CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Residential Instantaneous Water Heaters

Measure Number: 2016-RES-DHW1-D

Residential Water Heating

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team

July 2014

Prepared by: Sarah Schneider (Energy Solutions)

Bijit Kundu (Energy Solutions)

This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

TABLE OF CONTENTS

List of Tables

List of Figures

Document Information

Category: Codes and Standards

Keywords: Statewide CASE, Statewide Codes and Standards Team, Statewide C&S Team, Codes and Standards Enhancements, Title 24, 2016, efficiency, instantaneous water heater, storage water heater, domestic hot water system.

EXECUTIVE SUMMARY

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The goal of this CASE Report is to propose a code change for domestic water heating that includes a prescriptive requirement for gas instantaneous (tankless) water heaters (IWHs). The report contains pertinent information that justifies the code change including:

- Description of the code change proposal, the measure history, and existing standards (Section 2);
- Market analysis, including a description of the market structure for specific technologies, market availability, and how the proposed standard will impact building owners and occupants, builders, and equipment manufacturers, distributers, and sellers (Section 3);
- Methodology and assumption used in the analyses for energy and electricity demand impacts, cost-effectiveness, and environmental impacts (Section 4);
- Results of energy and electricity demand impacts analysis, Cost-effectiveness Analysis, and environmental impacts analysis (Section 5); and
- Proposed code change language (Section 6).

This is a draft version of the CASE Report. The 2016 Time Dependent Valuation (TDV) values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

Scope of Code Change Proposal

The proposed code change will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

Standards Requirements (see note below)	Compliance Option	Appendix	Modeling Algorithms	Simulation Engine	Forms
Ps	No	No	No	No	No

Note: An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

Measure Description

The Residential Instantaneous Water Heaters (IWH) measure proposes to modify the prescriptive requirements for gas domestic water heating systems in newly constructed single-family homes and multi-family buildings with dedicated water heaters for each individual dwelling unit. The current prescriptive approach allows the use of a gas storage water heater, gas IWH, or, if natural gas service is not connected to the buildings, an electric-resistance or electric IWH combined with a solar hot water system. In particular, the proposed measure would modify the prescriptive requirement language by specifying that the energy performance of the installed water heater would have to be equivalent to the federal minimum Energy Factor (EF) rating (effective in 2015) for a gas IWH. In other words, the energy budget for water heating will be based on a gas IWH versus the existing baseline gas storage water heater. Buildings using the performance approach to comply with the Standards could deploy a number of strategies to achieve the energy budget for water heating, including installing a high-efficiency condensing gas storage water heater.

In addition, a proposed alternative option for meeting the prescriptive requirement for gas water heating will be included as part of the code change proposal in the next version of the CASE Report that is submitted to CEC in Fall 2014. The Statewide CASE Team is currently developing a prescriptive alternative to enable stakeholders to comply with the Title 24 Standards prescriptively without having to install a gas IWH in the design of the building. A criterion for the prescriptive alternative is that it must meet or exceed the energy performance of a minimum federally-compliant gas IWH in each of California's 16 Climate Zones.

Reason for Proposed Code Change

Since gas IWHs are typically more energy efficient than storage water heaters and water heating accounts for the largest share of natural gas usage in California homes (approximately 49% according to the Residential Appliance Saturation Survey 2009), the proposed prescriptive requirement is anticipated to garner significant energy savings for California.

Furthermore, this measure builds upon 2013 Title 24 Standards for domestic water heating which requires domestic water heating systems in new residential construction (single-family and multi-family buildings with dedicated water heaters in individual dwelling units) to be designed to accommodate gas condensing storage water heaters and IWHs. By the time the 2016 Title 24 Standards take effect in 2017, builders will be accustomed to designing for IWHs. Moreover, given their longer product lifespans and lower utility costs, gas IWHs have also been proven to be cost effective in all climate zones across California.

Section 2 of this report provides detailed information about the code change proposal. Section 2.2 of this report provides a section-by-section description of the proposed changes to the Standards, Appendices, Alternative Compliance Manual and other documents that will be

modified by the proposed code change. See the following tables for an inventory of sections of each document that will be modified:

- Table 6: Scope of Code Change Proposal
- Table 7: Sections of Standards Impacted by Proposed Code Change
- Table 8: Appendices Impacted by Proposed Code Change
- Table 9: Sections of ACM Impacted by Proposed Code Change

Detailed proposed changes to the text of the Building Efficiency Standards, Residential Alternative Calculation Method (ACM) Reference Manual, and the Residential Compliance Manual are given in Section 6 of this report. This section proposes modifications to language with additions identified with underlined text and deletions identified with ~~strikeout~~ text.

