CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Solar Water Heating – Residential and Specialty Commercial

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team October 2011

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1. Introduction

Through Codes and Standards Enhancement (CASE) Studies, the California Investor Owned Utilities (IOUs) provide standards and code-setting bodies with the technical and cost-effectiveness information required to make informed judgments on proposed regulations for promising energy efficiency design practices and technologies.

The IOUs and their consultants began evaluating potential code change proposals in the fall, 2009. Throughout 2010, the CASE Team evaluated energy savings and costs associated with each code change proposal. The Team engaged industry stakeholders to solicit feedback on the code change proposals, energy savings analyses, and cost estimates. This CASE Report presents a code change proposal for solar hot water systems for residential low-rise, single-family buildings and introduces a new proposal for commercial buildings, specifically restaurants.

The contents of this report, including cost and savings analyses and proposed code language, were developed taking feedback from industry and the California Energy Commission (CEC) into account. All of the main approaches, assumptions and methods of analysis used in this proposal have been presented for review at three public Stakeholder Meetings hosted by the IOUs. At each meeting, the CASE team asked for feedback on the proposed language and analysis thus far, and sent out a summary of what was discussed at the meeting, along with a summary of outstanding questions and issues.

A record of the Stakeholder Meeting presentations, summaries and other supporting documents can be found at www.calcodesgroup.com. Stakeholder meetings were held on the following dates and locations:

- First Stakeholder Meeting: April 29, 2011, San Ramon Conference Center, San Ramon, CA
- Second Stakeholder Meeting: November 2, 2010, San Ramon Conference Center, San Ramon, CA
- Working Session: January 11, 2011, Webinar
- Third Stakeholder Meeting: April 6, 2011, Webinar

2. Overview

2.1 Measure Title

Solar Water Heating – Residential and Specialty Commercial

2.2 Description

This proposed measure increases the prescriptive required minimum fraction of water heat to be provided by solar water heating systems for individual dwelling units (i.e. single-family housing) with electric resistance (storage and instantaneous) water heaters using Package C. The solar fraction required will be equal across climate zones, at 0.7. The measure also introduces an option for individual dwelling units where the solar fraction is unable to be calculated. In addition to changing the requirements, this code change proposal addresses several limitations of the language, format and representation of the existing code in the standards document and the compliance manual, e.g. placing the requirement in a more central location in the standard and compliance manual, and clarifying language that seems to be remnant from previous code cycles. While natural gas is preferred over electric for water heating from a resource consumption perspective, the current documentation of the solar fraction requirement for residential buildings using Package C [§151f, TABLE 151-B] (particularly in cases of natural gas non-availability) provides inconsistent guidance and should be clarified.

The proposed measure also introduces a required minimum fraction of water heating provided by solar water heating systems for new construction full service restaurants with conditioned and unconditioned floor area of at least 12,600 square feet (SF or sq. ft.). The solar fraction will be equal across climate zones, at 0.25, except for Climate Zone 1, which is exempt.

The proposed measure introduces to Part 11 of Title 24 a minimum fraction of water heat to be provided by solar water heating systems for new construction restaurants with electric storage water heaters, and conditioned and unconditioned floor area of at least 1,600 SF. The solar fraction required is equal across climate-zones, except for Climate Zone 1, which is exempt.

The code change proposal also addresses the current limitations of how solar water heating is calculated for both prescriptive and performance compliance. The current method for calculating solar fraction is to use the software program F-chart, which provides an annual average savings value and is a separate calculator instead of being integrated into any existing building performance software programs. This measure proposes updates to F-chart or equivalent solar fraction calculator to include both residential and the most current non-residential systems and use of an hourly model of solar fraction to increase precision and to align with the California Energy Commission's (CEC) Time-Dependent Valuation (TDV) of energy calculations. In addition to recommending updating the F-Chart calculator and maintaining it for the prescriptive option, the measure also proposes integration of the solar modeling into the Residential and Non-Residential Alternative Calculation Method (ACM) while changing it from an "optional capability" to a "minimal capability", thereby simplifying and making consistent the solar inputs for the compliance analyst. This could make solar thermal a more broadly applied measure, while also improving enforcement and error checking. The measure proposes revisions to the compliance manual and compliance forms.

2.3 Type of Change

This proposed measure would change the prescriptive approach for residential Package C in Part 6 of Title 24 for electric resistance water heaters. The measure would change the prescriptive approach in Part 6 of Title 24 for natural gas storage water heaters in full service restaurants. The measure would also change the prescriptive approach in Part 11 of Title 24 for electric water heaters in restaurants. This measure would modify the calculation procedures and assumptions used in making performance calculations using the Residential Alternative Calculation Method (ACM) Manual. The change would also modify the language and visual representation of the solar fraction requirement in the residential standard, compliance manual and compliance forms.

2.4 Energy Benefits

The proposed measure results in energy savings and demand reduction beyond 2008 Title 24 Code. All yearly energy savings are multiplied against the 2013 TDV values to determine the monetary value of the energy savings over the entire measure life cycle. The TDV values weight peak savings more heavily than off-peak savings to account for the real cost of energy to society. For residential non-envelope measures, the TDV period of analysis is 30 years at a 3% discount rate. For nonresidential non-envelope measures, the TDV period of analysis is 15 years at a 3% discount rate. For the nonresidential non-envelope cost-effectiveness calculations for this analysis the Part 11 of Title 24 or “Reach Code” TDV multipliers were used (see Appendix A for more details).

The energy benefits of the proposed measures are summarized below. More detailed results are presented in Section 4 of this report.

Residential: Single Family – Electric Resistance Water Heating, Package C (Climate Zone Average)

The per unit savings are presented in the following table:

	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings	TDV Gas Cost Savings
Per Prototype Building	2,700	0.30	N/A	$10,480	N/A
Savings per square foot	1.00	0.0001	N/A	$3.90	N/A

The savings from this measures are expected to result in the following statewide first year savings:

Statewide Power Savings (MW)	Statewide Electricity Savings (GWh)	Statewide Natural Gas Savings (million Therms)	Total TDV Savings ($)
0.018	0.016	0	$618,500

Commercial: Restaurant - Natural Gas Storage Water Heating[1] (Climate Zone Average)

The per unit savings are presented in the following table:

	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Cost Savings	TDV Gas Cost Savings
Per Prototype Building	(530)	(.06)	1,650	($1,160)	$23,630
Savings per square foot	(0.04)	(0.000005)	.13	(.09)	$1.90

The savings from this measures are expected to result in the following statewide first year savings:

Statewide Power Savings (MW)	Statewide Electricity Savings (GWh)	Statewide Natural Gas Savings (million Therms)	Total TDV Savings ($)
(.012)	(0.11)	.34	$4.5 million

Commercial: Restaurant - Electric Storage Water Heating [2] (Climate Zone Average)

The per unit savings are presented in the following table:

	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	REACH TDV Electricity Cost Savings	TDV Gas Cost Savings
Per Prototype Building	10,580	2.10	N/A	$26,290	N/A
Savings per square foot	7.05	.0008	N/A	$17.90	N/A

The savings from this measures are expected to result in the following statewide first year savings:

Statewide Power Savings (MW)	Statewide Electricity Savings (GWh)	Statewide Natural Gas Savings (million Therms)	Total REACH TDV Savings ($)
0.27	1.3	N/A	$3.3 Million

[1] The natural gas water heating system saves a significant amount of natural gas, but uses a small amount of electricity, for the collector and heat exchange pumps, hence the negative electricity cost savings values.

[2] These are averages of Climate Zone 13 and 15. The measure in Climate Zone 1 was cost-ineffective and therefore not included in these calculations.

2.5 Non-Energy Benefits

We found little evidence to suggest there are substantive non-energy benefits. Increased property value may be likely, however, further research would be needed to quantify the benefit.

2.6 Environmental Impact

Emissions

	NOX	SOX	CO	PM10	CO2
Per Prototype Building (Residential)	0.47	2.60	0.60	0.20	1,560
Per Prototype Building (Commercial Natural Gas)	16.2	10.5	4.80	1.60	18,650
Per Prototype Building (Commercial Electric)	1.7	10.0	2.40	0.80	6,130

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year) [3]

	Mercury	Lead	Copper	Steel	Plastic / Rubber	Others (Identify)	Glass
Per Prototype Building (Residential)	NC	.01 (I)	1.24 (I)	18.8 (I)	1.1 (I)	Aluminum – 2.0 (I) USP Propylene Glycol - 3.5 (I)	6.97 (I)
Per Prototype Building (Commercial – Electric)	NC	.01 (I)	1.14 (I)	80.23 (I)	1.22 (I)	Aluminum – 1.71 (I) USP Propylene Glycol - 3.5 (I)	7.75 (I)
Per Prototype Building (Commercial – Natural Gas)	NC	.01 (I)	2.63 (I)	104.53 (I)	2.91 (I)	Aluminum – 6.47 (I) USP Propylene Glycol - 3.5 (I)	22.73 (I)

[3] Calculated based on one product from one manufacturer, Enerworks, divided by the life expectancies. Not representational of full market.

Statewide Materials Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year) [4]

	Mercury	Lead	Copper	Steel	Plastic / Rubber	Others (Identify)	Glass
Residential	0 (I)	6 (I)	1,450 (I)	20,400 (I)	1,080 (I)	Aluminum – 1,990 (I) USP Propylene Glycol – 620 (I)	6,490 (I)
Commercial (Electric)	0 (I)	20 (I)	9,680 (I)	21,810 (I)	9,310 (I)	Aluminum – 21,810 (I) USP Propylene Glycol – 2,030 (I)	71,070 (I)
Commercial (Natural Gas)	0 (I)	13 (I)	6,910 (I)	16,360 (I)	6,860 (I)	Aluminum – 16,360 (I) USP Propylene Glycol – 3,040 (I)	53,450 (I)

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Per Prototype Building (Residential)	+ 40gallons / Year
Per Prototype Building (Commercial Electric)	+ 220 gallons (from filling larger tank)
Per Prototype Building (Commercial Natural)	+ 270 gallons (from filling larger tank)

Water Quality Impacts:

Comment on the potential increase (I), decrease (D), or no change (NC) in contamination compared to the base case assumption, including but not limited to: mineralization (calcium, boron, and salts), algae or bacterial buildup, and corrosives as a result of PH change.

