Energy

Deconstructing the 2013 Title 24 Residential Appendices and ACM for Better Modeling

CABEC Conference 2014

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10-9-14

Introduction

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Session Learning Objectives

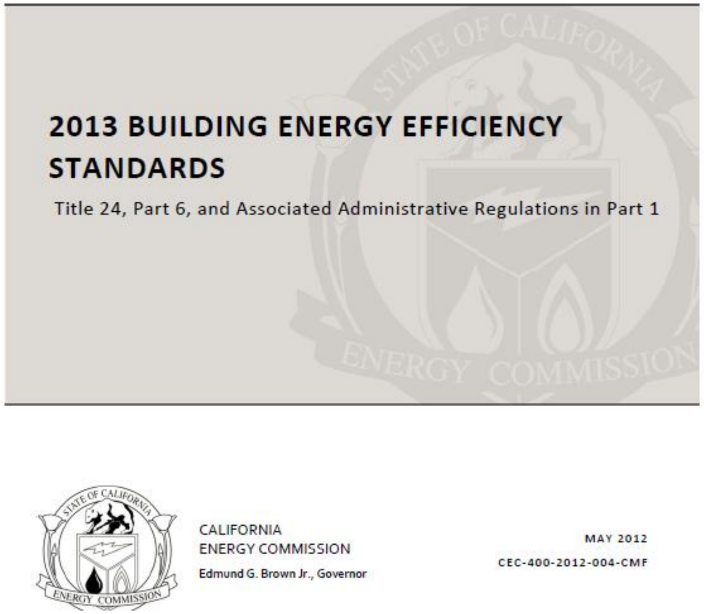
- Improved knowledge of lesser known 2013 Residential Title 24 Documents
  - Focus primarily on updates to 2013 Residential ACM
  - Know ***where*** to look up information
- Improved understanding of compliance software inputs and their impact on results
- Introduction to algorithims

NOT Session Learning Objectives

- Comprehensive review of all defaults, fixed assumptions in standard and proposed buildings and algorithims
- Software demo or list of implemented capabilities, and limitations, of the currently approved Residential ACM software programs
  - CBECC-RES
  - EnergyPro v6.3
  - Right-Energy Title 24 v1.1

2013 Title 24 Documents

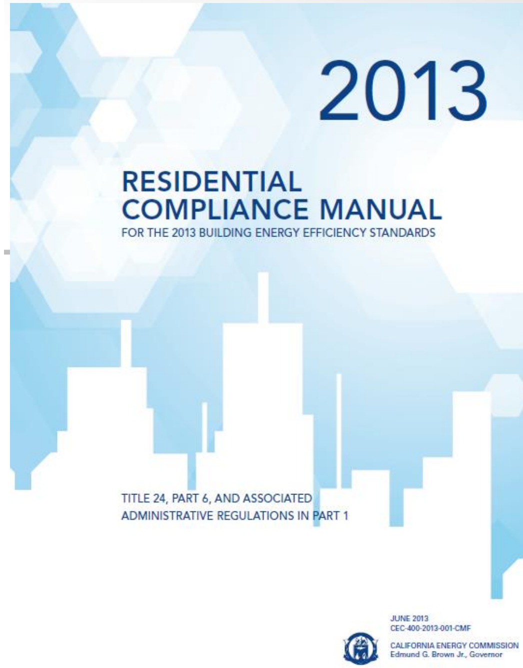
- 2013 Building Energy Efficiency Standards
- Residential Compliance Manual
- Non-residential Compliance Manual
- Reference Appendices
- Residential Alternative Calculation Method Reference Manuals and Algorithims
- Non-residential Alternative Calculation Method Reference Manuals and Algorithims


2013 BUILDING ENERGY EFFICIENCY STANDARDS

Title 24, Part 6, and Associated Administrative Regulations in Part 1

CALIFORNIA
ENERGY COMMISSION
Edmund G. Brown Jr., Governor

MAY 2012
CEC-400-2012-004-CMF


2013

RESIDENTIAL COMPLIANCE MANUAL
FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS

TITLE 24, PART 6, AND ASSOCIATED ADMINISTRATIVE REGULATIONS IN PART 1

JUNE 2013
CEC-400-2013-001-CMF

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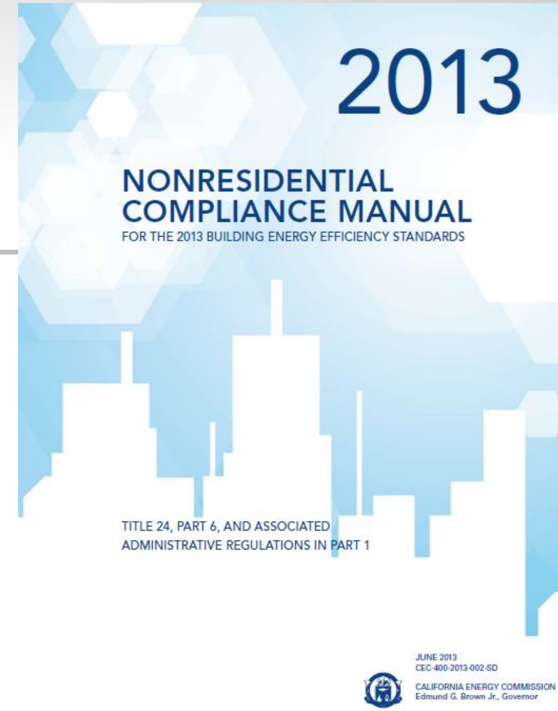
2013

NONRESIDENTIAL COMPLIANCE MANUAL
FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS

TITLE 24, PART 6, AND ASSOCIATED ADMINISTRATIVE REGULATIONS IN PART 1

JUNE 2013
CEC-400-2013-002-SD

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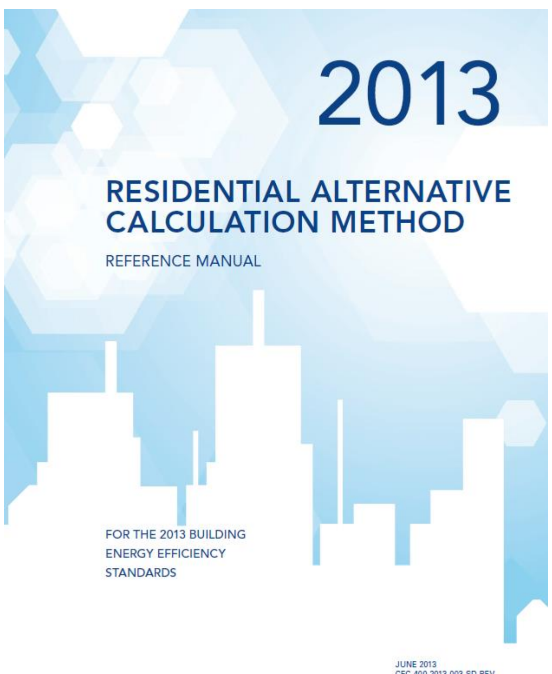
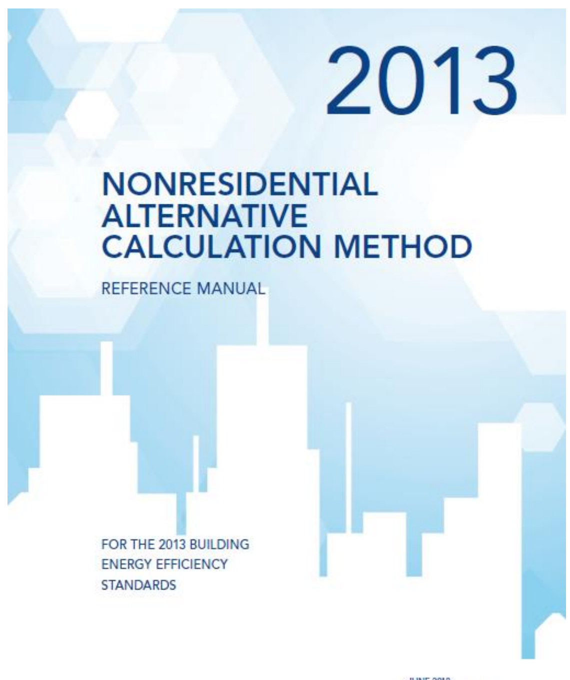