The following documents will be modified by the proposed change:

- 2013 Title 24 Standards, Part 6, Chapter 8, Section 150.1(c)8
- 2013 Residential ACM Reference Manual, Section 2.10
- 2013 Residential Compliance Manual, Section 5.4.1

Market Analysis and Regulatory Impact Assessment

The proposed code change is justified given the current and future residential water heating market, as there is widespread availability of qualifying IWHs in California. In addition, the incremental equipment cost between gas IWHs and their storage counterparts are made up for by IWH's longer lifespans and lower utility costs (i.e. higher energy efficiency reduces energy use and thus lowers utility costs to homeowners). Moreover, the proposed code change is also cost effective over the 30-year period of analysis. In sum, this proposal increases the wealth of the State of California as it will help California consumers (i.e. ratepayers) save more money on energy over what they spend on financing the efficiency measure. As a result this leaves more money available for discretionary and investment purposes.

The expected impacts of the proposed code change on various stakeholders are summarized below:

- **Impact on builders:** The potential effect of all proposed changes to Title 24 on builders will be small. Assuming that builders pass compliance costs on to consumers, demand for construction could decrease slightly if all other factors remain the same.
- **Impact on building designers:** The proposed code change will have little to no impact on building designers, as the existing Title 24 Standards already require domestic water heating systems in new residential construction to be designed for the installation of gas IWHs.
- **Impact on occupational safety and health:** The proposed code change is not expected to have an impact on occupational safety and health. It does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by California Division of Occupational Safety and Health. All existing health and safety rules will remain in place. Complying with the proposed code changes is not anticipated

to have any impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.

- Impact **on building owners and occupants:** The proposed code change will have a positive impact on building owners and occupants. For building owners, the longer lifespan of IWHs results in fewer water heater replacements over time. Occupants will benefit from an endless supply of hot water and lower utility bills.
- **Impact on equipment retailers (including manufacturers and distributors**): The proposed code change will have some impacts on manufacturers, distributors, and retailers. Sales will increase for manufacturers of qualifying water heaters and for retailers and distributors that stock qualifying products.
- **Impact on energy consultants:** There are no anticipated impacts to energy consultants from the proposed code change.
- **Impact on building inspectors:** As compared to the overall code enforcement effort, this measure has negligible impacts on the effort required to enforce the building codes.
- **Statewide Employment Impacts:** The proposed changes to Title 24 are expected to impact employment. An increase in employment in the water heating sector (e.g., in-state manufacturing, retailers) is expected while a slight employment decrease for installers may result, as IWHs have higher product life expectancies than storage water heaters; the rate of replacement is lower for the former.
- **Impacts on the creation or elimination of businesses in California:** Based on the California Air Resources Board's economic analyses, the proposed Title 24 code changes will encourage the creation of businesses in California.[1]
- **Impacts on the potential advantages or disadvantages to California businesses:** California businesses would benefit from an overall reduction in energy costs due to the decrease in energy demand from the residential sector. This could help California businesses gain competitive advantage over businesses operating in other states or countries and an increase in investment in California, as noted below.
- **Impacts on the potential increase or decrease of investments in California:** Based on the California Air Resources Board's economic analyses, the proposed Title 24 code changes will encourage more investments in California.
- **Impacts on incentives for innovations in products, materials or processes:** Updating Title 24 standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings.
- **Impacts on the State General Fund, Special Funds and local government:** The Statewide CASE Team expects positive overall impacts on state and local government revenues due to higher Gross State Production and personal income resulting in higher

[1] The California Air Resources Board's economic analyses are discussed in detail in Section 3.5 *Economic Impacts* of this CASE Report.

tax revenues. Higher property valuations due to energy efficiency enhancements may also result in positive local property tax revenues.

- **Cost of enforcement to State Government and local governments:** All revisions to Title 24 will result in changes to Title 24 compliance determinations. Local governments will need to train permitting staff on the revised Title 24 standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2016 code change cycle.
- **Impacts on migrant workers; persons by age group, race, or religion:** This proposal and all measures adopted by CEC into Title 24 Part 6 do not advantage or discriminate in regards to race, religion or age group.
- **Impact on Homeowners (including potential first time home owners):** This proposal is cost effective for homeowners. As a result the combined mortgage costs and utility bill payment for homeowners are less if the measure is incorporated into all new homes.
- **Impact on Renters:** This proposal is advantageous to renters as it reduces the cost of utilities which are typically paid by renters. Since the measure saves more energy costs on a monthly basis than the measure costs on the mortgage as experienced by the landlord, the pass-through of added mortgage costs into rental costs is less than the energy cost savings experienced by renters.
- **Impact on Commuters:** This proposal and all measures adopted by CEC into Title 24 Part 6 are not expected to have an impact on commuters.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the IWH measure.

Table 2: Estimated First Year Energy Savings

	First Year Statewide Savings			First Year TDV Energy Savings
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Energy Savings (TDV kBTU)
Proposed Measure	None	None	5.4	862
TOTAL	None	None	5.4	862

Section 4.6.1 discusses the methodology and Section 5.1.1 shows the results for the per unit energy impact analysis.