[4] Calculated based on one product from one manufacturer, Enerworks, divided by the life expectancies. Not representational of full market.

	Mineralization (calcium, boron, and salts)	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC
Comment on reasons for your impact assessment	Measure does not involve technology which impacts water quality.			

2.7 Technology Measures

Measure Availability:

Over the past several decades, availability of solar water heating systems has increased worldwide. Between 2000 and 2009, the number of solar thermal collector companies more than tripled, and sales nearly doubled (EIA 20011). Solar Rating and Certification Corporation (SRCC) currently rates 48 different solar water heating systems.

In California, system and contractor availability is strong, with manufacturers generally supplying the systems to the contractors. California Solar Initiative Thermal Program (CSI Thermal), as of February 1st, 2011, listed 25 different contractors across 9 of the 16 climate zones, having installed tanks with electric backup from 11 different manufacturers in residential single family buildings. For natural gas, in the same data set, there have been 7 different contractors across 6 Climate Zones, having installed natural gas tank systems from 11 different manufacturers in multi-family and commercial buildings.

Useful Life, Persistence, and Maintenance:

Compared to standard storage water heaters, solar water heating systems with utility back up are more complex, with many components and varying life expectancies. With proper installation and maintenance, however, systems are expected to maintain persistent savings over time. The table below summarizes the useful life of each component (Stakeholder Interviews 2010/2011):

Component	**Life Expectancy (years)**
Collector	20
Auxiliary and Auxiliary / Solar Combined Tank	10
Solar Tank	15
Motor and Pump	10
Controller	20
Heat Transfer Fluid	3

2.8 Performance Verification of the Proposed Measure

No additional performance verification such as diagnostic testing or acceptance tests will be required for compliance with this measure.

2.9 Cost Effectiveness

We began our cost-effectiveness analysis by examining all 16 climate zones, given the climate sensitivity of the measure. We first performed this analysis for residential solar systems with electric back up and commercial solar systems with natural gas back up. Then, for the commercial solar systems with electric back up, we modeled the three least-cost effective climate zones from these other two analyses.

The numbers below in column C and E are representative of costs which are equal across climate zones, but column F contains the averages from the climate zones of the respective number of climate zones modeled (Commercial Electric is the average of the two cost-effective climate zones). The LCC equals the sum of each row, rather than the average LCC savings across climate zones. As mentioned in Section 2.4, residential water heating measures are evaluated over a 30 year period of analysis and using base code TDV, and nonresidential water heating measures are evaluated over a 15 year period of analysis, using base code TDV for the large restaurant measure with natural gas back up, and using reach code TDV for the small restaurant measure with electric back up.

BASE TDV

A	B	C	E	F	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings – Per Proto Building (PV$) Climate Zone Average	LCC Savings Per Prototype Building ($) Climate Zone Average
		Per Proto Building	Per Proto Building		(c+e)-f Based on Current Costs
Residential Electric	30	$5,710	$4,110	$10,480	$660
Commercial – Natural Gas	15	$18,190	$3,090	$22,440	$1,190

REACH TDV

A	B	C	E	F	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)	PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)	PV of[4] Energy Cost Savings – Per Proto Building (PV$)	LCC Savings Per Prototype Building ($)
		Per Proto Building	Per Proto Building		(c+e)-f Based on Current Costs
Commercial – Electric	15	$24,190	$1,650	$26,880	$1,040

2.10 Analysis Tools

Thermal Energy System Specialists (TESS) provided water heating hourly energy usage numbers in order to align with hourly TDV, and therefore provide a more precise assessment of energy costs. The software used is called TRNSYS, (Transient Energy System Simulation Tool) from which F-Chart is based. While a more fully integrated TRNSYS modeling tool would be ideal for compliance purposes, we believe an integration of F-Chart into compliance software is sufficient. We recommend that F-Chart be updated to include current residential and non-residential system types and provide hourly energy modeling.

2.11 Relationship to Other Measures

This CASE proposes solar water heating requirements for *single family* homes. This CASE is related to three other solar water heating measures: 1) The multifamily SWH CASE proposes solar water heating and solar ready requirements for *multifamily* homes. 2) The Commercial Solar Ready CASE proposes solar ready requirements for PV systems in *commercial* buildings, 3) PV and SWH "solar ready" requirements for *single family* homes. These CASEs were developed collaboratively, with each CASE addressing distinct areas of the code.

3. Methodology

For the three separate components of this measure, we used the same basic methodology, with slight variations. The sections below describe the factors for selecting the base case systems and the proposed standards case systems, and data that informed the cost-effectiveness calculation.

3.1 Single Family Residential Buildings

As mentioned above, in this code change proposal for the residential sector, we examined individual dwelling unit buildings exclusively. A separate proposal in this code cycle addressed residential multi-family buildings.

3.1.1 Base Case System Selection:

While the current code contains a prescriptive requirement in Package C for a 25% solar fraction for homes with electric resistance water heating, market research suggests that many single family homes with electric water heaters are not being built with solar hot water systems. For example, the Residential Appliance Saturday Survey (RASS) 2009 database (KEMA 2010) indicates in a statewide survey covering all the investor owned utility service area including electric only areas, there were no homes built after 2001 with a solar water heater and electric backup. For the base case we therefore selected a standard electric resistance water heater with an 80-gallon tank and a 0.9 energy factor, instead of a solar system w/ electric backup with a 25% solar fraction. This represents an extremely conservative approach for a cost-effectiveness analysis, because our analysis assumes the full cost of the solar hot water system, despite the fact that a 25% solar fraction is already the minimum prescriptive requirement.

3.1.2 Proposed Standards Case System Selection:

With a wide range of systems in the marketplace, we initially selected four system types to model costs and energy savings. We modeled these systems across all 16 climate zones due to the variation in TDV and the climate-dependent energy consumption of solar water heating systems. As more field data became available, we focused our analysis on the most commonly installed system, an active indirect system w/ glycol freeze protection (CSI Thermal). This system was modeled with a 74 sq. ft flat plate collector and one 120 gallon tank with electric backup and a 0.9 energy factor. This size of system was based on estimates that this would provide the optimal solar fraction. It should be noted that a 1.5 to 2.0 gallon / sq. ft. ratio is needed to prevent the system from overheating (DOE 2010, Stakeholder Meeting 2010/2011).

It should also be noted that the standards for small federally regulated water heaters (Residential ACM Manual. Appendix B, Pg. 16) have a 0.97-(.00132 x V) energy factor requirement, as of January 20, 2004, however the energy factor used in modeling was 0.9, reflective of the values used by SRCC.

3.1.3 Calculation of Costs:

The three main costs of both systems are the energy costs, installation costs, and maintenance and replacement costs over the 30-year period of analysis for residential buildings.

The base case energy costs were calculated by the following equation:

Equation 1: *Energy Costs=∑ (Hourly ideal energy delivered to load (TESS 2011) / Energy Factor * TDV (CEC 2011 v3))*

The proposed standards system energy costs were calculated using a similar approach:

Equation 2: *Energy Costs=∑ (Hourly energy consumption (TESS 2011) * TDV (CEC 2011 v3))*

The inputs for calculating the hourly energy use and their sources are as follows:

- Prototype building size: 2,700 (Residential ACM manual, CEC 2008)
- Gallons Per Day: 56.5 (Residential ACM Manual, CEC 2008)
- Hourly Draw Schedule (Residential ACM Manual, CEC 2008)
- Inlet Water Temperatures: (NREL algorithm)
- Outlet Water temperature: 135 (Residential ACM manual, CEC 2008)
- Pipe size (OG 300 specification, SRCC 2011)
- Pipe insulation (Use OG 300 specification, SRCC 2011)
- System Orientation Due South (Residential ACM manual, CEC 2008)
- System Tilt 4:12 (Residential ACM manual, CEC 2008)

Installation and replacement for the base case were sourced from RSMeans (2010) for California. Using this methodology the installation costs for the Base Case system total $1,495. See Table 1 for the replacement costs. There was assumed to be no maintenance.

Table 1: Maintenance and Replacement Costs: Base Case System

	Material + Warranty Cost Per Unit ($)	Labor Rate ($)	Labor Time	Labor Cost ($)	Total Cost Overhead & Profit ($)	Replacements / Maintenance per building life	PV Replacements / Maintenance per building life ($)
Auxiliary Tank (80 gal)	$1,080	$35	5.0	$170	$1,500	1	$1,110

Installation, maintenance and replacements costs for the proposed Standards case system were derived from a variety of sources. For installation costs, we first determined the total costs for electric back up tank systems with 74 to 80 sq. ft. collectors from the California Solar Initiative - Thermal public database (2011).[5] To determine a state-weighted average, given the different material and labor rates in different parts of the state, we first multiplied these installation costs by the estimated percentages of the totals costs that equal labor and materials (20%, 80% respectively) for residential systems as determined by the Itron (2009). We then multiplied these labor and material costs by a respective normalizing conversion factor for each city based on population using data from the American

[5] The database included both new and retrofit installations, and while there was a cost differential between types, this differences was deemed statistically insignificant using T-Test methods at 95% confidence interval.

Community Survey 2006 – 2008 (Census 2010) and cost data from RSMeans data (2010). See Appendix B.

Using this methodology, the installation costs for the Proposed Case system are $7,200. See Table 2 for the maintenance and replacement costs, derived from Stakeholder Interviews (2010/2011) and Stakeholder Meetings (2010/2011), and weighted for California rates as well using RSMeans data (2010). See Appendix C for more details.

Table 2: Maintenance and Replacement Costs: Standards Case System

	Material + Warranty Cost Per Unit ($)	**Labor Rate ($)**	**Labor Time (hrs)**	**Labor Cost ($)**	**Total Cost Overhead & Profit ($)**	**Replacements / Maintenance per building life**	**PV Replacements/ Maintenance per building life ($)**
Collector (74 sq. ft.)	$1,500	$35	13	$450	$2,420	1	$1,340
Solar & Auxiliary Combined Tank (120 gal)	$1,080	$35	6	$200	$1,50	3	$2,510
Motor & Pump	$420	$35	1.75	$60	$570	3	$740
Controller	$175	$35	2.5	$90	$340	1	$190
Heat Transfer Fluid Check	-	$35	0.5	$20	$20	20	$90
Heat Transfer Fluid Check & Replace	$105	$35	2	$70	$175	9	$1,040
						Total	**$5,910**

The cost-effectiveness of the proposed Standards case system was determined by calculating the difference between life-cycle costs (energy costs + installation costs + NPV (maintenance & replacement)).