2013

RESIDENTIAL ALTERNATIVE CALCULATION METHOD

REFERENCE MANUAL

FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS

JUNE 2013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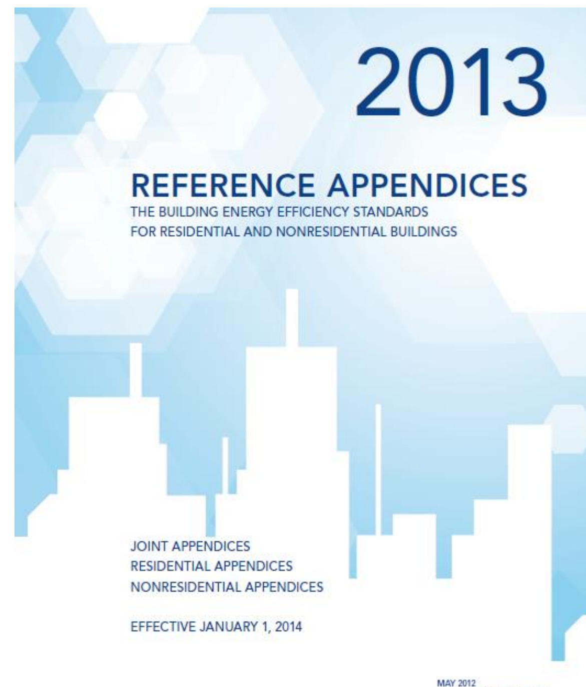
NONRESIDENTIAL ALTERNATIVE CALCULATION METHOD

REFERENCE MANUAL

FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS


2013

REFERENCE APPENDICES
THE BUILDING ENERGY EFFICIENCY STANDARDS
FOR RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

JOINT APPENDICES
RESIDENTIAL APPENDICES
NONRESIDENTIAL APPENDICES

EFFECTIVE JANUARY 1, 2014

MAY 2012

2013 Title 24 Residential Reference Appendices

- RA1 – Special Case Residential Field Verification and Diagnostic Test Protocols .
- RA2 – Residential HERS Verification, Testing, and Documentation Procedures
- RA3 – Residential Field Verification and Diagnostic Test Protocols
- RA4 – Eligibility Criteria for Energy Efficiency Measures

Table RA2-1 Summary of Measures Requiring Field Verification and Diagnostic Testing

- Essentially a list of measures you can recommend for your projects (if not mandatory measure that is)

Table RA2-1 – Summary of Measures Requiring Field Verification and Diagnostic Testing

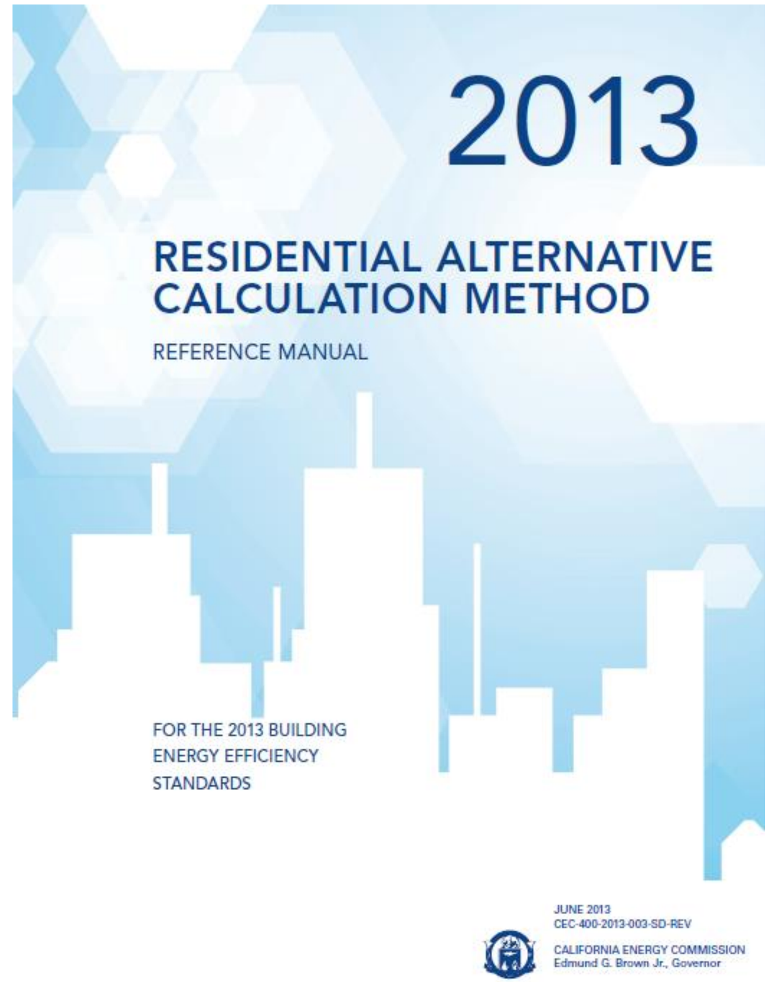
Measure Title	Description	Procedure(s)
	Duct Measures	
Duct Sealing	Component Packages require that space conditioning ducts be sealed. If sealed and tested ducts are claimed for compliance, field verification and diagnostic testing is required to verify that approved duct system materials are utilized, and that duct leakage meets the specified criteria.	RA3.1.4.3
Supply Duct Location, Surface Area and R-value	Compliance credit can be taken for improved supply duct location, surface area and R-value. Field verification is required to verify that the duct system was installed according to the design, including location, size and length of ducts, duct insulation R-value and installation of buried ducts.[1] For buried ducts measures, Duct Sealing and High Quality Insulation Installation (QII) is required.	RA3.1.4.1
Verification of ducts located entirely in directly conditioned space, and	When the Standards specify use of the procedures in Section RA3.1.4.3.8 to determine if space conditioning system ducts are located entirely in directly conditioned space, the duct system location shall be verified by diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the	RA3.1.4.3.8

Appendix RA4 – Eligibility Requirements for Energy Efficiency Measures

- RA4.1 Purpose and Scope
  - eligibility requirements when any of the following features are installed to achieve compliance
- RA4.2 Building Envelope Measures
- RA4.3 HVAC Measures
- RA4.4 Water Heating Measures
- RA4.5 Other Measures

2013 Residential ACM Reference Manual

1. Introduction
2. The Proposed and Standard Design
2013 RACM A – Certification Tests
2013 RACM C – Special Features
2013 RACM E – Water Heating Calculations
Res ACM Algorithims



Introduction to the Residential ACM Reference Manual

- Updated with code cycle significant changes in 2013 compared to 2008 version
- Documents the rules used for modeling residential buildings for performance compliance
- Explains how the standard design energy budget is established
- How the proposed design energy use is defined
- Lists CF-1R Reporting requirements

What’s New for 2013 Res ACM?