Cost-effectiveness

Results of the per unit Cost-effectiveness Analyses are presented in Table 3. The Time Dependent Valuation (TDV) Energy Costs Savings are the present valued energy cost savings over the 30-year period of analysis using CEC's TDV methodology. The Total Incremental Cost represents the incremental equipment and maintenance costs of the proposed measure relative to existing conditions (current minimally compliant construction practices). Costs

incurred in the future (such as periodic maintenance costs or replacement costs) are discounted by a 3% real discount rate, per CEC's LCC Methodology. The Planning Benefit to Cost (B/C) Ratio is the incremental TDV Energy Costs Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the discounted energy cost savings and the measure is deemed to be cost effective. For a detailed description of the Cost-effectiveness Methodology see Section 4.7 of this report.

Based on the results of the Cost-effectiveness Analysis for the proposed code change, the Planning B/C Ratio is greater than 1.0 in every climate zone. This means that the installation of gas IWHs, per the primary prescriptive requirement, is cost effective in every California climate zone, and will result in cost savings relative to the existing conditions in every climate zone. While the measure is cost effective in every climate zone, the magnitude of cost-effectiveness varies from a high Planning B/C ratio of 1.53 in Climate Zone 16 to a low Planning B/C ratio of 1.11 in Climate Zone 15.

Table 3: Cost-effectiveness Summary

Climate Zone	Benefit: TDV Energy Cost Savings + Other Cost Savings[2] (2016 PV $)	Cost: Total Incremental Cost[3] (2016 PV $)	Change in Lifecycle Cost[4] (2016 PV $)	Benefit to Cost Ratio[5]
Climate Zone 1	$1,523	-$506	-$2,029	3.01
Climate Zone 2	$1,459	-$506	-$1,965	2.88
Climate Zone 3	$1,453	-$506	-$1,959	2.87
Climate Zone 4	$1,428	-$506	-$1,934	2.82
Climate Zone 5	$1,448	-$506	-$1,954	2.86
Climate Zone 6	$1,389	-$506	-$1,895	2.75
Climate Zone 7	$1,344	-$506	-$1,850	2.66
Climate Zone 8	$1,363	-$506	-$1,869	2.69
Climate Zone 9	$1,349	-$506	-$1,854	2.67
Climate Zone 10	$1,350	-$506	-$1,856	2.67
Climate Zone 11	$1,396	-$506	-$1,902	2.76
Climate Zone 12	$1,420	-$506	-$1,926	2.81
Climate Zone 13	$1,340	-$506	-$1,846	2.65
Climate Zone 14	$1,397	-$506	-$1,903	2.76
Climate Zone 15	$1,168	-$506	-$1,674	2.31
Climate Zone 16	$1,602	-$506	-$2,108	3.17

1. Relative to existing conditions. All cost values presented in 2016 dollars. Cost savings are calculated using 2013 TDV values and will be updated to the 2016 TDV values when they are finalized by CEC.
2. Present value of TDV cost savings equals TDV electricity savings plus TDV natural gas savings; $\Delta TDV\$ = \Delta TDV\$E + \Delta TDV\$G$. Cost savings are calculated using 2013 TDV values and will be updated to the 2016 TDV values when they are finalized by CEC.
3. Total incremental cost equals incremental construction cost (post adoption) plus present value of incremental maintenance cost; $\Delta C = \Delta CI_{PA} + \Delta CM$.
4. Negative values indicate the measure is cost-effective. Change in lifecycle cost equals cost premium minus TDV energy cost savings; $\Delta LCC = \Delta C - \Delta TDV\$$.
5. The benefit to cost ratio is the TDV energy costs savings divided by the total incremental costs; $B/C = \Delta TDV\$ \div \Delta C$. The measure is cost effective if the B/C ratio is greater than 1.0.

Section 4.7 discusses the methodology and Section 5.2 shows the results of the Cost-Effectiveness Analysis.

Greenhouse Gas and Water Related Impacts

For more a detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measure, please refer to Section 5.3 of this report.

Greenhouse Gas Impacts

Table 4 presents the estimated avoided greenhouse gas (GHG) emissions of the proposed code change for the first year the Standards are in effect. Assumptions used in developing the GHG savings are provided in Section 4.8.1 of this report.

The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) and is thus included in the Cost-effectiveness Analysis prepared for this report.

Table 4: Estimated Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions ($MTCO_2e/yr$)	**Monetary Value of Avoided GHG Emissions ($2016)**
Proposed Measure	28,476	$1,361,103
TOTAL	28,476	$1,361,103

Section 4.8.2 discusses the methodology and Section 5.3.1 shows the results of the greenhouse gas emission impacts analysis.

Water Use Impacts

Potential water use impacts were considered but not factored into the savings calculations for the proposed measure. Section 4.8.2 discusses the Statewide CASE Team's rationale.

Field Verification and Diagnostic Testing

There are no field verification and diagnostic testing requirements associated with the proposed code change.

