Test

Table 6-6 - Side Fin Test Inputs

Run Label	Side Fins	Heating AFUE
03A54	Yes	0.65
09A54	Yes	0.40
12A54	Yes	0.62
14A54	Yes	0.65
16A54	Yes	0.70

The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12A54" are equal. The standard design equivalent building is included on the CALRES diskette as the input file labeled "12A54C".

6.5Exterior Mass Walls

The test for exterior mass walls is made relative to prototype A in five climate zones: 3, 9, 12, 14 and 16. All of the exterior walls of the building are assumed to be of mass construction: The mass is assumed to be 12 inches thick with a volumetric heat capacity of 10 Btu/F-cf and a conductivity of 1.064. The outside surface of the mass wall is modeled with a U-value of 2.63 (R = 0.38) to approximate the effect of an air film. Insulation is assumed to

~~be on the inside surface of the wall. This insulation is varied for each climate zone. Each computer run must result in greater energy use than prototype E. *Total of five runs.*~~

~~Table 6-7 – Exterior Mass Wall Inputs~~

~~Run Label~~	~~Exterior Mass Walls~~	~~Interior R-value~~
~~03A55~~	~~yes~~	~~4.20~~
~~09A55~~	~~yes~~	~~1.20~~
~~12A55~~	~~yes~~	~~3.575~~
~~14A55~~	~~yes~~	~~4.825~~
~~16A55~~	~~yes~~	~~6.95~~

~~The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12A55" are equal. The standard design equivalent building is included as the input file labeled "12A55C" on the CALRES input file diskette.~~

6.6 Optional Water Heating Capabilities Tests

6.6.1 Solar and Wood Stove Boiler Water Heating

Optional water heating capabilities include solar water heating and wood stove boiler-assisted water heating. Energy credit may be taken for the use of these technologies through the use of multipliers that adjust the water heating loads. For solar this adjustment is the Solar Savings Fraction (SSFj) derived from an f-Chart analysis and for wood stove boilers this adjustment is called the Wood Stove Adjustment Factor (WSAFj). These adjustments are used as shown in Section 4.21

6.6.2 Combined Hydronic Space/Water Heating

Combined hydronic space/water heating is a system whereby a water heater is used to provide both space heating and water heating. Hydronic systems or water heaters dedicated solely to space heating are covered in Section 6.6.3.

For combined hydronic systems, an effective AFUE, or for electric water heaters or heat pumps, an effective HSPF, is calculated and used in the space heating energy calculations. When a fan coil is used to distribute heat, the fan energy and the heat contribution of the fan motor must be considered. This shall automatically be added when the distribution type is "ducts". The effective AFUE or HSPF is calculated according to the following equations for each water heater type.

6.6.2.1 Storage Gas Water Heater

When storage gas water heaters are used in combined hydronic applications and there is no air distribution fan, then the effective AFUE is given by the following equation.

Equation 6-3

$$AFUE_{eff} = RE - \frac{PL}{RI}$$

Where

$AFUE_{eff}$ = The effective AFUE of the gas water heater in satisfying the space heating load.

RE = The recovery efficiency of the gas water heater. A default value of 0.76 may be assumed if the recovery efficiency is unknown.

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements is located in unconditioned space.

Equation 6-4

$$PL = \sum_{i=1}^{n} \frac{FT_i \times PLR_i}{8760}$$

RI = The rated input of the gas water heater (kBtu/h).

When there is an air distribution fan, then the energy used by the fan and the heat contributed by the fan is considered in the same manner as it is for a furnace (see Section 4.18)

6.6.2.2Storage Electric Water Heater

The HSPF of storage water heaters used for space heating in a combined hydronic system is given by the following equations. If the system has a fan coil, the $HSPF_{eff}$ is used. $HSPF_{w/o\_fan}$ is used if there is no fan coil.

Equation 6-5

$$HSPF_{eff} = \frac{1+.005(3.413)}{\left[\frac{1}{HSPF_{w/o\_fan}}\right]+.005}$$

Equation 6-6

$$HSPF_{w/o\_Fan} = 3.413\left[\frac{1-\frac{PL}{3.413kWi}}{1+\frac{W_{PUMP}}{1000kWiI}}\right]$$

Where:

$HSPF_{eff}$ = The effective HSPF of the electric water heater in satisfying the space heating load.

W_{pump} = The watts of the pump which circulates water between an electric storage water heater and the fan coil

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements is located in unconditioned space.

kWI = The kilowatts of input to the water heater.

6.6.2.3 Heat Pump Water Heater

The HSPF of heat pump water heaters used for space heating in a combined hydronic system is given by the following equations. If the system has a fan coil, the $HSPF_{eff}$ is used. $HSPF_{w/o\_fan}$ is used if there is no fan coil.