- New simulation engine and algorithims
- Air leakage and infiltration (ACH50)
- More zone inputs
- Modeling garages, attics, crawlspaces
- Interface shows proposed and standard u-values and SHGC for building model
- Construction assemblies
- Input of dwelling units
- Lighting and appliances

Simulation Overview

- CA Simulation Engine (CSE)
  - Calculates heating /cooling loads, HVAC energy use
- RACM
  - Calculates DHW energy use
- Compliance Manager Software
  - Program that manages the compliance process
  - Communicates with CSE and with the DHW engine calculator

The Proposed and Standard Building

2.1 Overview
2.2 Building
2.3 Building envelope
2.4 Building mechanical systems
2.5 Conditioned Zones
2.6 Attics
2.7 Crawlspaces
2.8 Basements
2.9 Garage/storage
2.10 Domestic Hot Water
2.11 Additions/Alterations
2.12 Documentation

For each subsection the ACM lists rules and requirements for:

- Proposed Design
- Standard Design
- Verification and Reporting

2.1 Overview

- Proposed Design
  - The building is defined through entries for zones, surfaces, and equipment consistent with plans
- Standard Design
  - The building with same general characteristics, wall and window areas distributed equally among all four main coordinates meeting Prescriptive Package A
    - Standard 150.1(c)
    - Table 150.1-A

2.1 Overview

- Garages must now be modeled with interior surfaces adjacent to the garage zone

Portion of Table 150.1-A

2013 Building Energy Efficiency Standards

TABLE 150.1-A COMPONENT PACKAGE-A Standard Building Design

				1	2	3	4	5	6	
sulation[1]	Roofs /Ceilings			U 0.025 R 38	U 0.031 R 30	U 0.031 R 30	U 0.031 R 30	U 0.031 R 30	U 0.031 R 30	U (R
	Walls	Above Grade	2x4 Framed[2]	U 0.065 R 15+4 or R 13+5	U 0.065 R 15+4 or R 13+5	U 0.065 R15+4 or R 13+5	U 0.065 R 15+4 or R 13+5	U 0.065 R 15+4 or R 13+5	U 0.065 R 15+4 or R 13+5	U (R RI
			Mass Wall Interior[3]	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U 0.070 R 13	U (R
			Mass Wall Exterior[3]	U 0.125 R 8.0	U 0.125 R 8.	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U 0.125 R 8.0	U (R

2.2 The Building

- 2.2.1 Climate and Weather
- 2.2.2 Standards Version
- 2.2.3 PV System Credit
- 2.2.4 Existing Condition Verified
- 2.2.5 Air Leakage and Infiltration
- 2.2.6 Insulation Construction Quality
- 2.2.7 Number of Bedrooms
- 2.2.8 Dwelling Types
- 2.2.9 Front Orientation
- 2.2.10 Natural Gas Availability
- 2.2.11 Attached Garage
- 2.2.12 Lighting and 2.2.13 Appliances

2.2 The Building

- 2.2.1 Climate and Weather

- 2.2.2 Standards Version
  - Allows user to choose compliance “Standard” that will be valid only before the federal requirements for *cooling equipment* change or compliance that will be valid before and after the change in January 2015

2.2.3 PV System Credit

- Smaller of
  - PV Generation Rate (kTDV/kWdc) * kWdc
  - Max PV Cooling Credit * Standard Design Cooling energy (kTDV)

Table 2-1: PV Credit Calculation Factors

Climate Zone	PV Generaton Rate (kTDV/kWdc)	Max PV Cooling Credit (% of Standard Design Cooling kTDV/ft2)
09	30269	13%
10	30342	15%
11	29791	18%
12	29556	17%
13	29676	17%
14	31969	16%
15	29536	19%

2.2.4 Existing Conditions Verified

Proposed Design

- Yes or No
- Yes requiring a HERS rater verification of existing conditions

- Standard Design
  - Conditions based on 150.2(b), Table 150.2-B and varies when HERS verification completed prior to construction

2.2.5 Air Leakage and Infiltration

- 2.2.5.1 ACH50
  - Air leakage is a building level input
  - Must be field verified if modeled less than defaults
  - Single family only
  - No multifamily air leak testing reference standard

- 2.2.5.2 Defining Airnet Leakage
  - New algorithims
  - Air flows simulated between conditioned zones, unconditioned zones, and outside

2.2.5.1 ACH50 Defaults

Used for Proposed and Standard

Building Type	Ducts in Unconditioned Space	No Ducts outside of Condition Space
Single Family and Townhome	5	4.4
Multifamily	7	6.2

Table 2-3 Residential ACM

2.2.5.2 Air Net Leakage

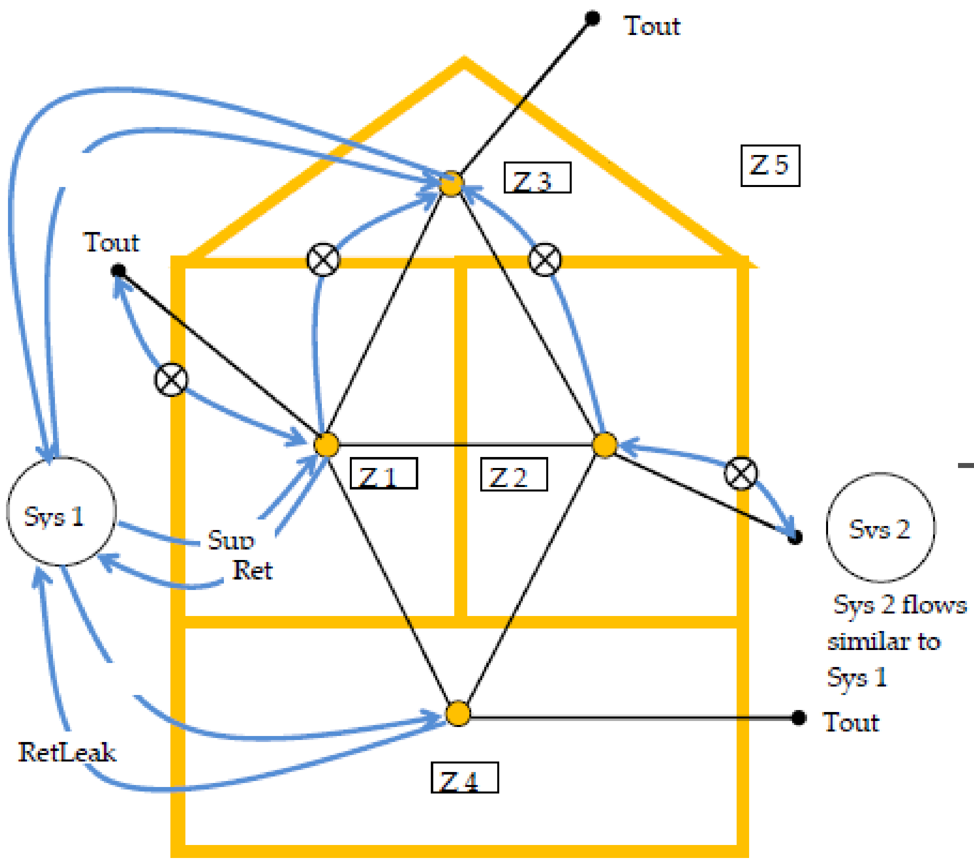
- Compliance manager distributes ACH50 across surfaces according to Table 2-2
  - Air network insensitive to wind direction
  - Multifamily buildings with floors between dwelling units must define each floor as separate zone or each dwelling unit as a separate zone

Table 2-2: Air Leakage Distribution

	% of Total Leakage by Surface			
Configuration	Ceilings	Floors	Exterior Walls	House to Garage Surfaces
Slab on grade	50	0		
Raised Floor	40	10		
No Garage			50	0
Attached Garage			40	10

Airnet Flow Network

Figure 23. Schematic of Flow Network



- The black lines represent one or more pressure difference driven and/or buoyancy driven flows between zones.
- The blue lines in represent scheduled fan flows not directly dependent on zone-to zone pressure differences.