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The goal of this CASE Report is to propose a code change for domestic water heating that includes a prescriptive requirement for gas instantaneous (tankless) water heaters (IWHs). The report contains pertinent information that justifies the code change.

Section 2 of this CASE Report provides a description of the measure, how the measure came about, and how the measure helps achieve the state's zero net energy (ZNE) goals. This section presents how the Statewide CASE Team envisions the proposed code change would be enforced and the expected compliance rates. This section also summarized key issues that the Statewide CASE Team addressed during the CASE development process, including issues discussed during a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

Section 3 presents the market analysis, including a review of the current market structure, a discussion of product availability, and the useful life and persistence of the proposed measure. This section offers an overview of how the proposed standard will impact various stakeholders including builders, building designers, building occupants, equipment retailers (including manufacturers and distributors), energy consultants, and building inspectors. Finally, this section presents estimates of how the proposed change will impact statewide employment.

Section 4 describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. Key assumptions used in the analyses can be also found in Section 4.

Results from the energy, demand, costs, and environmental impacts analysis are presented in Section 5. The Statewide CASE Team calculated energy, demand, and environmental impacts using two metrics: (1) per unit, and (2) statewide impacts during the first year buildings complying with the 2016 Title 24 Standards are in operation. Time Dependent Valuation (TDV) energy impacts, which accounts for the higher value of peak savings, are presented for the first year both per unit and statewide. The incremental costs, relative to existing conditions are presented as are present value of year TDV energy cost savings and the overall cost impacts over the year period of analysis.

The report concludes with specific recommendations for language for the Standards, Alternate Calculation Manual (ACM) Manual, and Compliance Manual.

This is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

2. MEASURE DESCRIPTION

2.1 Measure Overview

2.1.1 Measure Description

The Residential Instantaneous Water Heaters (IWH) measure proposes to modify the prescriptive requirements for gas domestic water heating systems in newly constructed single-family homes and multi-family buildings with dedicated water heaters for each individual dwelling unit. The current prescriptive approach allows the use of a gas storage water heater, gas IWH, or, if natural gas service is not available, an electric-resistance or electric IWH combined with a solar hot water system. In particular, the proposed measure would modify the prescriptive requirement language by specifying that the energy performance of the installed water heater would have to be equivalent to the federal minimum Energy Factor (EF) rating (effective in 2015) for a gas IWH. In other words, the energy budget for water heating will be based on a gas IWH versus the existing baseline gas storage water heater. Buildings using the performance approach to comply with the Standards could deploy a number of strategies to achieve the energy budget for water heating, including installing a high-efficiency condensing gas storage water heater.

In addition, a proposed alternative option for meeting the prescriptive requirement for gas water heating will be included as part of the code change proposal in the next version of the CASE Report that is submitted to CEC in Fall 2014. The Statewide CASE Team is currently developing a prescriptive alternative to enable stakeholders to comply with the Title 24 Standards prescriptively without having to install a gas IWH in the design of the building. A criterion for the prescriptive alternative is that it must meet or exceed the energy performance of a minimum federally-compliant gas IWH in each of California's 16 Climate Zones.

Reason for Proposed Code Change

Since gas IWHs are typically more energy efficient than storage water heaters, water heating accounts for the largest share of natural gas usage in California homes (approximately 49% according to the Residential Appliance Saturation Survey 2009), and that 90% of California

homes use natural gas to heat water (Hoeschele & Weitzel 2012), the proposed prescriptive requirement is anticipated to garner significant energy savings for California.

Furthermore, this measure builds upon 2013 Title 24 Standards for domestic water heating which requires domestic water heating systems in new residential construction (single family and multi-family buildings with dedicated water heaters in individual dwelling units) to be designed to accommodate gas condensing storage water heaters and IWHs. By the time the 2016 Title 24 Standards take effect in 2017, builders will be accustomed to designing for IWHs. Moreover, given their longer product lifespans and lower utility costs, gas IWHs have also been proven to be cost effective in all climate zones across California.

2.1.2 Measure History

In 2011, the Statewide CASE Team submitted a Title 24 CASE Report to CEC that proposed standards to support building components compatible with high-efficiency water heaters (HEWHs), such as gas IWHs. The proposed standards applied to single-family homes and multi-family buildings with dedicated water heaters serving each individual dwelling unit. Through review of installation requirements for HEWHs and discussions with manufacturers and contractors, the following four improvement areas were identified and ultimately adopted into the 2013 Title 24 Standards:

1. Accessibility of electrical power supply to support draft fans and controls.
2. Vent to accommodate acidic exhaust from high efficiency water heaters, including but not limited to condensing water heaters.
3. Condensate drains must meet local jurisdiction requirements.
4. Gas pipe sizing to support IWHs without any exemptions so that homeowners have the option to install condensing IWHs in the future.