The final component of the methodology was the calculation of the annual solar fraction. The solar fraction was calculated using **Equation 3**, as derived from SRCC (2011)

Equation 3*: Annual Solar Fraction = 1 – Energy Factor (EF) / Solar Energy Factor (SEF)*

Where: EF = 0.9 for a standard electric auxiliary tank.

Solar Energy Factor = Qdel / (Qaux + Qpar)
Where:
QDEL = Energy delivered to the hot water load (TESS 2011)

QAUX = Annual amount of energy used by the auxiliary water heater or backup element with a solar system operating, (Btu/year) (TESS 2011)

QPAR = Parasitic energy: Annual amounts of AC electrical energy used to power pumps, controllers, shutters, trackers, or any other item needed to operate the SDHW system, (Btu/year). (TESS 2011)

3.2 Non-Residential Buildings

In determining the potential applications for solar water heating systems in the commercial sector, we first examined the non-residential (non-hotel/non-motel)[6] building types with the greatest hot water demand. The ACM Manual formula for calculating hot water demand (Btu/hr/sq ft.) indicates that restaurants surpass others by an order of magnitude, so we selected this occupancy type for our analysis. We analyzed electric and natural gas water heating separately, given their differences in efficiencies and utility costs. Some initial evidence suggests that laundromats have a high hot water demand in gallons per day, and that the Btu/hr/sq. ft values for this building type in the ACM Manual should be re-examined, but is outside the scope of this proposal.

It is important to note that while the building prototype is specified in the Residential ACM, with both gallons per day of hot water and sq. footage defined, the Non-Residential ACM applies a different approach: it specifies Btu/h of hot water per person by occupancy type and the number of people per 1,000 sq. ft. Multiplying these values together provides the standard recovery load, in Btu/hr/sq.ft. Since prototype building square footage by occupancy is not specified, however, we developed our own value for analysis. Instead of researching and defining the prototype size, we instead used the approach of determining square footage thresholds for cost-effectiveness. These thresholds were determined by the results of the LCC analysis. To calculate energy use and costs, instead of using the Residential ACM standard recovery load and hourly profiles, we utilized the gallons per day metric, and ASHRAE hourly profiles for hot water demand used by the California Solar Thermal Initiative (see Appendix D). Once we determined the threshold of gallons per day for cost-effectiveness, we plugged this value into the ACM formula for Standard Recovery Load Btu/h/sq. ft. to determine the resulting square footage (see Appendix E).

3.2.1 Base Case System Selection:

The base case for restaurants with a standard electric storage water heater is an 80-gallon tank, found in a small restaurant or coffee shop (Food Service Technology Center 2010). The tank was estimated to have a 0.9 energy factor (SRCC 2011). For restaurants with a natural gas storage water heater, the base case is a 400,000 Btu/hr rated, 100 gallon tank (Wallace & Fisher 2007). The tank was estimated to have a 0.74 operating efficiency (assumed to be the commercial equivalent of energy factor) based on a 0.80 thermal efficiency (FSTC 2011)

3.2.2 Proposed Standards Case System Selection:

For restaurants with electric water heating we modeled costs and energy savings of the most commonly installed system according to CSI Thermal (2011) and California Center for Sustainable Energy – Solar Hot Water Pilot Program (CCSE) database (2010): an active indirect system w/ glycol freeze protection. [7] For sizing the system, we first used the same specifications as the residential system given the comparable hot water demand. However, this sizing of 80 Sq. ft. and a 120 gallon tank proved to be cost-ineffective. We therefore determined that a larger, two-tank system was needed

[6] A separate CASE report in this code cycle is addressing non-residential hotel and motel buildings.

[7] Given the constraint of available roof space, we limited the maximum system size to this number of collectors.

(a 300 gallon solar tank, and an 80 gallon electric storage back up) and sized with 200 sq. ft. of collectors. The energy factor of the tank was estimated to be 0.9 for the reasons mentioned in above in section 3.1.2. The collector sizing was determined to be limited by the available roof space of this prototype restaurant (Stakeholder Meetings 2010/2011).

Using the results from the residential modeling, we chose to model these systems across the 3 least cost-effective climate zones. Cost-effectiveness in these climate zones can be assumed to demonstrate cost-effectiveness across all climate zones.

For restaurants with natural gas heating, the proposed Standards case system is a two-tank system (350 gallon solar tank, and a 100 gallon natural gas boiler) with 0.80 thermal efficiency. This results in the same operating efficiency as the base case (FSTC 2011).

For the solar system, we modeled two types of active indirect systems, drain-back and glycol freeze protection and immersed and external heat exchangers, with 240 sq. ft. of flat-plate collectors. Sizing was also limited by available roof space of this prototype restaurant. Once we determined the external heat exchanger glycol system had the most savings, we also modeled this system with unglazed and evacuated tube collector, though the flat plate collector proved to result in the most savings.

3.2.3 Calculation of Costs:

The three main costs of both systems are the energy costs, installation costs, and the post-installation costs (maintenance and replacement) of the 15-year useful building life.

Energy Costs:

The base case energy costs were calculated by the following equation:[8]

Equation 4: ***Energy Costs*=∑ *(Hourly ideal energy delivered to load (TESS 2011) / Energy Factor * TDV (CEC 2011 v3))***

The proposed standards system energy costs were calculated using a similar approach:

Equation 5: *Energy Costs=∑ (Hourly energy consumption (TESS 2011) * TDV (CEC 2011 v3))*

Where:

Hourly Energy Consumption - Electric = Collector Pump + PV Controller + Electric Auxiliary (TESS 2011)

Hourly Energy Consumption - Natural Gas = Collector Pump + Heat Exchanger Pump + Natural Gas Auxiliary (TESS 2011)

The inputs for calculating the hourly energy use and their sources are as follows:

- Prototype building size:

  Given that there are no prototypes for building square footage by type specified in the non-residential ACM (CEC 2008a), as mentioned above, we tested for square footage thresholds and the corresponding gallons per day using the non-residential ACM Manual Table N-2 (CEC 2008a) to show cost-effectiveness. To calculate the corresponding square footages, we used assumptions from the ACM Manual, as indicated in the following formulas:

Equation 6: *Sq. ft. = Gallons / day * 1 / Gallons/ day /sq. ft*

Where:

Equation 7: *Gallons / day / sq. ft = (Standard Recovery Load / day/ 1,000 sq. ft) * 1/ (total degrees raised* Btu/degree per gallon)*

Where*:*

Equation 8 : *Standard Recovery Load / day/ 1,000 sq .ft. = (∑ (people/sq. ft. & Btu/h/person (ACM, Table N2-5))* occupancy load profile for year(ACM, Table N2-5)) /(days in a year)*

- Gallons Per Day:
  1. Electric Water Heating: 250 gallons per day (estimate)
  2. Natural Gas Water Heating: 2,000 gallons per day (Karas and Fisher 2007).
- Hourly Draw Schedule / Occupancy Load Profile
  1. Electric Water Heating: ASHRAE, from CSI Thermal, Food Service B (2011a)
  2. Natural Gas Water Heating: ASHRAE, from CSI Thermal, Food Service A. (2011a)
- Inlet Water Temperatures: (NREL algorithm)
- Outlet Water temperature: (Karas and Fisher 2007)
- Pipe size (OG 300 specification)
- Pipe insulation (Use OG 300 specification)
- System Orientation Due South (Residential ACM manual)
- System Tilt 4:12 (Residential ACM manual)

<u>Installation & Post-Installation costs</u>

Installation, maintenance and replacement costs for the base case and for proposed standard case system for both electric water heating and natural gas were sourced from CSI Thermal and CCSE (2010), RSMeans (2010), Census (2010) and Stakeholder Meetings (2010/2011). One key additional modification to the methodology for the system w/ natural gas back up, was that since there was a smaller sample of these exact sized systems in the CSI Thermal and CCSE, we used regression analysis to estimate the costs (see Appendix F). It is important to note that when developing the appropriate regression methodology, we took into consideration feedback from stakeholders (2010/2011) and other sources (RSMeans 2010). There was input from stakeholders suggesting that several linear curves are an accurate reflection of how costs increase when increasing collector size.

The installation costs for the Base Case electric storage water heater is $1,600. The installation costs for the Base Case natural gas storage water heater is $10,240.The installation costs for the Proposed Standards Case solar system with electric storage back up is $23,800. The installation cost for the Proposed Standards Case natural gas storage water heater is $28,330. Table 3, 4, 5, and 6 summarize the maintenance and replacement costs for these systems. Table 7 summarizes the building prototype used in this analysis.

Table 3:Maintenance and Replacement Costs: Base Case System Commercial Electric Storage

	Material + Warranty Cost Per Unit	Labor Rate	Labor Time	Labor Cost	Total Cost O&P (Per unit)	Replacements/ Maintenance per building life	PV Replacements/ Maintenance per building life ($)
Auxiliary Tank (80 Gal)	$1,080	$53	5	$267	$1,610	1	$1,530

Table 4: Maintenance and Replacement Costs: Proposed Standards System Commercial Solar System w/ Electric Storage Back up

	Material + Warranty Cost Per Unit	Labor Rate	Labor Time	Labor Cost	Total Cost O&P (Per unit)	Replacements/ Maintenance per building life	PV Replacements/ Maintenance per building life ($)
Auxiliary Tank (80 gal)	$1,080	$53	5	$270	$1,610	1	$1,530
Motor & Pump	$420	$53	1.75	$90	$610	1	$455
Controller	$180	$53	2.5	$130	$395	0	-
Heat Transfer Fluid Check	0	$53	0.5	$30	$30	10	$140
Heat Transfer Fluid Replace	$105	$53	2	$110	$210	5	$820
						Total	**$2,945**

Table 5: Maintenance and Replacement Costs: Base Case System Commercial Natural Gas Storage

	Material + Warranty Cost Per Unit	Labor Rate	Labor Time	Labor Cost	Total Cost O&P (Per unit)	Replacements / Maintenance per building life	PV Replacements / Maintenance per building life ($)
Auxiliary Tank (100 Gal, 400 GPH)	$7,500	$53	20	$1,070	$10,140	1	$ 7,550

Table 6 : Maintenance and Replacement Costs: Proposed Standards System Commercial Natural Gas Storage

	Material + Warranty Cost Per Unit	Labor Rate	Labor Time	Labor Cost	Total Cost O&P (per unit)	Replacements / Maintenance per building life	PV Replacements / Maintenance per building life ($)
Auxiliary Tank (100 Gal, 400 GPH)	$7,500	$53	20	$1,070	$10,140	1	$7,550
Heat Transfer Fluid Check	0	$53	0.5	$30	$20	10	$140
Heat Transfer Fluid Replace	$110	$53	2	$110	$210	5	$1,750
						Total	$**9,400**

Table 7: Prototype Size

	Occupancy Type (Residential, Retail, Office, etc)	Area (Square Feet)	Number of Stories
Prototype 1	Residential Low Rise - Individual Dwelling Unit	2,700 Sq. Ft.	2
Prototype 2	Commercial – Restaurant, electric storage water heater	1,600 Sq. Ft	1
Prototype 3	Commercial – Restaurant, natural gas storage water heater	12,600 Sq. Ft.	1

3.2.4 Statewide Energy Savings

The statewide energy savings associated with the proposed measures were calculated by multiplying the each of the three per unit estimate by the statewide number of applicable new construction in 2014.