2.2.6 Insulation Construction Quality

- Proposed Design
  - Set at the building level
  - “Verified” assumes all ceilings/attics, knee walls, exterior walls and exterior floors perform as rated as rated
  - “Standard” results in de-rating of cavity insulation only
- Standard Design
  - Modeled with “Standard” insulation quality
- Verification/Reporting
  - HERS required verification listed on CF-1R

Modeling Rules for Standard Insulation Installation Quality

Component	Modification
Walls	Multiply the cavity insulation R-value/inch by 0.7
Ceilings/Roofs	Multiply the blown and batt insulation R-value/inch by 0.96-0.00347*R
Ceiling below Attic	Add a heat flow from the conditioned zone to the attic of 0.015 times the area of the ceiling below attic times (the conditioned zone temperature - attic temperature) whenever the attic is colder than the conditioned space

Table 2-3 Residential ACM

2.2.8 Dwelling Unit Types

- Internal gains and indoor air quality (IAQ) depend on the number of bedrooms and CFA
- For multifamily buildings with individual IAQ ventilation systems, each different combinations of bedrooms and CFA has a different minimum cfm requirement
- A dwelling unit type is each of which has the same
  - floor area
  - # bedrooms
  - # units in building

2.2.8 Dwelling Unit Types

- Proposed Design
  - Unit name
  - Number of units of this type
  - CFA of unit
  - Number of bedrooms
- Standard Design
  - Same as proposed
- Reporting and Verification
  - # of units of each dwelling unit type and minimum IAQ reported on the CF-1R for field verification

2.12 Lighting

Added in 2013 based on HERS Technical Manual.

Not a compliance variable

- Proposed Design
  - Average per dwelling unit input at the building level
    - Quantity, Type, Location, Control

- Proposed Design
  - Tracks proposed

2.1.13 Appliances

Added in 2013 to better account for internal heat gain using HERS Technical Manual approach. Not a compliance variable.

- Proposed Design
  - Refrigerator (default 775 kWh or specified value)
  - Dishwasher (default based on # rooms, or specified value)
  - Clothes washer
  - Clothers dryer
  - Cooking
- Standard Design
  - Same as proposed

2.3 Building Envelope

- The 2008 Standards required JA4 assembly u-factor for compliance
- In 2013, semi-custom constructions allowed
- 2.3.1 Materials and 2.3.2 Construction Assembly
  – New approach lets user select material layers that make up construction from CEC approved library of materials
  – Can still use JA4 or build up layers per CEC materials
  – Organized around the concept of parallel path calculation used by CSE simulation engine

2.3 Building Envelope

- 2.3.3 Spray Foam Insulation

2.3.3 Spray Foam Insulation

The R-values for spray applied polyurethane foam insulation differs depending on whether the product is open cell or closed cell.

Table 2-5: Required Thickness Spray Foam Insulation

Required R-values for SPF insulation	R-11	R-13	R-15	R-19	R-21	R-22	R-25	R-30	R-38
Required thickness closed cell @ R5.8/inch	2.00 inches	2.25 inches	2.75 inches	3.50 inches	3.75 inches	4.00 inches	4.50 inches	5.25 inches	6.75 inches
Required thickness open cell @ R3.6/inch	3.0 inches	3.5 inches	4.2 inches	5.3 inches	5.8 inches	6.1 inches	6.9 inches	8.3 inches	10.6 inches

Additional documentation and verification requirements for a value other than default values shown in Table 2-5 is required (see RA3.5.6).

2.4 Building Mechanical Systems

- 2.4.1 Heating Subsystems
- 2.4.2 Special systems – Hydronic Distribution Systems and Terminals
- 2.4.3 Ground Source Heat Pumps
- 2.4.4 Cooling Subsystems
- 2.4.5 Distribution Subsystems
- 2.4.6 Space Conditioning Fan Subsystems
- 2.4.7 Space Conditioning Systems
- 2.4.8 Indoor Air Quality
- 2.4.9 Ventilation Cooling System

2.4.1 Heating Subsystems

- Proposed Design
  - User inputs heating system type and rated efficiency
  - Heating capacity not a input except for heat pumps
    - Input heating capacity at 47° F and 17° F
    - Software automatically sizes electric back-up heat
- Standard Design
  - If proposed is electric heating
    - Split DX HP, or room HP if proposed uses room HP
    - Standard design heat pump sized on a/c capacity
  - If proposed is natural gas heating
    - standard is natural gas furnace with same distribution type as proposed
  - Meeting prescriptive Package A

Table 2-6: HVAC Heating Equipment Descriptors

Recommended Descriptor	Heating Equipment Reference
CntrlFurnace	Gas- or oil-fired central furnaces, propane furnaces or heating equipment considered equivalent to a gas-fired central furnace, such as wood stoves that qualify for the wood heat exceptional method. Gas fan-type central furnaces have a minimum AFUE=78%. Distribution can be gravity flow or use any of the ducted systems. [Efficiency metric: AFUE]
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. Can refer to floor furnaces and wall heaters within the description field for CntrlFurnaces, [Efficiency metric: AFUE]
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. Systems in which the boiler provides space heating and fires an indirect gas water heater (IndGas) may be listed as Boiler/CombHydro Boiler and is listed under "Equipment Type" in the HVAC Systems listing. [Efficiency metric: AFUE]
SplitHeatPump	Heating side of a split heat pump heating system that has one or more outdoor units supply heat to each habitable space in the dwelling unit. Heat is at least partly distributed using one of the ducted systems. [Efficiency metric: HSPF]
DuctlessHeatPumpSystem	One or more heat pump outdoor units that use refrigerant to transport heat to at least one terminal in each habitable space in the dwelling unit. These include small ductless mini-split and multiple-split heat pumps and packaged terminal (commonly called "through-the-wall") units. Heat is not distributed using ducts either inside or outside of the conditioned space. [Efficiency metric: COP]
RoomHeatPump	Same as DuctlessHeatPumpSystem except that heat is not supplied to each habitable space in the dwelling unit. [Efficiency metric: COP]
PkgHeatPump	Heating side of central packaged heat pump systems. Central packaged heat pumps are heat pumps in which the blower, coils and compressor are contained in a single package, powered by single phase electric current, air cooled, rated below 65,000 Btuh. Distribution system is one of the ducted systems. [Efficiency metric: HSPF]
LrgPkgHeatPump	Heating side of large packaged units rated at or above 65,000 Btu/hr (heating mode). Distribution system is one of the ducted systems. These include water source and ground source heat pumps. [Efficiency metric: COP]
Electric	All electric heating systems other than space conditioning heat pumps. Included are electric resistance heaters, electric boilers and storage water heat pumps (air-water) (StoHP). Distribution system can be Radiant, Baseboard or any of the ducted systems. [Efficiency metric: HSPF]
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).

2.4.4 Cooling Subsystems

- Revised Cooling Algorithm
  - Adds calculation of indoor humidity and latent load
  - Evaporator air flow and conditions affect sensible heat ratio
  - Cooling size calculated by CSE and used in simulation, but not a compliance variable
- Proposed Design
  - Input cooling system type and efficiency
- Standard Design
  - Input cooling system type and efficiency

2.4.4 Cooling HERS

Table 2-9: Summary of Air Conditioning Measures Requiring Verification

Measure	Description	Procedures (Need Update)
Verified Refrigerant Charge	Air-cooled air conditioners and air-source heat pumps be diagnostically tested to verify that the system has the correct refrigerant charge. The system must also meet the system airflow requirement.	RA3.2, RA1.2
Verified Charge Indicator Display	A Charge Indicator Display can be installed as an alternative to refrigerant charge testing.	RA3.4.2
Verified System Airflow	When compliance requires verified System Airflow greater than or equal to a specified criterion.	RA3.3
Verified Air-handling Unit Fan Efficacy	To verify that Fan Efficacy (Watt/cfm) is less than or equal to a specified criterion.	RA3.3
Verified EER	Credit for increased EER by installation of specific air conditioner or heat pump models.	RA3.4.3, RA3.4.4.1
Verified SEER	Credit for increased SEER.	RA3.4.3, RA3.4.4.1
Evaporatively Cooled Condensers	Must be combined with duct leakage testing, refrigerant charge, and verified EER.	RA3.1, RA3.1.4.3, RA3.2, RA1.2, RA3.4.3, RA3.4.4.1