Equation 6-7

$$HSPF_{eff} = \frac{1+.005(3.413)}{\left[\frac{1}{HSPF_{w/o\_fan}}\right]+.005}$$

Equation 6-8

$$HSPF_{w/o\_Fan} = 3.413\left(\frac{RE_{hp}}{CZ_{adj}} - \frac{PL}{3.413kWi}\right)$$

Where:

$HSPF_{eff}$ = The effective HSPF of the heat pump water heater in satisfying the space heating load.

RE_{hp} = The recovery efficiency of the heat pump water heater. The following equation may be used as a default if the recovery efficiency is not known.

Equation 6-9

$$\mathrm{RE}_{\mathrm{hp}} = \frac{1}{\frac{1}{EF_{DOE}} - 0.1175}$$

CZ_{adj} = The climate zone adjustment (see water heating calculation method) (see Table 4-9).

PL = Pipe losses (kBtu/h). This can be assumed to be zero when less than 10 feet of the piping between the water heater storage tank and the fan coil or other heating elements is located in unconditioned space.

kWI = The kilowatts of input.

EF_{DOE} = The energy factor of the heat pump water heater when tested according to the DOE test procedure.

6.6.2.4 Pipe Losses

Pipe losses must be considered when pipes between the water heater storage tank and the fan coil or other heating element are located in unconditioned space. To simplify compliance, pipe losses can be ignored when no more than ten feet of pipe (in plan view) is located in unconditioned space. Hourly loss rates are given by the following equation.

Equation 6-10

—

PL = Hourly pipe loss (kBtu/h).

PLR_i = The annual pipe loss rate per foot of length for the i^{th} pipe (kBtu/y-ft).

FT_i = The length in feet of the i^{th} pipe located within unconditioned space. Can be assumed to be zero if less than ten feet in plan view.

n = The number of unique pipe size or insulation conditions.

The annual pipe loss rate per foot of length (PLRi) is calculated from the following equation

$$PLR_i = 8.76\left(\frac{T_s - T_a}{\frac{\ln\left(\frac{D_{io}}{D_{po}}\right)}{2\pi Ki} + \frac{1}{\pi\, ha\, D_{io}}}\right)$$

Where

8.76 = Conversion factor from Btu/hour to kBtu/year

T_s = Supply Temperature. This is assumed to be a constant 135 F.

T_a = Ambient Temperature. This is assumed to be 60.3 in all California climate zones.

D_{io} = Outside diameter of insulation. ft (actual not nominal).

D_{po} = Outside diameter of pipe, ft (actual not nominal).

Ki = Insulation conductivity, constant 0.023 Btu/h-ft-F

ha = Air film coefficient, constant 1.65 Btu/h-ft^2-F

Pipe loss rates (PLR) values for typical conditions are shown in the table below

Table 6-8 Annual Pipe Loss Rates (kBtu/y-ft)

		Insulation Thickness		
Nominal Pipe Size	None	1/2 inch	3/4 inch	1 inch
1/2 inch		71.6	60.9	54.2
3/4 inch		91.1	75.8	66.6
1 inch		109.9	90.1	78.1
1 - 1/2 inch		146.7	117.5	100.3
2 inch		182.9	144.3	121.7

6.6.2.5Tests

Prototype A is used for this test, but combined hydronic systems are substituted for the gas furnace in the basecase. Three types of combined hydronic systems are tested -- labeled K, L and M.

K A 75 gallon storage gas water heater is used for both space conditioning and water heating. Hot water base boards are used for heat distribution and insulated pipes are located in unconditioned space.

L An electric water heater is used for both space conditioning and water heating and air is distributed through a fan coil system that delivers air to ducts located in an attic.

M An electric heat pump is used for both space conditioning and water heating. Distribution is provided through hot water baseboards. All pipes are located within conditioned space.

The specifications for these three systems are shown in Table 6-9 below. The AFUEeff and HSPF w/o fan must match the values shown in the table.

Table 6-9 -Combined Hydronic Test Results

		K	L	M
Water Heater Type		SG	SE	HP
Recovery Efficiency	unitless	0.7800	n.a.	n.a.
Rated Input	kBtu/sf	60.0000	n.a.	n.a.
Rated Input	kW	n.a.	5.0000	n.a.
Wpump	W	n.a.	60.0000	n.a.
EF	unitless	n.a.	n.a.	2.0000
Pipe Length	ft	100.0000	n.a.	n.a.
Run Label		AFUEeff	HSPF w/o fan	HSPF w/o fan
03A56		0.768	3.37	9.01
09A56		0.768	3.37	9.70
12A56		0.768	3.37	8.34
14A56		0.768	3.37	8.58
16A56		0.768	3.37	5.95

The optional capability test also requires that the vendor demonstrate that the ACM correctly defines the standard design building and calculates the custom budget. This test involves running the standard design equivalent building for climate zone 12 and showing that the custom budget figures from computer run "12A56" are equal. The standard design equivalent building is included in Appendix D and labeled "12A56C".