The number of single family buildings with electric water heating was estimated by multiplying 47,000 — the new construction single family (HMG 2010) — by both 2.5% — the total single family built between ’01-08 with “Standard Tank Electric Water Heaters” (RASS 2009) — and 5% — the estimated percentage of new residential construction using the prescriptive method.

The number of restaurants above 12,600 SF was estimated by dividing 5,081,000 — the square footage of new construction restaurants in 2014 (HMG 2010) — by 2,000 sq. ft. — the average restaurant size, and then multiplying 8% — the national percentage of restaurants above 12,600 sq. ft. (DOE 2006, See Appendix G). The average restaurant size was determined by dividing 182 million — the current square feet of stock of restaurants — by 90,000 — the number of restaurants as estimated by CRA 2011 .

The number of restaurants above 1,600 SF was estimated by dividing 5,081,000 — the square footage of new construction restaurants in 2014 (HMG 2010) — by 2,000 sq. ft. — the average restaurant size, and them multiplying by and 5% — the estimated percentage of restaurants above using 1,600 sq. ft. using electric water heating (FSTC 2011). The average restaurant size was determined by dividing 182 million — the current square feet of stock of restaurants — by 90,000 — the number of restaurants as estimated by CRA 2011.

Details on the method and data source of the new construction forecast are presented in Appendix H.

4. Analysis and Results

Our analysis resulted in several conclusions. First, installing and utilizing solar water heating with an electric resistance backup water heater in residential, individual unit dwellings saves a significant amount of energy in all 16 climate zones. Moreover, the most common system, an active indirect system with glycol freeze protection is cost-effective.

Table 8 summarizes the energy savings, energy cost savings, incremental cost and the life-cycle cost savings for the Standards Case for residential buildings with electric resistance water heating, as well as the corresponding solar fraction achieved by the solar system.

Table 8: ORIGINAL Proposed Standards Case Results: Residential Solar w/ Electric back up

Climate Zone	Annual Energy Savings (kWh)	30 Year PV BASE TDV Energy Cost Savings ($)	Incremental Measure Cost (installation and PV maintenance and replacement) ($)	Life Cycle Cost Savings ($)	Solar Fraction
1	2,920	$11,390	$9,820	$1,570	0.64
2	3,300	$12,540	$9,820	$2,720	0.77
3	3,320	$12,650	$9,820	$2,830	0.77
4	3,340	$12,750	$9,820	$2,930	0.79
5	3,590	$13,650	$9,820	$3,830	0.84
6	3,430	$12,560	$9,820	$2,740	0.84
7	3,450	$13,160	$9,820	$3,340	0.86
8	3,370	$12,380	$9,820	$2,560	0.84
9	3,330	$12,150	$9,820	$2,330	0.84
10	3,350	$12,120	$9,820	$2,300	0.85
11	3,170	$12,020	$9,820	$2,200	0.77
12	3,150	$12,030	$9,820	$2,210	0.75
13	2,980	$11,330	$9,820	$1,510	0.75
14	3,550	$12,740	$9,820	$2,920	0.87
15	3,050	$10,910	$9,820	$1,090	0.89
16	3,530	$12,920	$9,820	$3,100	0.75

Stakeholder feedback regarding these results suggested that most of these solar fractions were too high and would result in systems overheating. To address this concern, we decreased the solar fraction to .7 while also inserting a requirement for system to have overheating protection per the Solar Rating Certification Corporation and/or the CSI-Thermal Handbook. Table 9 and the code language reflect the results of this change.

Table 9: AMENDED Proposed Standards Case Results: Residential Solar w/ Electric Resistance back up

Climate Zone	Annual Energy Savings (kWh)	30 Year PV BASE TDV Energy Cost Savings ($)	Incremental Measure Cost (installation and PV maintenance and replacement) ($)	Life Cycle Cost Savings ($)	Solar Fraction
1	3,180	$12,240	$10,200	$2,040	0.70
2	2,730	$10,710	$9,630	$1,080	0.70
3	2,710	$10,650	$9,630	$1,020	0.70
4	2,680	$10,540	$9,630	$910	0.70
5	2,620	$10,370	$9,430	$940	0.70
6	2,580	$10,620	$9,310	$1,310	0.70
7	2,550	$10,590	$9,210	$1,380	0.70
8	2,570	$10,590	$9,210	$1,380	0.70
9	2,580	$10,570	$9,210	$1,360	0.70
10	2,570	$10,570	$9,210	$1,360	0.70
11	2,720	$10,610	$9,630	$980	0.70
12	2,760	$10,650	$9,630	$1,020	0.70
13	2,730	$10,510	$9,630	$880	0.70
14	2,620	$10,660	$9,630	$1,030	0.70
15	2,380	$9,810	$9,100	$710	0.70
16	2,800	$10,850	$9,630	$1,220	0.70

Second, installing and utilizing solar water heating with a natural gas backup water heater in restaurants 12,600 sq. ft. or larger is cost-effective over the base case, a natural gas storage water heater, in every climate zone, except Climate Zone 1. Table 10 summarizes the energy, energy cost savings and the life-cycle cost savings for the Standards Case for restaurants with natural gas water heating, as well as the corresponding solar fraction achieved by the solar system using Equation 10. NOTE: Because this proved cost-effective for natural gas, we concluded that it would be cost effective for electric water heating at this threshold as well, without performing the modeling, given the relative cost of electricity over natural gas.

Table 10: Proposed Standards Case Results: Restaurant above 12,600 sq. ft. (BASE TDV)

Climate Zone	Annual Energy Savings (Therms)	15 Year PV BASE TDV Energy Cost Savings ($)	Incremental Measure Cost (installation and PV maintenance and replacement)	Life Cycle Cost Savings ($)	Solar Fraction
1	1,440	$19,490	$20,950	($1,800)	0.18
2	1,650	$22,240	$20,950	$940	0.25
3	1,610	$21,680	$20,950	$390	0.24
4	1,670	$22,540	$20,950	$1,250	0.25
5	1,690	$23,080	$20,950	$1,790	0.25
6	1,610	$22,110	$20,950	$820	0.25
7	1,620	$22,580	$20,950	$1,300	0.26
8	1,630	$22,310	$20,950	$1,030	0.26
9	1,650	$22,540	$20,950	$1,260	0.26
10	1,670	$22,840	$20,950	$1,560	0.27
11	1,680	$22,570	$20,950	$1,270	0.26
12	1,640	$21,980	$20,950	$690	0.25
13	1,590	$21,300	$20,950	$20	0.26
14	1,810	$24,810	$20,950	$3,530	0.28
15	1,660	$22,730	$20,950	$1,450	0.31
16	1,780	$24,290	$20,950	$3,010	0.24

The third conclusion is that installing and utilizing solar water heating with 200 sq. feet of flat-plate collectors with an electric storage backup water heater in commercial restaurants 1,600 sq. ft. large (with 250 gallons per day hot water demand) is cost-effective over the base case (an electric storage water heater), when using Reach Code TDV, in every climate zone except for Climate Zone 1. Table 11 summarizes the energy, energy cost savings and the life-cycle cost savings for the Standards Case for restaurants with electric storage water heating, as well as the corresponding solar fraction achieved by the solar system.

Table 11: Proposed Standards Case Results: Restaurant above 1,600 sq. ft. w/ Electric back up (REACH TDV)

Climate Zone	Annual Energy Savings (kWh)	15 Year PV REACH TDV Energy Cost Savings ($)	Incremental Measure Cost (installation and PV maintenance and replacement)	Life Cycle Cost Savings ($)	Solar Fraction
1	8,280	$23,140	$23,800	($660)	0.38
13	10,150	$26,580	$23,800	$2,780	0.54
15	11,010	$27,170	$23,800	$3,370	0.67

4.1 Statewide Energy Savings

The total energy and energy cost savings potential for residential solar with electric back up are 0.0001/SF, 1.0 kWh/SF, and $3.90/SF. Applying these unit estimates to the statewide estimate of new construction of 59 new dwelling units per year in the first year statewide energy savings of 0.018 MW, 0.016 GWh, and $618,500.

The total energy and energy cost savings potential for restaurants above 12,600 sq. ft. are -0.0000005 kW/SF, -0.04 kWh/SF, 0.13 therms/SF and $1.90/SF. Applying these unit estimates to the statewide estimate of new construction of 203 new units per year results in first year statewide energy savings of -0.012 MW, -0.11 GWh, 0.34 MM therms and $4.5 million.

The total energy and energy cost savings potential for restaurants above 1,600 S sq. ft. with electric back up are 0.0008 kW/SF, 7.05 kWh/SF, and $17.90/SF. Applying these unit estimates to the statewide estimate of new construction of 127 new units per year results in first year statewide energy savings of 0.27 MW, 1.3 GWh, and $3.3 million

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

5.1 Title 24, Part 6

RESIDENTIAL STANDARDS:

Subchapter 8

SECTION 151 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

Section 151(b)1

(b) **Performance Standards**. A building complies with the performance standard if the combined depletable TDV energy use for water heating Section 151(b)1 and space conditioning Section 151(b)2 is less than or equal to the combined maximum allowable TDV energy use for both water heating and space conditioning, even if the building fails to meet either the water heating or space conditioning budget alone.