2.4.4.1 Verified Refrigerant Charge or CID

- Proposed Design
  - Compressor efficiency multiplier to 0.90 to account for the impact of improper refrigerant charge or 0.96 for proper charge and HERS verification
  - Ducted split and packaged DX air conditioners, heat pumps, and mini-split heat pumps
- Standard Design
  - diagnostically tested refrigerant charge OR field verified Charge Indicator Display (CID)
  - **0.96** efficiency multiplier in CZ02, CZ08 through CZ15
  - **0.90** elsewhere

2.4.4.4 Verified EER and 2.4.4.5 Verified SEER

- Proposed
  - Claim higher than 11.7 EER in compliance 2015
  - As of 2015, federal code requires minimum 14 SEER 11.7 EER ratings for central a/c equipment
- Standard
  - 11.7 EER when in compliance 2015
- Reporting and Verification
  - EER values higher than 11.7 EER reported on CF-1R
  - HERS verified using data from AHRI Directory of Certified Product Performance at www.ahridirectory.com
  - If SEER higher than default modeled in software, the SEER requires field verification

Cooling Model

Primary model parameters. The following values characterize the AC unit and are constant for a given unit:

Cap95 = AHRI rated total cooling capacity at 95 °F, Btuh

$CFM_{per\ ton}$ = Air flow rate per ton of cooling capacity, cfm/ton.

$$= \frac{\text{Operating air flow rate, cfm}}{\text{Cap95 / 12000}}$$

EFan = Fan operating electrical power, W/cfm. Default = 0.365.

SEER = AHRI rated Seasonal Energy Efficiency Ratio, Btuh/W. EER shall be used in lieu of the SEER for equipment not required to be tested for a SEER rating.

EER = AHRI rated energy efficiency ratio at 95 °F, Btuh/W. If EER is not available, it is derived from SEER as follows:

If SEER	>=16	>=13 & <16	<13
EER	13	11.3 + 0.57 x (SEER-13)	10+0.84×(SEER– 11.5)

F_{chg} = Refrigerant charge factor, default = 0.9. For systems with a verified charge indicator light (Reference Residential Appendix RA3.4) or verified refrigerant charge (Reference Residential Appendix RA3), the factor shall be 0.96.

F_{size} = Compressor sizing factor, default = 0.95. For systems sized according to the Maximum Cooling Capacity for compliance software Credit (see Section <TODO>), the factor shall be 1.0.

2.4.4.2 Verified System Airflow

Adequate airflow from the conditioned space is required to allow ducted air conditioning systems to operate at their full efficiency and capacity

- Proposed Design
  - Default is 350 cfm/ton for ducted air conditioning
  - may model higher airflow and receive credit
- Standard Design
  - Assumes 350 cfm/ton and a system that complies with mandatory and prescriptive requirements for applicable climate zone
- Verification and Reporting
  - HERS verified per Residential Appendix RA3.3

2.4.4.3 Verified Air Handling Unit Fan Efficacy

- § 150.0(m)13 requires AHU fan efficacy less than or equal to 0.58 Watts/cfm and HERS rater verified
  - Credit if modeled less than 0.58 W/cfm and verified per Reference Appendices RA3.3
- Must be done with Verified System Airflow
- Alternative is HERS verification of a return duct design that conforms to the specification given in Standards Table 150.0-C or Table 150.D

HERS Measures not Required by Standard

- Bypass ducts
- Zonally controlled
- Multi-speed compressor

2.4.4.6 Verified Evaporatively Cooled Condensers

- Proposed
  - Can specify evaporatively cooled condensers
  - Installation must comply with the requirements of RA4.3.2 to ensure the predicted energy savings are achieved
- Standard
  - Split DX per prescriptive requirements
- This credit must be combined with verified refrigerant charge testing, EER, and duct leakage testing.

2.4.5 Distribution Systems

Same rules and basic model as 2008 ACM

- Proposed Design
  - Duct location
  - Duct insulation
  - Leakage description per Table 2-15

2.4.5 Distribution Systems

- Duct/Air Handler Leakage Factor

Table 2-15: Duct/Air Handler Leakage Factors

Case	Average of Supply and Return
Untested duct systems in homes built prior to June 1, 2001	0.86
Untested duct systems in homes built after June 1, 2001	0.89
Sealed and tested duct systems in existing dwelling units	0.915
Sealed and tested new duct systems	0.96
Verified low leakage ducts in conditioned space	1.00
Low leakage air handlers in combination with sealed and tested new duct systems	0.97 or as measured

2.4.5 Distribution Systems

- Standard Design
  - For non-central HVAC systems, the standard design shall have no ducts.
  - The standard heating and cooling system for central systems is modeled with
    - Air distribution ducts located in an attic space attic or as described in Table 2-12
    - Verified low-leakage ducts
    - Duct insulation per Package A
      - R-6 in climate zones 1-10, 12-13
      - R-8 in climate zones 11 and 14-16

2.4.5 Distribution Systems

Table 2-12: Summary of Standard Design Duct Location

Configuration of the Proposed Design	Standard Design	
	Standard Design Duct Location	Detailed Specifications
Attic over the dwelling unit	Ducts and air handler located in the attic	Ducts sealed (mandatory requirement) No credit for verified R-value, location or duct design
No attic but crawl space or basement	Ducts and air handler located in the crawl space or basement	
No attic, crawl space or basement	Ducts and air handler located indoors	

Table 2-13: Location of Default Supply Duct Area

Supply duct location	Location of Default Supply Duct Surface Area	
	One story	Two or more story
All in Crawl space	100% crawl space	65% crawl space 35% conditioned space
All in Basement	100% Basement	65% basement 35% conditioned space
Other	100% attic	65% attic 35% conditioned space

2.4.8 Indoor Air Quality Ventilation

2013 code requires mechanical ventilation that complies with ASHRAE 62.1

- Proposed Design
  - Standalone or Central Fan Integrated,
    - Input fan power if
      - >1.20 W/cfm fan power stand alone
      - >0.58 W/cfm central systems
  - Default is standalone capable of continuously providing required ventilation cfm per
    - Equation 2-6 Q_{fan}=.01*$Area_{floor}$ + 7.5(N_{br} +1)

2.4.8 Indoor Air Quality Ventilation

- Standard Design
  - Same as proposed except fan power tracks proposed fan power up to 1.2 W/cfm for standalone and 0.58 W/cfm for central systems
- Verification and Reporting
  - Required ventilation and system type reported on CF-1R under HERS verification
  - Diagnostic Testing per RA3.3

2.4.9 Cooling Ventilation Systems

- Proposed Design
  - Either none, whole house fan or central fan ventilation cooling per Table 2-18
- Standard Design
  - Whole house fan in CZ08 – CZ14
  - None in other climate zones
- Verification and Reporting
  - Special feature on CF-1R and HERS verification of make/model number and controls

2.4.9 Cooling Ventilation Systems

- Table 2-18 System Description and Defaults

Measure	Description
Whole House Fan	Mounted in ceiling to exhaust air from the house to attic Assumed runs from dawn to 11pm at 25% of rated flow Fan must be listed in CEC Whole House Fan Directory
Central Fan Ventilation Cooling	Central fan ventilation system using dampers to induce outdoor IAQ and distribute through HVAC system

2.5 Conditioned Zones

- New zone inputs required for the CSE infiltration algorithims using Airnet
  - Floor elevation
  - Floor to floor height
  - Window head height

2.4.7.4 Zonal Control

- Credit changes
  - Only heating credit
  - no zonal control cooling credit.
  - Based on field research that indicates zonal control cooling system uses more energy, not less.
- Eligibility/installation requirements unchanged from 2008.