The HEWH-Ready measure aimed to remove all infrastructure barriers for adopting forced draft, condensing, and/or gas IWHs, for both new construction and future replacements. The Statewide CASE Team held several discussions on the new proposal ideas with CEC in order to conduct market research and technical analyses to directly address CEC's concerns. Detailed development of the proposed measure was based on application considerations collected from water heater installation guidelines, contractors, and industry experts. Therefore, when the HEWH-Ready proposal was presented at the stakeholder meetings and CEC rulemaking meetings, there were no strong objections or major concerns from either stakeholders or CEC staff.

2.1.3 Existing Standards

Existing Title 24 Standards include requirements for domestic gas water heating systems for newly constructed and existing single-family and multi-family buildings. The current prescriptive Standards for residential new construction allow for the installation of a gas storage water heater (75,000 BTU or less), a gas IWH (200,000 BTU or less), or an electric storage or electric IWH as part of a solar hot water system in new residential construction

(including multi-family buildings with dedicated water heaters for each individual dwelling unit).

Table 5 displays the federal residential water heater standards that will take effect in April 2015. In addition to higher EF ratings, the federal standards will require gas storage water heaters larger than 55 gallons to be condensing type and require IWHs to be power vented.

Table 5: Federal Water Heater Standards (Effective 2015)

Product Class	Rated Storage Volume	Energy Factor (EF)
Gas Storage Water Heater	≥ 20 gallons and ≤ 55 gallons	0.675 – (0.0015*Vs)
Gas Storage Water Heater	< 55 gallons and ≤100 gallons	0.8012 – (0.00078* V_s)
Gas Instantaneous Water Heater	< 2 gallons	0.82 – (0.0019*V_s)
Electric Water Heater	≥20 gallons and ≤ 55 gallons	0.960 – (0.0003*V_s)
Electric Water Heater	< 55 gallons and ≤120 gallons	2.057 – (0.00113*V_s)
Oil Water Heater	≤ 50 gallons	0.68 – (0.0019*V_s)
Instantaneous Electric Water Heater	< 2 gallons	0.93 – (0.00132*V_s)

V_s: Rated Storage Volume – the water storage capacity of a water heater (in gallons).

Federal Test Procedure Rulemaking

The United States Department of Energy (DOE) is currently conducting a rulemaking to update the test procedure for residential water heaters. Two important aspects being considered are the hot water draw schedule and the EF rating of water heater products. Though the proposed measure uses CEC's draw schedule in the savings analysis, and not DOE's draw schedule, the Statewide CASE Team does rely on the federal EF ratings for all our analyses. We are closely following DOE's test procedure rulemaking to see what impacts the updated test procedure will have on Title 24 Standards.

2.1.4 Alignment with Zero Net Energy (ZNE) Goals

The Statewide CASE Team and CEC are committed to achieving the State of California's ZNE goals. This measure will help achieve the residential ZNE goals by contributing to energy savings through the installation of gas IWHs that align with federal water heater Standards (and other high-efficiency water heaters) instead of less energy efficient storage water heaters that have historically been installed in residential buildings in California. This measure will also set the foundation for future code changes that will help ensure ZNE goals are achieved.

2.1.5 Relationship to Other Title 24 Measures

The proposed measure does not overlap with any other Title 24 code change proposals for the 2016 code update.

2.2 Summary of Changes to Code Documents

The sections below provide a summary of how each Title 24 document will be modified by the proposed change. See Section 6 of this report for detailed proposed revisions to code language.

2.2.1 Catalogue of Proposed Changes

Scope

Table 6 identifies the scope of the code change proposal. This measure will impact the following areas (marked by a "Yes").

Table 6: Scope of Code Change Proposal

Mandatory	Prescriptive	Performance	Compliance Option	Trade-Off	Modeling Algorithms	Forms
N/A	Yes	N/A	N/A	N/A	N/A	N/A

Standards

The proposed code change will modify the sections of the California Building Energy Efficiency Standards (Title 24, Part 6) identified in Table 7.

Table 7: Sections of Standards Impacted by Proposed Code Change

Title 24, Part 6 Section Number	Section Title	Mandatory (M) Prescriptive (Ps) Performance (Pm)	Modify Existing (E) New Section (N)
150.1(c)8	Domestic Water-Heating Systems	Ps	E

Appendices

The proposed code change will modify the sections of the indicated appendices presented in Table 8. If an appendix is not listed, then the proposed code change is not expected to have an effect on that appendix.

Table 8: Appendices Impacted by Proposed Code Change

APPENDIX NAME		
Section Number	Section Title	Modify Existing (E) New Section (N)
	N/A	

Residential Alternative Calculation Method (ACM) Reference Manual

The proposed code change will modify the sections of the Residential ACM References identified in Section 2.10.