1. **Water heating budgets**. The water heating budgets for each climate zone shall be the calculated consumption of energy from depletable sources required for water heating in buildings in which the requirements of Section 151(a) and of Section 151(f)8A for systems serving individual dwelling units or of Section 151(f)8C for systems serving multiple dwelling units are met. To determine the water heating budget, use an approved calculation method.

(f) **Prescriptive Standards/ Component Packages**. Buildings that comply with the prescriptive standards shall be designed, constructed, and equipped to meet all of the requirements of one of the packages of components shown in TABLE 151-B**Error! Reference source not found.**or TABLE 151-D for the appropriate climate zone shown in FIGURE 101-A. In TABLE 151-B**Error! Reference source not found.**and TABLE 151-D, a NA (not allowed) means that feature is not allowed in a particular climate zone and a NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

….

8. **Domestic Water-heating systems.** Water heating systems shall meet the requirements of either A, B, ~~or~~ C or D and meet the requirements of E and F, or shall meet the requirements of Section 151(b)1.

   A. For systems serving individual dwelling units, a single gas or propane storage type water heater with an input of 75,000 Btu per hour or less and no recirculation pumps, and that meets the tank insulation requirements of Section 150(j) and the requirements of Sections 111 and 113 shall be installed.

   B. For systems serving individual dwelling units, a single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no recirculation pumps or storage tank, and that meets the requirements of Sections 111 and 113 shall be installed.

   C. For systems serving multiple dwelling units, a central water heating system that has gas or propane water heaters, boilers or other water heating equipment that meet the minimum efficiency requirements of Sections 111 and 113 and a water heating recirculation loop that meets the requirements of Section 113(c)2 and Section 113(c)5 shall be installed.

   D. For systems serving individual dwelling units, electric-resistance water heating may be installed as the main water heating source in Package C only if natural gas is unavailable and only if the water heater is located within the building envelope and is served by a solar water heating system that has a calculated solar fraction no less than .7 and follows freeze and overheat protection guidelines of SRCC and/or CSI Thermal Handbook, or a system having the following characteristics:

      1. Collector rating : Collectors shall have a SRCC OG-100 rating of having a Y intercept no less than 0.706 and a slope no less than -.865 btu/hr ft^2^ ° F

      2. Collector type: collector shall be a glazed flat-plate collector.

3. Collector size and orientation: Collectors shall be at least the area specified below by Climate Zone, facing within 45° of due South, having a tilt angle between 14.02°(3:12) and 22.62° (5:12)° from horizontal, Over 90% of collector area shall be unshaded for at least 8 hours on the equinox.

Climate Zone	Collector Sq. Ft.
1	55
2	36
3	36
4	30
5	30
6	30
7	30
8	30
9	30
10	36
11	36
12	36
13	36
14	18
15	18
16	36

4. Solar Storage tank: internal volume of at least 2 gallons per 1 sq. ft. of collector and insulated according to Section 113(c)4.
5. Freeze protection: as specified in CSI Thermal Handbook
6. Overheat protection: as specified as by SRCC guidelines, or if not available, as specified by CSI Thermal Handbook
7. Pump. Pumps shall have an electronically commutated motor.

E. All hot water pipes from the heating source to the kitchen fixtures shall be thermally insulated as specified by Section 150(j)2.

F. All buried hot water piping shall be insulated to meet the requirements of Section 150(j)2 and be installed in a waterproof and non-crushable casing or sleeve that allows for installation, removal and replacement of the enclosed water piping. The internal cross-section or diameter of the casing or sleeve shall be large enough to allow for insulation of the hot water piping.

TABLE 151-B COMPONENT PACKAGE C

Climate Zone	1, 16	3	4	5	6	7	8, 9	10	2, 11-13	14	15
BUILDING ENVELOPE											
Insulation minimums[1]											
Ceiling	R49	R38	R38	R38	R38	R38	R38	R49	R49	R49	R49
Wood-frame walls	R29	R25	R25	R25	R21	R21	R21	R25	R29	R29	R29
"Heavy mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
"Light mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Below-grade walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Slab floor perimeter	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7
Raised floors	R30	R30	R30	R30	R21	R21	R21	R30	R30	R30	R21
Concrete raised floors	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radiant Barrier	NR	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ
Roofing Products	See TABLE 151-C, COMPONENT PACKAGE D										
FENESTRATION											
Maximum U-factor[2]	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Maximum total area	14%	14%	14%	16%	14%	14%	14%	16%	16%	14%	16%
Maximum West facing area	NR	NR	5%	NR	NR	5%	5%	5%	5%	5%	5%
THERMAL MASS[4]	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
SPACE-HEATING [5]											
Electric-resistant allowed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If gas, AFUE =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If heat pump, HSPF[6] =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE-COOLING											
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system, Refrigerant charge measurement or charge indicator display	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ
Central Forced Air Handler:	See TABLE 151-C, COMPONENT PACKAGE D										
DUCTS											
Duct sealing	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
Duct Insulation	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
WATER HEATING Either prescriptive requirements in §151(f)8F or SOLAR FRACTION of:	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
~~WATER HEATING~~	~~System shall meet Section 151(f)8 or Section 151(b)1~~ [7]										

Footnote requirements to TABLE 151-B **Error! Reference source not found.**and TABLE 151-D.

1 The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see Section 151(f)1A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by 0.65. Any insulation installed on heavy or light mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air. The exterior wall used to meet the R-value in parentheses cannot also be used to meet the thermal mass requirement.

2 The installed fenestration products shall meet the requirements of Section 151(f)3.

3 The installed fenestration products shall meet the requirements of Section 151(f)4.

4 If the package requires thermal mass, the thermal mass shall meet the requirements of Section 151(f)5.

5 Thermostats shall be installed in conjunction with all space-heating systems in accordance with Section 151(f)9.

6 HSPF means "heating seasonal performance factor."

~~7 Electric-resistance water heating may be installed as the main water heating source in Package C only if the water heater is located within the building envelope and a minimum of 25 percent of the energy for water heating is provided by a passive or active solar system.~~

8 As an alternative under Package E in climate zone 1, glazing with a maximum 0.57 U-factor and a 92% AFUE furnace or an 8.4 HSPF heat pump may be substituted for the Package E glazing U-factor requirement. All other requirements of Package E must be met.

9 As an alternative under Package E in climate zone 16, glazing with a maximum 0.57 U-factor and a 90% AFUE furnace or an 8.4 HSPF heat pump may be substituted for may be substituted for the Package E glazing U-factor requirement. All other requirements of Package E must be met.

10 A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

RESIDENTIAL MANUAL:

- 5.1.3 Water Heater Types:
  - Add: <u>Solar Water Heater w/ electric resistance storage backup</u>
  - Add: <u>Solar Water Heater w/electric resistance instantaneous backup</u>
  - Add: <u>Solar Water Heater w/ natural gas storage backup</u>
- 1-18-1 Package C
  - "Electric resistance water heating may only be used with Package C if the water heater is located within the building envelope and <u>a .7 solar fraction of the energy for water heating is provided by a passive or active solar system as specified in Table 151-B COMPONENT Package C."</u>

TABLE 151-B COMPONENT PACKAGE C

Climate Zone	1, 16	3	4	5	6	7	8, 9	10	2, 11-13	14	15
BUILDING ENVELOPE											
Insulation minimums[1]											
Ceiling	R49	R38	R38	R38	R38	R38	R38	R49	R49	R49	R49
Wood-frame walls	R29	R25	R25	R25	R21	R21	R21	R25	R29	R29	R29
"Heavy mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
"Light mass" walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Below-grade walls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Slab floor perimeter	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7
Raised floors	R30	R30	R30	R30	R21	R21	R21	R30	R30	R30	R21
Concrete raised floors	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radiant Barrier	NR	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ
Roofing Products											
FENESTRATION											
Maximum U-factor[2]	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Maximum Solar Heat Gain Coefficient (SHGC)[3]	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Maximum total area	14%	14%	14%	16%	14%	14%	14%	16%	16%	14%	16%
Maximum West facing area	NR	NR	5%	NR	NR	5%	5%	5%	5%	5%	5%
THERMAL MASS[4]	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
SPACE-HEATING [5]											
Electric-resistant allowed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If gas, AFUE =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If heat pump, HSPF[6] =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE-COOLING											
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system, Refrigerant charge measurement or charge indicator display	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ
Central Forced Air Handler:											
DUCTS											
Duct sealing	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
Duct Insulation	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
<u>WATER HEATING</u> <u>Either prescriptive requirements in §151(f)8F or SOLAR FRACTION of:</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>	<u>0.70</u>
~~WATER HEATING~~	~~System shall meet Section 151(f)8 or Section 151(b)1~~ [7]										

Footnote requirements to TABLE 151-B **Error! Reference source not found.**and TABLE 151-D.

1 The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see Section 151(f)1A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by

0.65. Any insulation installed on heavy or light mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air. The exterior wall used to meet the R-value in parentheses cannot also be used to meet the thermal mass requirement.

2 The installed fenestration products shall meet the requirements of Section 151(f)3.

4 The installed fenestration products shall meet the requirements of Section 151(f)4.

4 If the package requires thermal mass, the thermal mass shall meet the requirements of Section 151(f)5.

5 Thermostats shall be installed in conjunction with all space-heating systems in accordance with Section 151(f)9.

6 HSPF means "heating seasonal performance factor."

7 ~~Electric resistance water heating may be installed as the main water heating source in Package C only if the water heater is located within the building envelope and a minimum of 25 percent of the energy for water heating is provided by a passive or active solar system.~~

8 As an alternative under Package E in climate zone 1, glazing with a maximum 0.57 U-factor and a 92% AFUE furnace or an 8.4 HSPF heat pump may be substituted for the Package E glazing U-factor requirement. All other requirements of Package E must be met.

9 As an alternative under Package E in climate zone 16, glazing with a maximum 0.57 U-factor and a 90% AFUE furnace or an 8.4 HSPF heat pump may be substituted for may be substituted for the Package E glazing U-factor requirement. All other requirements of Package E must be met.

10 A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

- 5-1.5. pg. 5-5
    - Revise: "~~So~~ Solar water heating is also required <u>if electric resistance water heater is installed</u> (using prescriptive package C)."