2.6 Attics

- Compliance manager models attics as a separate thermal zone and includes interactions between attic and house, solar gains on roof, and other factors such as duct interactions
- Attic ventilation is no longer a compliance variable and 1/300 soffit ventilation assumed
- Truss heal height and roof pitch added for raised truss attic/roof constructions
- Ceiling below attic is modeled by compliance manager

Standard Truss and Raised Heel Truss

Figure 2-12: Section at Attic Edge with Standard Truss

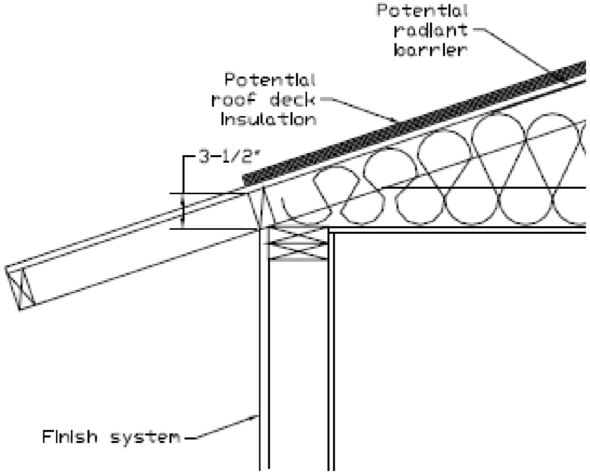
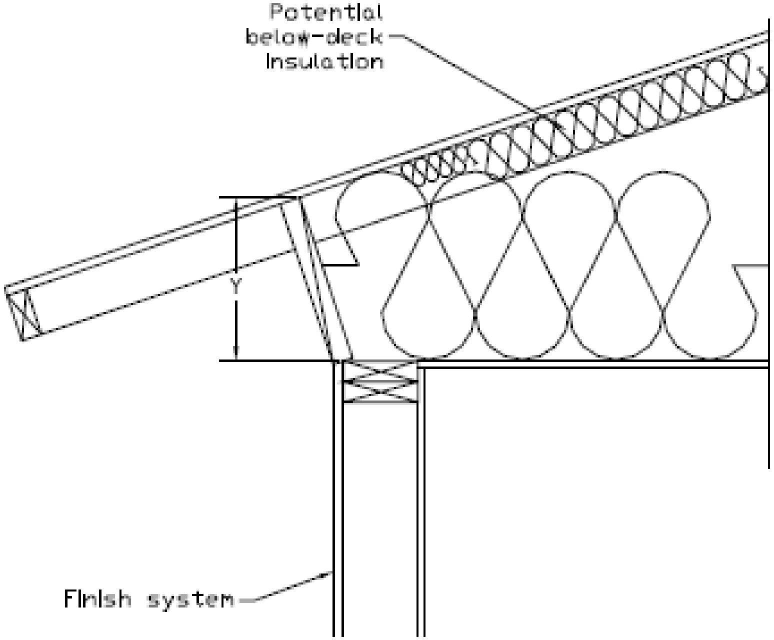
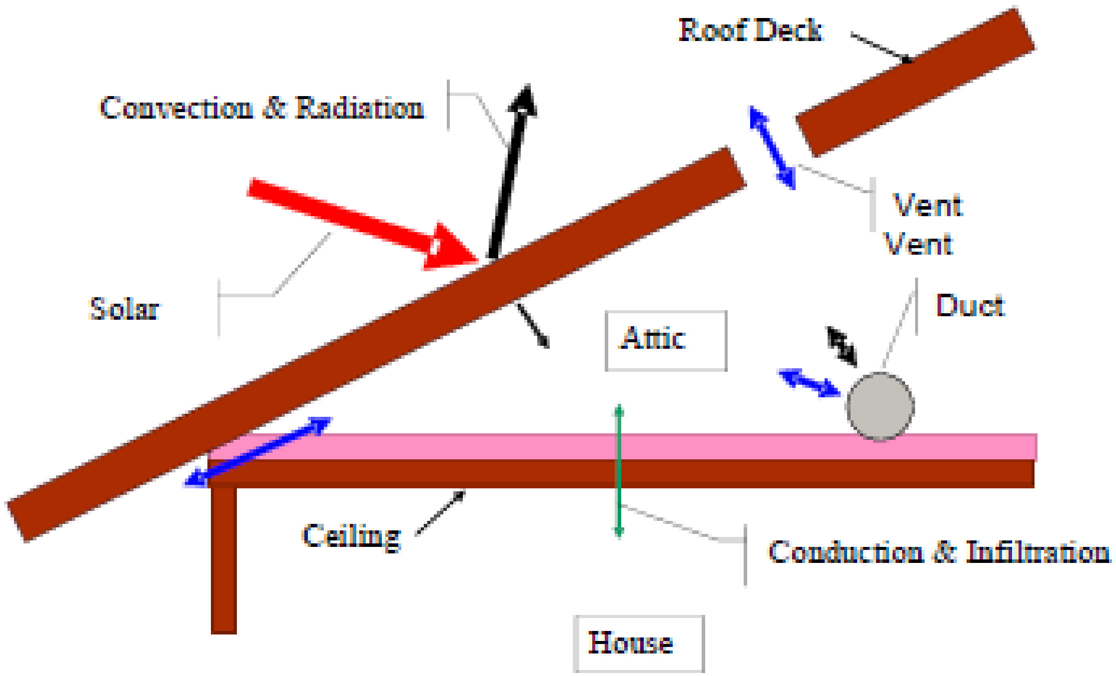


Figure 2-13: Section at Attic Edge with a Raised Heel Truss



2.6 Attic Model Components

Figure 2-11: Attic Model Components



2.6 Attic Components

- Proposed Design
  - Modeled as designed, except for
  - Roofs with PV systems or with thermal mass over the roof membrane with a weight of at least 25 lb/ft3 may model the Package A requirements for aged solar reflectance and emmittance
- Standard Design
  - R-30 CZ2-CZ10 and R-38 in CZ01, CZ10-CZ16
  - Low-sloped roofs in CZ13 and CZ15: 0.63 aged reflectance and 0.75 emmittance
  - Steep sloped roofs in CZ10 – CZ15: 0.20 aged reflectance and 0.75 emmittance

2.7 Crawlspaces

- Proposed Design
  - Either typical vented crawlspace or
  - Insulated and mechanically ventilated crawl space
    - Input perimeter and height for both types
- Standard Design
  - Typical vented crawlspace when proposed modeled with crawlspace
    - R-6 modeled on crawlspace walls

2.8 Basements and Underground Surfaces

- Not yet implemented

2.10 Domestic Hot Water

- Proposed Design
  - Model as designed
    - Individual or MF Central
    - System type
    - Distribution system characteristics
- Standard Design
  - Individual Systems
    - Small storage gas: 0.575 EF in 2014, 0.60 EF in 2015
    - Small storage electric: 0.904 in 2014, 0.945 in 2015
    - If proposed has recirculation controls, than standard has recirculation loop with manual controls, otherwise no control

2.10 Domestic Hot Water

- Standard Design
  - MF Central Systems
    - Same equipment type as proposed (large boiler, indirect boiler, etc) meeting minimum efficiency requirements
    - Recirculation pump with demand control
    - Two circulation pumps if serving more than 8 dwelling units – this is new to 2013 DWH calcs
    - A central water heating system standard design also includes a solar fraction of 0.20 in climate zones 1 through 9, and 0.35 in climate zones 10 through 16.