Table 9: Sections of ACM Impacted by Proposed Code Change

Residential Alternative Calculation Method Reference		
Section Number	**Section Title**	**Modify Existing (E) New Section (N)**
2.10	Domestic Hot Water (DHW), *Standard Design*	E

Simulation Engine Adaptations

The proposed code change can be modeled using the current simulation engine. Changes to the simulation engine are not necessary.

2.2.2 Standards Change Summary

This proposal would modify the following sections of the Title 24 Building Energy Efficiency Standards as shown below. See Section 6.1 of this report for the detailed proposed revisions to the Standards language.

The proposed code change will modify the prescriptive requirements for gas domestic water heating systems in newly constructed single family homes and multi-family buildings with dedicated water heaters for each individual dwelling unit. The current prescriptive approach requires the installation of a gas storage water heater (option A), the installation of a gas IWH (option B), or the installation of an electric-resistance water heater or electric IWH as part of a solar water heating system (option D).[2] The proposed measure will modify the language for the standard design (option A) by specifying that the Energy Factor (EF) rating of the water heater would have to be at least as high as the federal minimum EF (effective in 2015) for gas IWHs (0.82).

In addition, a proposed alternative option for meeting the prescriptive requirement for water heating will be included as part of the code change proposal in the next version of the CASE Report that is submitted to CEC in Fall 2014. The Statewide CASE Team is currently developing a prescriptive alternative to enable stakeholders to comply with the Title 24 Standards prescriptively without having to install a gas IWH in the design of the building. A criterion for the prescriptive alternative is that it must meet or exceed the energy performance of a minimum federally-compliant gas IWH in each of California's 16 Climate Zones.

The existing prescriptive standard language is included below. Note that the proposed code change will not change the scope of the existing Title 24 Standards nor will it change the mandatory requirements for residential water heating.

Existing Standards

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR NEWLY CONSTRUCTED RESIDENTIAL BUILDINGS

[2] Prescriptive option C involves central water heating systems for multiple dwelling units, which is outside the scope of the proposed measure. No changes to Package C are being proposed at this time.

(c) **Prescriptive Standards/Component Package.** Buildings that comply with the prescriptive standards shall be designed, constructed, and equipped to meet all of the requirements for the appropriate Climate Zone shown in TABLE 150.1-A. In TABLE 150.1-A, a NA (not allowed) means that feature is not permitted 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 C, or D.

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 that meets the tank insulation requirements of Section 150.0(j) and the requirements of Sections 110.1 and 110.3 shall be installed. For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.

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 storage tank, and that meets the requirements of Sections 110.1 and 110.3 shall be installed. For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.

C. For systems serving multiple dwelling units, a central water-heating system that includes the following components shall be installed:

i. Gas or propane water heaters, boilers or other water heating equipment that meet the minimum efficiency requirements of Sections 110.1 and 110.3; and

ii. A water heating recirculation loop that meets the requirements of Sections 110.3(c)2 and 110.3(c)5 and is equipped with an automatic control system that controls the recirculation pump operation based on measurement of hot water demand and hot water return temperature and has two recirculation loops each serving half of the building; and

EXCEPTION to Section 150.1(c)8Cii: Buildings with eight or fewer dwelling units are exempt from the requirement for two recirculation loops.

iii. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.20 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.35 in Climate Zones 10 through 16. The solar savings fraction shall be determined using a calculation method approved by the Commission.

D. For systems serving individual dwelling units, an electric-resistance storage or instantaneous water heater may be installed as the main water heating source only if natural gas is unavailable, the water heater is located within the building envelope, and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.

2.2.3 Standards Reference Appendices Change Summary

There are no modifications to the Standards Appendices as a result of the proposed code change.

2.2.4 Residential Alternative Calculation Method (ACM) Reference Manual Change Summary

This proposal will modify Section 2.10 of the Residential ACM Reference Manual. The proposed code change will revise the standard design requirement described in the Residential ACM Reference Manual to include a gas IWH in place of a gas storage water heater. See Section 6.3 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

2.2.5 Residential Compliance Manual

This proposal would modify Section 5.4 of the Residential Compliance Manual to reflect the changes made to the standard. See Section 6.4 of this report for the detailed proposed revisions to the text of the Residential Compliance Manual.

2.2.6 Compliance Forms Change Summary

The proposed code change will not modify the compliance forms.

2.2.7 Simulation Engine Adaptations

The proposed code change will not modify the simulation engine that is currently modeled for the proposed measure.

2.2.8 Other Areas Affected

There are no other areas of the existing standards affected as a result of the proposed code change.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

There will be no additional requirements for code enforcement entities for determining if a building complies with the proposed code change based on existing Title 24 Standards. As such, no changes to the compliance forms for domestic water heating are needed as a result of this proposed code change.