5.2 Title 24 Part 6 & Part 11

NON RESIDENTIAL STANDARDS

PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

PART 6

Add:

(a) Nonresidential Occupancies. A service water heating system installed in a nonresidential building complies with this section if it complies with the following requirements:

1. All service water heating systems shall comply with the applicable requirements of Sections 111, 113 and 123 of Title 24 Part 6; and

2. Service water heating systems providing hot water to restaurants (designated as “restaurant” or area category as “dining” and a total square footage (conditioned floor area & non-conditioned floor area) of 12,600 or greater shall provide 25% of the energy for water heating from solar water heating (calculated by Solar Rating and Certification Corporation (SRCC) approved methodology) with a passive or active solar system complying with the freeze and overheat protection guidelines of SRCC. If the system uses a pump, the pump shall have an electronically commutated motor.

PART 11

Add:

- Buildings with building category designated as “restaurant” or area category as “dining” and a total square footage (conditioned floor area & non-conditioned floor area) of 1,600 or greater may install an electric storage water heater if the water heater is located within the building envelope and a minimum of 50% percent of the energy for water heating is provided by a passive or active solar system.

  Exception: When indoor lighting and mechanical plans are both submitted for construction in an existing building envelope.

  Exception: Where building is located in Climate Zone 1.

  A service water heating system installed in this building type and all nonresidential buildings complies with this section if it also complies with the applicable requirements of Part 6, Sections (111,113 and 123).

NON RESIDENTIAL MANUAL

- 4.7 Service Water Heating
  - Service Water Heaters in Restaurants
  - Service water heating systems providing hot water to restaurants with a total square footage (conditioned floor area & non-conditioned floor area) of 12,600 or greater shall provide 25% of the energy for water heating is provided by a passive or active solar

system, and follows freeze and overheat protection guidelines of SRCC and/or CSI Thermal Handbook

Restaurants unable to calculate the % of energy savings from solar may meet the requirements by using the following example:

- The system shall be an active solar system with glazed flat plate collectors with an area of at least 1 sq. ft. of collector per 50 sq. ft. of conditioned floor space.
- Solar storage tanks shall have an internal volume of at least 1 gallon per 1 sq. ft. of collector and insulated according to Section 113(c) 4.
- The collectors shall a. SRCC OG-100 rating with a Y intercept no less than 0.706 and a slope no less than -0.865 Btu/hr ft2·°F
- Collectors shall face within 35 degrees of due South, and shall have a tilt angle of at least 14 degrees (3:12) from horizontal, Over 95% of collector area shall be unshaded for at least 8 hours on the equinox.
- Pump shall have an electronically commutated motor.

5.3 Compliance Forms

RESIDENTIAL

- CF-1R – Certificate of Compliance - Residential New Construction (page 4 of 5) Water Heating:
  - Add: electric resistance water heating with solar fraction requirement and reference to Solar Water Heating and CF-SR (Solar Water Heating Calculation).

- CF-6R-MECH-01 – Domestic Hot Water (DHW) (page 1 of 2):
  - Add: electric resistance water heating with solar fraction requirement

- CF-6R-MECH-02 - Solar Domestic Hot Water Systems (SDHW) (page 1 of 1):
  - Revise: “Net Solar Fraction”

NON-RESIDENTIAL

- Section 4.7.1:
  - Solar Water Heating Calculations: Solar water heating can be used as a tradeoff under the performance approach. The building standards use solar fraction (SF) to determine the impact of the solar water heating systems. The SF is the percent of the total energy required by the water heating system that is provided by the solar system. Note that systems used for compliance must have received

a rating by the Solar Rating and Certification Corporation (SRCC). When using the prescriptive approach, the designer has two options. The first option is to achieve a solar fraction by selecting the applicable type and number of collectors, storage volume, as well as the tilt and orientation of the collectors. To use this approach, go to the following website to download the calculator: ______. The second option is to follow the specifications in Section 4.7 of the Compliance Manual.

- MECH-2C
    - Add: "Building Area (ft^2)" and "Restaurant (Building Category) or Dining (Area Category) (see LTG-1C) and "Solar Fraction."

5.4 Residential and Nonresidential ACM Manual

- Integrating Hourly Solar Water Heating Hourly Modeling Calculation

6. Bibliography and Other Research

[CEC] California Energy Commission. 2008. Residential Alternative Calculation Method (ACM) Approval Manual for the 2008 Building Energy Efficiency Standards. December 2008.

[CEC] California Energy Commission. 2008a. Nonresidential Alternative Calculation Method (ACM) Approval Manual for the 2008 Building Energy Efficiency Standards. December 2008.

California Solar Thermal Initiative. 2011. https://www.csithermal.com/public_export/. March 03 2011.

California Solar Thermal Initiative. 2011a. "CSI-Thermal Multifamily/Commercial; SRCC OG-100 Incentive Calculator Guide" https://www.csithermal.com/media/docs/CSI-Thermal_SRCC_OG-100_Incentive_Calculator_Guide.pdf

[Census] U.S. Census Bureau. 2010. *American Community Survey 2006 – 2008.* http://www.census.gov/acs/www/. U.S. Census Bureau. December 2010.

[CRA] California Restaurant Association . 2011. "About the CRA"

http://www.calrest.org/go/CRA/about-the-CRA/index.cfm

[DOE] Department of Energy. 2006. CBECS "Table B11. Selected Principal Building Activity: Part 1, Number of Buildings for Non-Mall Buildings, 2003" http://www.eia.gov/emeu/cbecs/

[FSTC] Food Service Technology Center. 2010 & 2011. Personal Communication. October 20, 2010 and March 26, 2011

Itron. 2009. *Solar Water Heating Pilot Program: Interim Evaluation Report.* Prepared by Itron for the California Center for Sustainable Energy. January 16, 2009. Vancouver, Wash.

Itron. 2006. *California Commercial End-Use Survey* (CEUS). Prepared for California Energy Commission. March 2006. http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF

KEMA. 2010. *California Residential Appliance Saturation Study* (RASS) 2009. Prepared for California Energy Commission.

Karas, Angelo and Don Fisher. 2007. *Energy Efficiency Potential of Gas-Fired Water Heating Systems in a Quick Service Restaurant: An Emerging Technology Field Monitoring Study.* October 2007. FSTC Report 5011.07.19. San Ramon, Calif. Food Service Technology Center.

Wallace, Charles and Don Fisher. 2007a. *Energy Efficiency Potential of Gas-Fired Commercial Hot Water Heating Systems in Restaurants: An Emerging Technology Field Monitoring Study.* April 2007. FSTC Report 5011.07.04. San Ramon, Calif. Food Service Technology Center.

[DOE] U.S. Department of Energy. "Sizing a Solar Water Heating System" http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12880 Washington, D.C.: U.S. Department of Energy

[EIA] U.S. Energy Information Administration. 2011. "Solar Thermal Data and Information Release Date: January 2011" http://www.eia.doe.gov/cneaf/solar.renewables/page/solarthermal/solarthermal.html Washington, D.C.: U.S. Department of Energy

RSMeans. 2010. Costworks. *2010 4th Quarter Data*. http://www.meanscostworks.com/

[CCSE] California Center for Sustainable Energy. 2010. Project Report. Solar Hot Water Pilot Program. 2010. Excel. August 12, 2010.

[SRCC] Solar Rating Certification Corporation. 2011. http://www.solar-rating.org/ratings/ratings.htm.

Stakeholder Interviews. 2010/2011. Personal Communication.

Stakeholder Meetings. 2010/2011. “Solar Topics: Title 24: California Statewide Utility Codes and Standards Program. Hosted by Energy Solutions & Heschong Mahone Group, Inc. on behalf of Pacific Gas and Electric Co., Southern California Edison and Sempra Energy. November 2nd, 2010 and January 11, 2011.

[TESS]. Thermal Energy System Specialists. 2011. Excel spreadsheet.Appendices

7. Appendices

7.1 Appendix A: TDV Part 11 of Title 24 (Reach Code) Multipliers

	Electricity	Gas	Propane
Res 30yr	1.259	1.331	1.152
Non-Res 15yr	1.253	1.375	1.197
Non-Res 30yr	1.27	1.354	1.182

7.2 Appendix B: Population Weighting for Plumbing Labor and Materials

		Plumbing			Plumbing		
		Labor			**Material**		
Metro Region	Population (millions) American Community Survey, Census 2007-2009)	Location Factor (*US Rate) RS Means	Weighted Loc. Factor (Pop. Location Factor)	State/City Ratio	Location Factor (*US Rate)	Weighted Loc. Factor	State/City Ratio
Alhambra	0.086	96.3	8.282	1.096	93.4	8.032	1.067
Anaheim	0.334	112.9	37.709	0.934	100.1	33.433	0.995
Bakersfield	0.318	94.2	29.956	1.120	100.1	31.832	0.995
Berkeley	0.108	123.2	13.306	0.856	93.4	10.087	1.067
Eureka	0.027	102.4	2.765	1.030	93.3	2.519	1.068
Fresno	0.472	107.8	50.882	0.979	100.2	47.294	0.994
Inglewood	0.116	96.3	11.171	1.096	93.4	10.834	1.067
Long beach	0.463	96.3	44.587	1.096	93.4	43.244	1.067
Los Angeles	3.75	112.9	423.375	0.934	100.2	375.750	0.994
Marysville	2007-2009 Population unavailable	-	-	-	-	-	-
Modesto	0.204	107.8	21.991	0.979	100.1	20.420	0.995
Mojave	2007-2009 Population unavailable	-	-	-	-	-	
Oakland	0.362	136.1	49.268	0.776	100.2	36.272	0.994
Oxnard	0.176	112.9	19.870	0.934	100.1	17.618	0.995
Palm Springs	0.039	96.3	3.756	1.096	93.3	3.639	1.068
Palo Alto	0.063	122.3	7.705	0.863	93.4	5.884	1.067
Pasadena	0.138	96.3	13.289	1.096	93.4	12.889	1.067
Redding	0.091	98.7	8.982	1.069	100.1	9.109	0.995
Richmond	0.099	119.7	11.850	0.881	93.4	9.247	1.067
Riverside	0.302	112.9	34.096	0.934	100.1	30.230	0.995
Sacramento	0.447	110.8	49.528	0.952	100.1	44.745	0.995
Salinas	0.144	108.2	15.581	0.975	93.4	13.450	1.067
San	0.208	96.4	20.051	1.094	93.3	19.406	1.068