MF central DHW System Credits

Table RE-2 Distribution System Multipliers within a Dwelling Unit with One or More Water Heaters

Distribution System Types	Assigned Distribution System Multiplier	System Type 1and 2	System Type 3 and 4
No HERS Inspection Required			
Trunk and Branch -Standard (STD)	1.0	Yes	Yes
Pipe Insulation (PIC)	0.9	Yes	Yes
Parallel Piping (PP)	1.05	Yes	
Recirculation: Non-Demand Control Options (R-ND)	7.0	Yes	
Recirculation with Manual Demand Control (R-DRmc)	1.15	Yes	
Recirculation with Motion Sensor Demand Control (R-DRsc)	1.3	Yes	
Optional Cases: HERS Inspection Required		Yes	
Pipe Insulation (PIC-H)	0.8	Yes	Yes
Parallel Piping with 5' maximum length (PP-H)	0.95	Yes	
Compact Design (CHWDS-H)	0.7	Yes	
Point of Use (POU-H)	0.3	Yes	
Recirculation with Manual Demand Control (R-DRmc-H)	1.05	Yes	
Recirculation with Motion Sensor Demand Control (RDRsc-H)	1.2	Yes	

ACM Appendix E – DHW Calculations

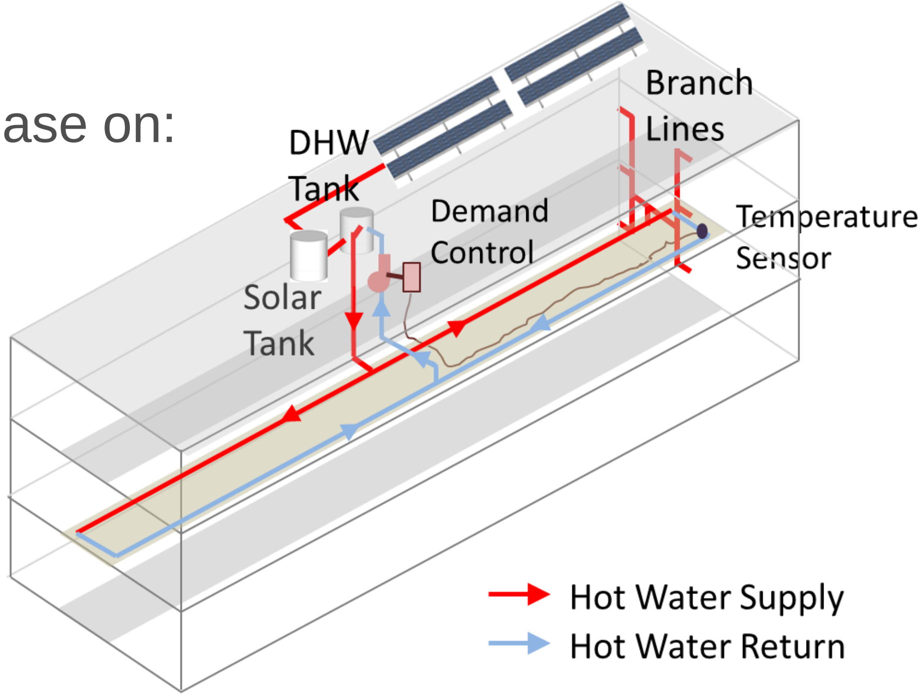
- ACM Reference Manual Appendix E documents the methods and assumptions used for calculating the hourly energy use for residential water heating systems for both the proposed design and the standard design.

Appendix E Updates

- Standard Design Updated – Prescriptive Requirement
  - Distribution: two-loop recirculation with demand control
  - Solar water heating: SF by CZ
- Four Components of Hourly Adjusted Recovery Load (HARL)
  - Hourly end use adjusted by in-unit distribution loss
    - HW supply Temp: 135F to 130 F
  - Solar WH – offset hourly end use (not distribution loss)
  - **Central recirculation system heat loss**
    - Performance of controls
    - Recirculation plumbing designs
    - Branch pipe performance
  - Storage tank surface heat loss – no change

MF Central DHW Standard Recirc Design

- Pipe Heat Loss Model Adapted from PIER Study Results
  - Model validated by field monitoring results
  - Plumbing designs based on field survey (>30 buildings)
- Standard Design
  - Streamlined piping design base on:
    - # of unit, story, and floor area
  - Two-loop design
    - Smaller pipe size



MF DHW ACM – Proposed Design

- Use default or User-input Design
  - Recirculation loop represented by 6 pipe sections
- Default Design
  - Less optimized design than the standard design
    - Slightly longer pipe than the standard design
    - Better than most designs observed in the field
  - One-loop design: Pipe size larger than standard design
- User-input Design – Pipe surface area validated/adjusted
  - HERS verified dual-loop design – validated by standard design
  - All Others - validated by the default design

Appendix C – Special Conditions

- Good source for energy efficiency measures for project

Res ACM Algorithims

- CA Simulation Engine
- Compliance Manager
- Summary of algorithims
- Snapshot of a couple algorithim details

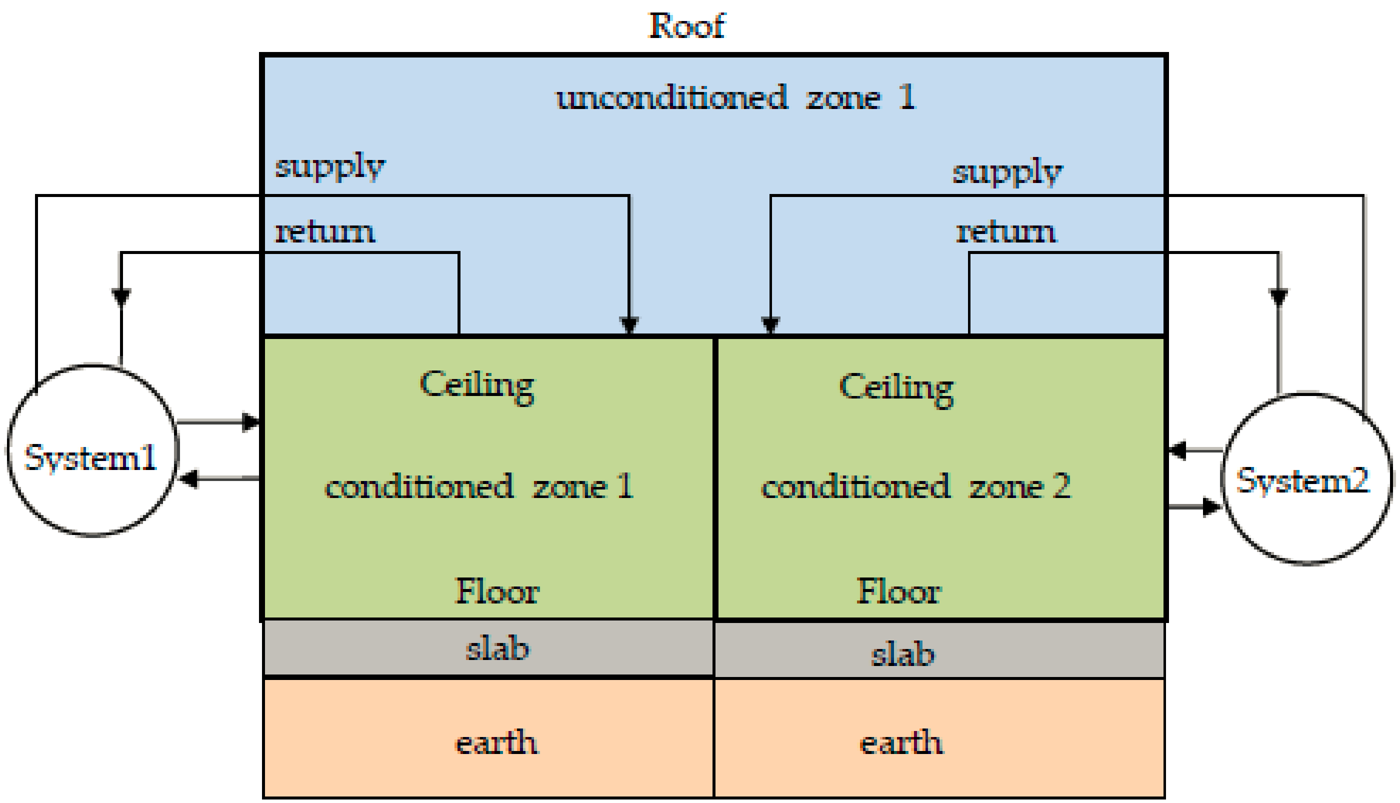
California Simulation Engine

- Overview
- Updating Layered Mass Temperatures
- Zone Energy Balance
- Discretization Errors
- Surface Heat Transfer Coefficients
- Distribution of SW and LW Radiation Inside the Zone
- Window Model
- Slab Model
- Ventilation and Infiltration Air Network
- Duct System Model
- Variable Insulation Conductivity
- Ceiling Bypass Model
- Zone Humidity Balance
- HVAC Equipment Models