2.3.2 Code Implementation

Since domestic water heating systems are already regulated by Title 24, builders are required to install the necessary components (e.g., vent, electrical connection, ¾ inch gas pipe) for the installation of a gas IWH (effective July 1, 2014). Further, according to our conversations with various stakeholders, builders have been frequently specifying IWHs in their residential new construction designs. Therefore, builders are not only accustomed to complying with Title 24 but also to complying with the proposed measure. As such, it will be relatively easy for building inspectors to verify compliance during inspection of the mandatory water heating requirements, particularly since the proposed measure pertains to the water heating unit itself. Even if the IWH is installed in a crawl space, the location necessitates access by homeowners to conduct regular maintenance, and thus, must be accessible.

2.3.3 Field Verification and Diagnostic Testing

Though field verification and diagnostic testing are required for many residential measures, they are not needed in order to assure optimum performance of the measure, as the proposed code change pertains to the water heater unit and not the water heating system design. Furthermore, the proposed measure does not need Home Energy Rating System (HERS) verification, which does require field verification.

2.4 Issues Addressed During CASE Development Process

The Statewide CASE Team solicited feedback from a variety of stakeholders when developing the code change proposal presented in this report. In addition to personal outreach to key stakeholders, the Statewide CASE Team conducted a public stakeholder meeting to discuss the proposal on May 20, 2014. The main issues that were addressed during development of the code change proposal are summarized below.

There were several common concerns expressed by stakeholders. The largest concern involved the potential violation of federal preemption policy. In response, the Statewide CASE Team is developing an alternative prescriptive option to the primary prescriptive option to avoid violating federal preemption of federally-covered water heaters. The proposed alternative option will be included in the next version of the CASE Report submitted to CEC in Fall 2014.

Stakeholders were also concerned about the update to DOE's test procedure for residential water heaters (currently in process) and the changes that may arise to the federal minimum EF values for storage and IWHs when the updated test procedure is released. The Statewide CASE

Team is closely following DOE's test procedure rulemaking and will consider the implications for the 2016 Title 24 code change if the federal minimum EF values do in fact change from what was adopted by the federal government in 2010.

Another concern shared by stakeholders was the incremental cost increase of moving from a gas storage water heater that meets the federal minimum standard to a gas IWH. Though there will be an incremental cost as a result of the proposed measure, the proposed code change has been shown to be cost effective in every climate zone across California, largely due to lower utility bills from operating more energy efficient water heaters (i.e. IWHs do not have standby losses).

Finally, some stakeholders requested the Statewide CASE Team focus on heat pump water heaters (HPWH) as a prescriptive alternative with natural gas is not available. Proposing a HPWH alternative prescriptive option is outside of the scope of this measure, which focuses on updating prescriptive requirements when natural gas is available.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market players. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders including statewide CASE program staff, CEC, and a wide range of industry actors who were invited to participate in Statewide CASE Team's public stakeholder meetings held in May 2014.

3.1 Market Structure

The residential water heater market is comprised of manufacturers, distributors/suppliers, retailers, and consumers. Water heaters are purchased through brick and mortar and online retailers and may be installed in new construction or in existing buildings when upgrading or replacing an old, broken, or inefficient water heater or installing a second water heater (typically for building additions). Market research reveals that the top retailers of IWHs are Home Depot, Lowe's Home Improvement, and Sears (PG&E 2012). IWHs can also be purchased directly from suppliers or distributors (i.e. wholesalers). The Statewide CASE Team assumes that builders and contractors who purchase a number of water heaters do so through distributors and not through retailers. In addition to builders and contractors, IWHs are purchased by home owners, plumbers, and other permitted or licensed installers. Figure 1 below depicts the various distribution channels for residential water heaters.