Bernardino							
San Diego	1.25	113.3	141.625	0.931	100.2	125.250	0.994
San Francisco	0.798	165.1	131.750	0.639	100.2	79.960	0.994
San Jose	0.905	138.5	125.343	0.762	100.1	90.591	0.995
San Luis Obispo	0.048	96.4	4.627	1.094	93.4	4.483	1.067
San Mateo	0.093	137.1	12.750	0.770	93.4	8.686	1.067
San Rafael	0.054	132.9	7.177	0.794	93.4	5.044	1.067
Santa Ana	0.328	96.3	31.586	1.096	93.3	30.602	1.069
Santa Barbara	0.086	112.9	9.709	0.934	100.1	8.609	0.995
Santa Cruz	0.055	108.2	5.951	0.975	100.1	5.506	0.995
Santa Rosa	0.153	132.1	20.211	0.799	93.3	14.275	1.069
Stockton	0.286	98.8	28.257	1.068	100.1	28.629	0.995
Susanville	2007-2009 Population unavailable	-	-	-	-	-	-
Vallejo	0.114	112	12.768	0.942	100.1	11.411	0.995
Nan nyus	2007-2009 Population unavailable	-	-	-	-	-	-
TOTAL	12.117		1409.752			1198.981	
	Population (millions)						
California	36	105.501			99.647		
Weighted	23.883	Weighted			Weighted		
Rest of State	12.117	100.00			100.00		

7.3 *Appendix C: Cost Data*

Replacement & Maintenance Costs	**Residential Solar Hot Water w/ Electric Storage Backup**		
Costs are for Active Indirect Glycol System, the most common system across sizes. Data points for Drainback were limited, though generally suggests it is a slightly higher cost systems.Thermospyhpon, ICS are less expensive by difficult to model. Active Direct Water systems are less expensive, but less prevalent.			

Overall Assumptions		**Source**
Building Life (years)	30	CEC TDV
Collector Size (Sq. Ft)	80	
Labor Rates (See Tab)	35	RS Means 11
Labor O&P (See tab)	63%	RS Means 11
Material O&P	12%	RS Means 11
Labor	20%	Itron 2009
Material	80%	Itron 2009

Component Assumptions

Component	**Life Expectancy / Frequency**	**Number of Implementations During Building Life**	**Cost Per Replacement**
Collector	20	1	$ 2,419.03
Solar & Auxiliary Tank	10	2	$ 1,936.24
Motor and Pump	10	2	$ 572.13
Controller	20	1	$ 338.12
Heat Transfer Fluid Check	1	20	$ 17.44
Heat Transfer Fluid Check & Replacement	3	9	$ 175.25

Replacement & Maintenance Costs	**Commercial Solar Hot Water w/ Electric Storage Backup**		
Costs are for Active Indirect Glycol System, the most common system across sizes. Data points for Drainback were limited, though generally suggests it is a slightly higher cost systems.Thermospyhpon, ICS are less expensive by difficult to model. Active Direct Water systems are less expensive, but less prevalent.			

Overall Assumptions		**Source**
Building Life (years)	15	CEC TDV
Collector Size (Sq. Ft)	200	
Labor Rates (See Tab)	53.4	RS Means 11
Labor O&P (See tab)	49%	RS Means 11
Material O&P	12%	RS Means 11
Labor	20%	Itron 2009
Material	80%	Itron 2009

Component Assumptions

Component	**Life Expectancy / Frequency**	**Number of Implementations During Building Life**	**Cost Per Replacement**
Collector	20	0	$ 2,717
Auxilary Tank	10	1	$ 1,610
Solar Tank	15	0	$ 4,135
Motor and Pump	10	1	$ 612
Controller	20	0	$ 395
Heat Transfer Fluid Check	1	10	$ 27
Heat Transfer Fluid Check & Replacement	3	5	$ 212

Appendix D: Daily Hot Water Demand Load Profiles

Below are the daily hot water demand load profiles for "full service" (Type A) and "quick service" (Type B) restaurants from which new occupancy loads were derived.

Profiles for Restaurants

Hour	Food Services (Type A) gph/unit	Food Service (Type B) gph/unit
1	-	0.08
2	-	0.06
3	-	0.04
4	-	0.04
5	-	0.02
6	-	0.02
7	-	0.02
8	-	0.01
9	0.02	0.02
10	0.03	0.04
11	0.04	0.02
12	0.04	0.03
13	0.05	0.05
14	0.17	0.05
15	0.08	0.03
16	0.03	0.04
17	0.02	0.04
18	0.07	0.05
19	0.20	0.07
20	0.10	0.05
21	0.09	0.05
22	0.04	0.05
23	0.01	0.05
24	-	0.05

Day of Week	Food Services (Type A)	Food Service (Type B)
Sunday	1	1
Monday	1	1
Tuesday	1	1
Wednesday	1	1
Thursday	1	1
Friday	1	1
Saturday	1	1

Month of Year	Food Services (Type A)	Food Service (Type B)
January	1	1
February	1	1
March	1	1
April	1	1
May	1	1
June	1	1
July	1	1
August	1	1
September	1	1
October	1	1
November	1	1
December	1	1

Source: California Solar Thermal Initiative. 2011a, originally from ASHRAE HVAC Applications 2007 section 49.18, figure 24.

7.4 Appendix E: ACM formula for Standard Recovery Load Btu/h/sq. ft.

Hot Water Demand determined by T24 ACM Manual 2.6.1.1, 2-115

Standard Recovery Load in Btu/hr per 1,000 Sq. ft. (SRL) x Hourly load multiplier for the nth hour (Fwhp(n) for each day over 365 days = 38,847,789 Annual Btu / 365 days = 106,432 Btu/day / 80 degree temp. difference (RES ACM Inlet Water Temp Avg) * 8.33Btu/Deg = 159 GPD / 1,000 sq. ft.

Where: Standard Recovery Load in Btu/hr per 1,000 Sq. ft. - Restaurants = 16,470

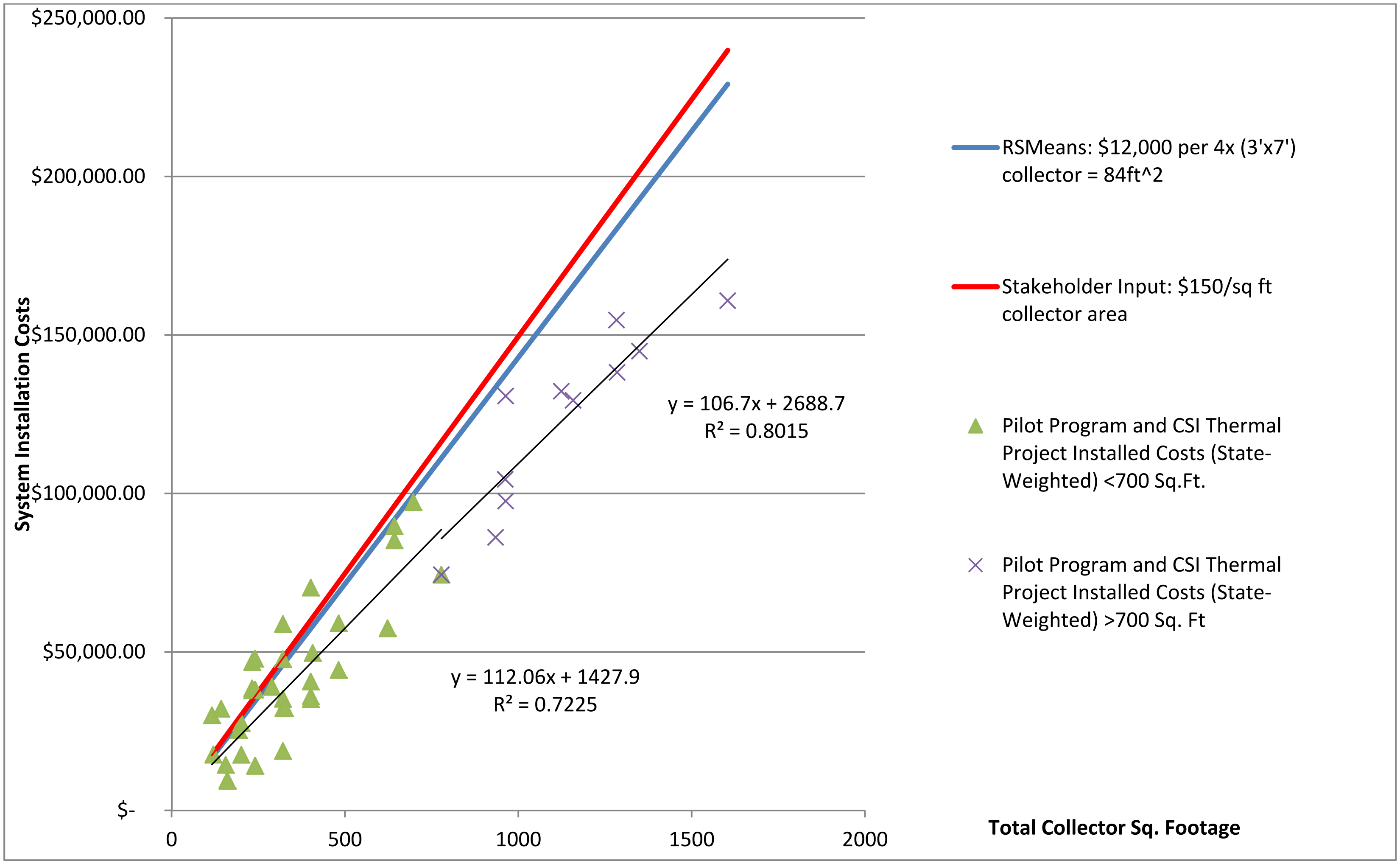
= 45 people per 1,000 Sq. Ft. x 366 Hot Water Btu/h per person

250 GPD (Cost Effective Threshold for Commercial Electric) / 159 GPD / 1,000 sq. ft. = 1.57 * 1,000 Sq. Ft. = 1,570 Sq. Ft. Round to 1,600 Sq. Ft.

2,000 GPD (Cost Effective Threshold for Commercial Natural Gas) / 159 GPD / 1,000 sq. ft. = 12.58 * 1,000 Sq. Ft. = 12,580 Sq. Ft. Round to 12,600 Sq. Ft.