CSE Calculation Sequence

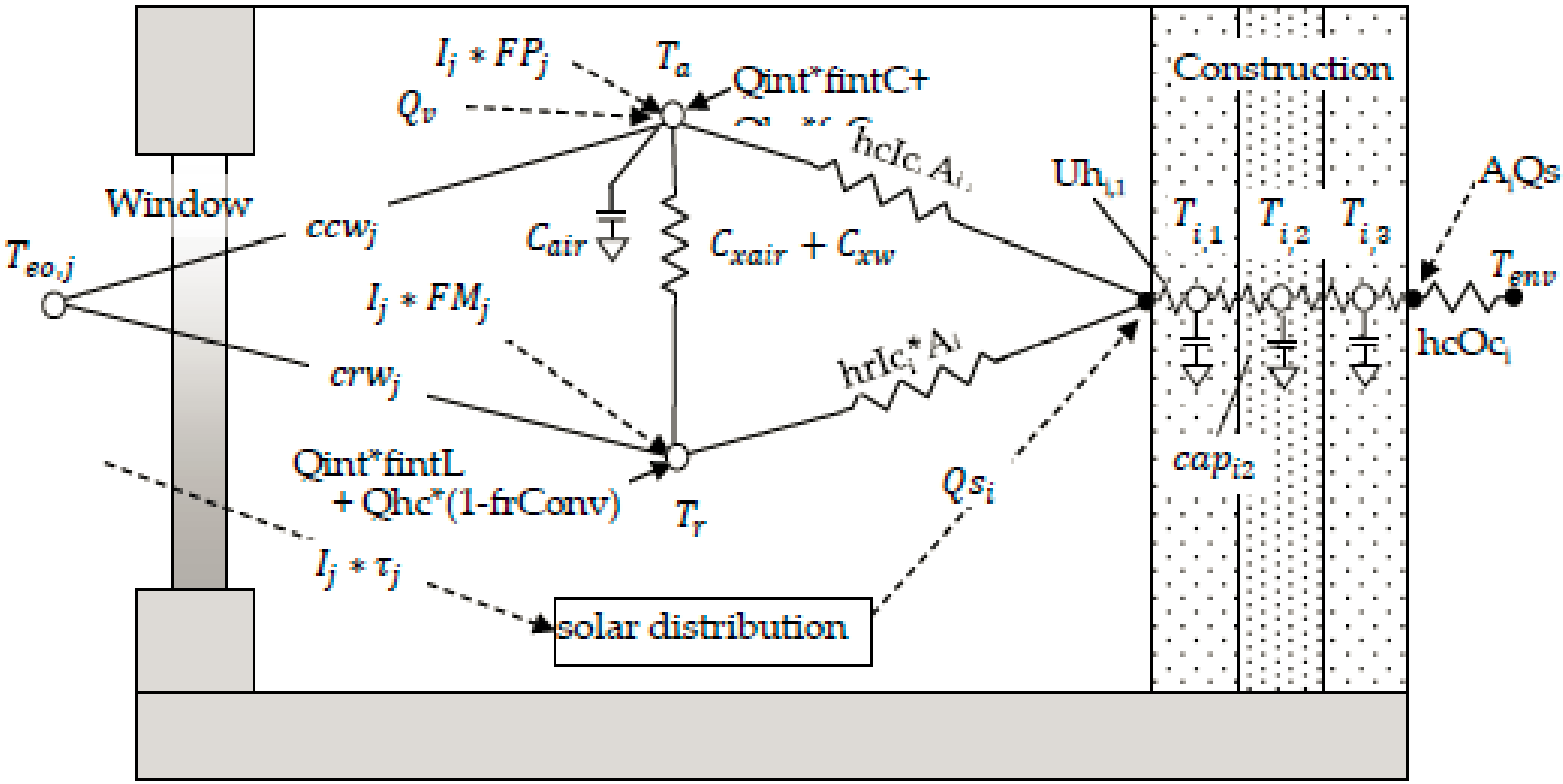
- Hour
  - Determine and distribute internal gains.
- Sub-hour
  - Determine solar gain on surfaces.
  - Determine surface heat transfer coefficients.
  - Update mass layer temperatures.
  - Find AirNet mass flows for non-venting situation (building leakage + last step HVAC air flows).
  - Determine HVAC requirements for all zones by comparing floating temp to setpoints (if any)
  - Determine HVAC air flow to zones (may be less than requested); determine zone final zone air temperatures.
  - Determine system run fraction and thus fuel requirements.
  - Determine zone humidity ratio for each zone.
  - Calculate comfort metrics for each

Schematic of Zones and Air Handlers



Although shown partly outside of the envelope, all ducts are assumed to be in either the conditioned or unconditioned zones only.

Schematic of Simulation Network



Building Heating and Cooling Load Related Calculations

- 2.2 Updating Layered Mass Temperatures
  - Heat transfer through surfaces Assumed to be 1-D
- 2.3 Zone Energy Balance
  - Accounting for interactions between construction assembly surfaces and zone flows
  - Thermostatic logic when system is in cooling, heating or ventilation only mode
- 2.5 Surface Heat Transfer Coefficients
  - Heat flows inside zones
  - Net heat transfer of zones

Building Heating and Cooling Load Related Calculations

- 2.6 Distribution of SW and LW Radiation Inside the Zone
- 2.7 Window Model
  - – Calculates heat transfer from window to zone
  - – ASHWAT algorithim not well documented
- 2.8 Slab Model
  - – Bajanac simplified model (perimeter and core)
- 2.9 Ventilation and Infiltration Air Network
  - – Describes infiltration calculations
  - – Wind direction independent

Building Heating and Cooling Load Related Calculations

- 2.9 Ventilation and Infiltration Air Network
  - – Describes infiltration calculations
  - – Wind direction independent
  - – Components/models for:
    - Vertical pressure distribution
    - Power law flow equation (ACH50 to ELA)
    - Large horizontal opening

HVAC Related Calculations

- 2.10 Duct system Model
  - Instantaneous duct loss and system efficiencies
  - Small time steps (sub-hourly)
  - Supposed to have multiple duct branches as inputs, but not implemented yet
  - Calculates supply and return air temps
  - Calculates supply and return heat loss
  - Calculates heating and cooling delivered to zones

2.15 HVAC Equipment Models

The HVAC equipment models have not changed much since 2008 ACM

- Compression Air-Conditioner Model
  - Used for A/C systems (PTAC, split, packaged)
  - Calculates annual energy use to meet building loads previously calculated

$$AC_{kWh} = \frac{Fan_{Wh} + Comp_{Wh}}{1{,}000}$$

Equation 219

Some Defaults for A/C Model

EER = AHRI rated energy efficiency ratio at 95 °F, Btuh/W. If EER is not available, it is derived from SEER as follows:

If SEER	>=16	>=13 & <16	<13
EER	13	11.3 + 0.57 x (SEER-13)	10+0.84×(SEER– 11.5)

F_{chg} = Refrigerant charge factor, default = 0.9. For systems with a verified charge indicator light (Reference Residential Appendix RA3.4) or verified refrigerant charge (Reference Residential Appendix RA3), the factor shall be 0.96.

F_{size} = Compressor sizing factor, default = 0.95. For systems sized according to the Maximum Cooling Capacity for compliance software Credit (see Section <TODO>), the factor shall be 1.0.

2.15 HVAC Equipment Models

- Air-source heat pump model (heating mode)
  - Calculates electric heat back-up capacity
  - Can incur penalty of heat pump capacity is under-sized
  - Not much other detail on calculations

Summary

- The 2013 Residential ACM can provide much insight into the defaults, assumptions, and calculations used by CEC approved compliance software
- Good **reference** for understanding the modeling inputs, outputs, and limitations
- “the more I learn, the less I know”

Questions and Discussion Time