6.6.3 Dedicated Hydronic Systems

Dedicated hydronic systems have boilers or other heating devices which produce hot water that is distributed through the building for heating. Such systems are permitted when the AFUE is known and can be entered. If the systems have pipes located in unconditioned space, then the AFUE must be adjusted for the pipe losses.

When water heaters are used in hydronic systems for space heating alone (a separate water heater for domestic service), the water heater functions as a boiler and is required by NAECA to have a minimum AFUE of 0.80. The AFUE of a water heater if tested as a boiler would be approximately equal to the average of the EF and the RE, and will generally not meet the minimum NAECA requirement. Water heaters proposed for use in hydronic systems for space heating only must be tested as a boiler using the DOE AFUE and appropriate safety standard test procedures.

6.7 Building Additions

The low-rise residential Building Energy Efficiency Standards permit two ways of analyzing building additions using the performance approach. The addition may be analyzed alone, in which case the internal loads are prorated on a floor area basis. Alternatively, the addition may be analyzed together with the existing house. This second method permits improvements to be made to the existing house which may allow the building addition to have more glass or less insulation.

6.7.1 Addition Alone

When the addition is analyzed alone, the internal loads are prorated on a floor area basis in both the standard design and the proposed design runs. The total internal gain is based on the fractional dwelling unit value, which is used as the "Number-Dwelling-Units" in Equation 4.3 (see Section 4.5). An addition alone may not be modeled as zonal control.

Equation 6-11

$$IntGainAdd = IntGainTotal \times FractionalDwellingUnit$$

$$FractionalDwellingUnit = CFAadd \div (CFAadd + CFAexisting)$$

6.7.2 Addition Plus Existing

When the building addition is analyzed together with the existing building, the procedure described in Chapter 6 of the *Residential Manual*, is followed.

It is necessary to manage information about the existing building and the addition in four categories as described below. These may be grouped in each table or separate C-2R forms may be generated for each category of information.

1. Features of the existing building that will not be upgraded or changed.
2. The current condition of existing building features that will be modified or upgraded.
3. The improved condition of existing building features that are upgraded. The total surface areas in this category will usually be less than those in the second category because an existing wall is usually eliminated where the addition is attached to the existing building.
4. Features of the proposed building addition.

6.8 Solar Water Heating and Space Heating

Modeling of solar water heating and space heating systems is not an optional capability for residential ACMs, but ACMs must provide an input for the energy provided by solar or other nondepletable sources. These inputs are described in Chapter 4.

The Commission has approved the use of various versions of the f-Chart program for analyzing active solar systems. These programs may be used to estimate the energy credit to enter in the ACM. Guidelines for the use of f-Chart are included in Chapter 7 of the *Residential Manual*.

This Manual does not address approval of solar analysis programs. The application package for approval of solar water heating and space conditioning programs is included as Appendix G.

When a credit is taken for nondepletable energy, the ACM standard input reports must flag this and include a statement in the *Special Features and Modeling Assumptions* section of the reports. The ACM user must also attach supporting calculations or worksheets of Commission approved methods.

6.9Form 3 Report Generator

This test requires that ACMs correctly calculate the U-value of several construction assemblies. These construction assemblies are shown in Appendix E. The Form 3 generator must produce the values indicated in Table 6-10 for U-value. Construction assembly U-values must be calculated in a manner consistent with the manner and examples shown in the *Residential Manual*, in the glossary under "R-value" and "U-value", and in Appendix E.

Table 6-10 - Form 3 Generator Results

Construction Assembly Code	U-value
W.19.2x6.16	.065
R.38.2x4.24	.025
R.22.2x4.24	.041
RP.22.2x6.48	.044
FC.30.2x10.16	.028
FX.30.2x10.16	.034

6.10Exceptional Methods Which May Be Approved In The Future

The Commission may approve additional Exceptional Methods in the future, for instance, additional water heating credits. All approved ACMs must provide an input for space heating, space cooling and water heating systems to allow the user to enter a value for these possible credits. The ACM standard reports identify all non-zero values and place a statement in the *Special Features and Modeling Assumptions* section of the standard reports. The ACM user must include supporting calculations, worksheets or equipment specifications with the building permit application.