7.5 *Appendix F: Installation Cost Data*

Statewide Avg. Installation Costs vs. Collector Size: Active Indirect Glycol



7.6 *Appendix G: Commercial Building Energy Consumption Survey Data*

Commercial Buildings Energy Consumption Survey

National Building Data

Released: June 2006

http://www.eia.doe.gov/emeu/cbecs/

Table B11. Selected Principal Building Activity: Part 1, Number of Buildings for Non-Mall Buildings, 2003

	Number of Buildings (thousand)							
		Principal Building Activity						
					Health Care			
	All Buildings*	Education	Food Sales	Food Service	Inpatient	Outpatient	Lodging	Retail (Other Than Mall)
All Buildings*	4,645	386	226	297	8	121	142	443
Building Floorspace (Square Feet)								
1,001 to 5,000	2,552	162	164	202	N	56	38	241
5,001 to 10,000	889	56	44	65	N	38	21	97
10,001 to 25,000	738	60	Q	23	Q	19	38	83
25,001 to 50,000	241	48	Q	Q	Q	Q	23	14
50,001 to 100,000	129	39	Q	Q	Q	3	11	Q
100,001 to 200,000	65	16	Q	N	Q	Q	7	4
200,001 to 500,000	25	5	N	Q	2	Q	4	Q
Over 500,000	7	Q	N	N	1	N	Q	Q
Year Constructed								
Before 1920	330	12	Q	32	Q	Q	Q	37
1920 to 1945	527	26	Q	34	Q	Q	11	66
1946 to 1959	562	78	Q	30	Q	Q	17	62
1960 to 1969	579	60	Q	Q	1	Q	25	59
1970 to 1979	731	58	Q	46	2	14	25	90
1980 to 1989	707	44	33	46	2	18	21	44
1990 to 1999	876	75	56	66	0	36	30	68
2000 to 2003	334	32	Q	Q	Q	Q	6	17

Table A6. Building Size, Floorspace for All Buildings (Including Malls), 2003

	Total Floorspace (million square feet)								
		Building Size							
	All Buildings	1,001 to 5,000 Square Feet	5,001 to 10,000 Square Feet	10,000 to 25,000 Square Feet	25,001 to 50,000 Square Feet	50,001 to 100,000 Square Feet	100,001 to 200,000 Square Feet	200,001 to 500,000 Square Feet	Over 500,000 Square Feet
All Buildings	71,658	6,922	7,033	12,659	9,382	10,291	10,217	7,494	7,660
Principal Building Activity									
Education	9,874	409	399	931	1,756	2,690	2,167	1,420	Q
Food Sales	1,255	409	356	Q	Q	Q	Q	N	N
Food Service	1,654	544	442	345	Q	Q	N	Q	N
Health Care	3,163	165	280	313	157	364	395	514	973
Inpatient	1,905	N	N	Q	Q	Q	Q	467	973
Outpatient	1,258	165	280	312	Q	206	Q	Q	N
Lodging	5,096	99	160	631	803	841	930	1,185	Q
Mercantile	11,192	771	1,173	2,409	1,291	1,505	1,677	462	1,905
Retail (Other Than Mall)	4,317	638	725	1,284	578	Q	524	Q	Q
Enclosed and Strip Malls	6,875	Q	448	1,124	713	1,234	1,153	Q	1,752
Office	12,208	1,382	938	1,887	1,506	1,209	1,428	1,493	2,365
Public Assembly	3,939	336	518	1,077	301	474	868	Q	Q
Public Order and Safety	1,090	122	Q	Q	Q	Q	Q	Q	Q
Religious Worship	3,754	416	744	1,235	930	Q	Q	Q	N
Service	4,050	1,034	722	1,021	560	Q	Q	Q	Q
Warehouse and Storage	10,078	895	868	2,064	1,043	1,494	1,162	1,322	Q
Other	1,738	Q	Q	Q	Q	Q	Q	Q	Q
Vacant	2,567	239	Q	Q	471	Q	Q	Q	Q

Released: June 2006

http://www.eia.doe.gov/emeu/cbecs/

7.7 Appendix H: Non-Residential Construction Forecast Details

7.7.1 Summary

The Non-Residential construction forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from Dodge construction database, the demand forecast office future generation facility planning data, and building permit office data.

All CASE reports used the statewide construction forecast for 2014. The TDV savings analysis is calculated on a 15 or 30 year net present value, so it is correct to use the 2014 construction forecast as the basis for CASE savings.

7.7.2 Additional Details

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ) as well as building type (based on NAICS codes). The 16 climate zones are organized by the generation facility locations throughout California, and differ from the Title 24 building climate zones (BCZ). The Heschong Mahone Group (HMG) has reorganized the demand forecast office data using 2000 Census data (population weighted by zip code) and mapped FCZ and BCZ to a given zip code. The construction forecast data is provided to CASE authors in BCZ in order to calculate Title 24 statewide energy savings impacts. Though the individual climate zone categories differ between the demand forecast published by the CEC and the construction forecast, the total construction estimates are consistent; in other words, HMG has not added to or subtracted from total construction area.

The demand forecast office provides two (2) independent data sets: total construction and additional construction. Total construction is the sum of all existing floor space in a given category (Small office, large office, restaurant, etc.). Additional construction is floor space area constructed in a given year (new construction); this data is derived from the sources mentioned above (Dodge, Demand forecast office, building permits).

Additional construction is an independent dataset from total construction. The difference between two consecutive years of total construction is not necessarily the additional construction for the year because this difference does not take into consideration floor space that was renovated, or repurposed.

In order to further specify the construction forecast for the purpose of statewide energy savings calculation for Title 24 compliance, HMG has provided CASE authors with the ability to aggregate across multiple building types. This tool is useful for measures that apply to a portion of various building types' floor space (e.g. skylight requirements might apply to 20% of offices, 50% of warehouses and 25% of college floor space).

The main purpose of the CEC demand forecast is to estimate electricity and natural gas needs in 2022 (or 10-12 years in the future), and this dataset is much less concerned about the inaccuracy at 12 or 24 month timeframe.

It is appropriate to use the CEC demand forecast construction data as an estimate of future years construction (over the life of the measure). The CEC non-residential construction forecast is the best publicly available data to estimate statewide energy savings.

7.7.3 Citation

"NonRes Construction Forecast by BCZ v7"; Developed by Heschong Mahone Group with data sourced August, 2010 from Abrishami, Moshen at the California Energy Commission (CEC)

7.8 Appendix I: Residential Construction Forecast Details

7.8.1 Summary

The Residential construction forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from the California Department of Finance and California Construction Industry Research Board (CIRB) building permits. The Department of Finance uses census years as independent data and interpolates the intermediate years using CIRB permits.

CASE stakeholders expressed concern that the Residential forecast was inaccurate compared with other available data (in 2010 CEC forecast estimate is 97,610 new units for single family and the CIRB estimate is 25,526 new units). In response to this discrepancy, The Heschong Mahone Group (HMG) revised the CEC construction forecast estimates. The CIRB data projects an upward trend in construction activity for 2010-2011 and again from 2011-2012. HMG used the improvement from 2011-2012 and extrapolated the trend out to 2014. The improvement from 2011-2012 is projected to be 37%. Instead of using the percent improvement year on year to generate the 2014 estimate, HMG used the conservative value of the total units projected to be built in 2011-2012 and added this total to each subsequent year. This is the more conservative estimate and is appropriate for the statewide savings estimates. Based on this trend, the new construction activity is on pace to regain all ground lost by the recession by 2021. The multi-family construction forecasts are consistent between CEC and CIRB and no changes were made to the multi-family data.

Residential New Construction Estimate (2014)

Residential New Construction Estimate (2014)			
	Single Family	**Multi-family Low Rise**	**Multi-family High Rise**
CZ 1	378	94	-
CZ 2	1,175	684	140
CZ 3	1,224	863	1,408
CZ 4	2,688	616	1,583
CZ 5	522	269	158
CZ 6	1,188	1,252	1,593
CZ 7	2,158	1,912	1,029
CZ 8	1,966	1,629	2,249
CZ 9	2,269	1,986	2,633
CZ 10	8,848	2,645	1,029
CZ 11	3,228	820	81
CZ 12	9,777	2,165	1,701
CZ 13	6,917	1,755	239
CZ 14	1,639	726	-
CZ 15	1,925	748	-
CZ 16	1,500	583	-
Total	**47,400**	**18,748**	**13,845**

Residential construction forecast for 2014, in total dwelling units

7.8.2 Additional Details

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ). These 16 climate zones are organized by the generation facility locations throughout California, and differ from the Title 24 building climate zones (BCZ). HMG has reorganized the demand forecast office data using 2000 Census data (population weighted by zip code) and mapped FCZ and BCZ to a given zip code. The construction forecast data is provided to CASE authors in BCZ in order to calculate Title 24 statewide energy savings impacts. Though the individual climate zone categories differ between the demand forecast published by the CEC and the construction forecast, the total construction estimates are consistent; in other words, HMG has not added to or subtracted from total construction area.

The demand forecast office provides two (2) independent data sets: total construction and decay rate. Total construction is the sum of all existing dwelling units in a given category (Single family, Multi-family low rise and Multi-family high rise). Decay rate is the number of units that were assumed to be retrofitted, renovated or demolished. The difference in total construction between consecutive years (including each year's decay rate) approximates the new construction estimate for a given year.

In order to further specify the construction forecast for the purpose of statewide energy savings calculation for Title 24 compliance, HMG has segmented all multi-family buildings into low rise and high rise space (where high rise is defined as buildings 4 stories and higher). This calculation is based on data collected by HMG through program implementation over the past 10 years. Though this sample is relatively small (711), it is the best available source of data to calculate the relative population of high rise and low rise units in a given FCZ.

Most years show close alignment between CIRB and CEC total construction estimates, however the CEC demand forecast models are a long-term projection of utility demand. The main purpose of the CEC demand forecast is to estimate electricity and natural gas needs in 2022, and this dataset is much less concerned about the inaccuracy at 12 or 24 month timeframe.

It is appropriate to use the CEC demand forecast construction data as an estimate of future years construction (over the life of the measure), however to estimate next year's construction, CIRB is a more reliable data set.

7.8.3 Citation

"Res Construction Forecast by BCZ v4"; Developed by Heschong Mahone Group with data sourced September, 2010 from Sharp, Gary at the California Energy Commission (CEC)