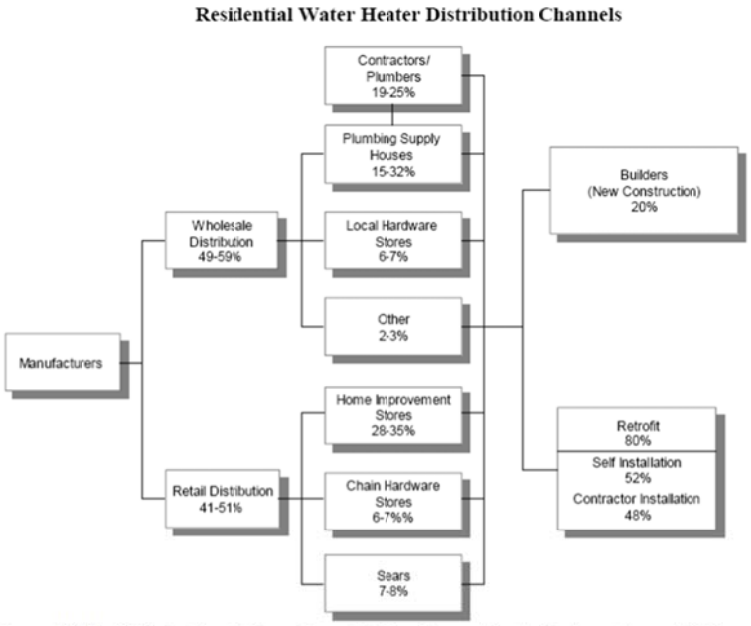

Figure 1: Residential Water Heater Distribution Channels

3.2 Market Availability and Current Practices

There is widespread availability of qualifying IWHs in California and nationally. As of April 2, 2014, there are 12 different manufacturers of qualifying products (non-condensing gas instantaneous with EF = 0.82 or higher) listed in CEC's Appliance Database. Among these manufacturers, there are 30 unique brands and 817 models of non-condensing gas IWHs (with EFs between 0.82 and 0.89). The number of available IWHs listed on the ENERGY STAR® Qualified Product List (as of April 14, 2014) is significantly larger, with approximately 1,248 gas IWHs (with EFs between 0.82 and 0.87) available nationwide. In sum, the market for gas IWHs appears to be more than sufficient to meet the proposed standard.

The widespread availability of IWHs can be attributed to numerous factors, including growing consumer interest. According to Kema's (2010) IOU energy efficiency program evaluation study (2006-08), as well as industry predictions, the water heater and residential retrofit markets are embracing IWHs. The Northwest Energy Efficiency Alliance (NEEA) (2012) reported that improving energy efficiency and tankless on demand water heaters are perceived to be the two most significant market trends in the water heating industry, based on survey responses from retailers and manufacturers (see Figure 2 below). NEEA also reported a 61% increase in Internet search traffic for "tankless water heater" between January 2004 and January 2011 (NEEA Water Heater Update 2012). This reflects growing consumer interest in IWHs.

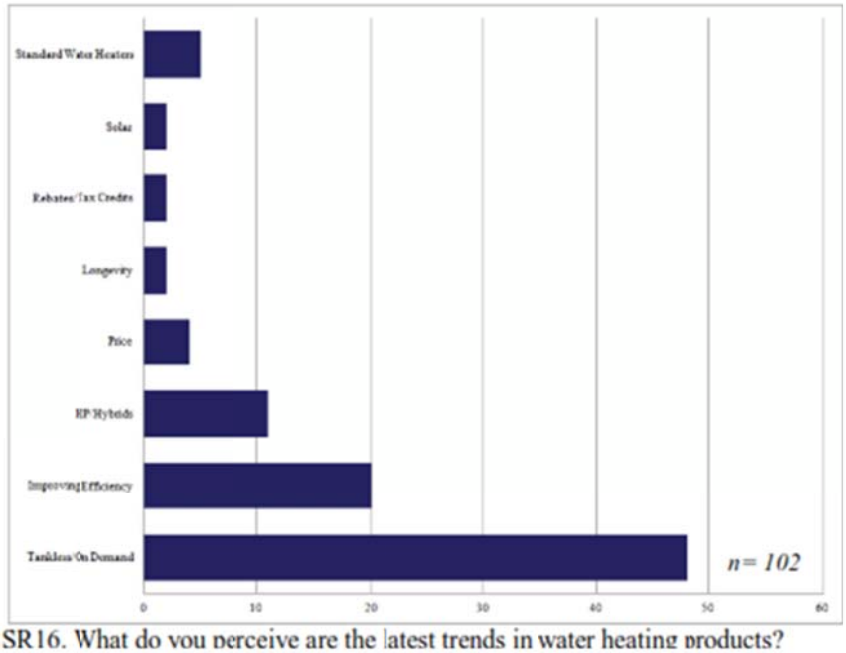

Figure 2: Key Market Trends in Water Heating Industry

Source: Northwest Energy Efficiency Alliance Water Heater Market Update, 2011.

The interest in IWHs can be attributed to their many benefits, such as their compact size, longer product lifespan, and higher EF ratings, as well as their end-user benefits such as an endless supply of hot water and lower utility bills. Rodgers and O'Donnell (2008) assert that bringing consumer attention to these other benefits that IWHs provide may be changing the dynamic of the water heater market as a whole.

In addition, state and federal water heating standards will influence the market trend toward instantaneous (tankless) water heating. The updated federal standards for water heaters, effective in 2015, will most certainly accelerate the market penetration of IWHs. Moreover, the 2013 Title 24 domestic water heating standards, effective July 2014, will require new residential construction to be designed for the installation of high efficiency water heaters, including instantaneous units.

Finally, the market penetration of gas IWHs has grown due to the success of reach codes and incentive programs, such as ENERGY STAR and utility rebate programs (e.g. Southern California Gas' rebate program for IWHs). Industry projections indicate a future annual growth rate of more than 10% per year (Title 24 2013 High Efficiency Water Heater Ready CASE Report 2011). The growth in market share of IWHs will result in decreasing product costs, which is another factor driving the trend toward instantaneous water heating.

In terms of current practice in the design and specification of water heaters in residential new construction, anecdotal evidence reveals that builders are frequently offering gas IWHs in addition to gas storage water heaters. In fact, IWHs are now more commonly found in the design plans for new homes in Southern California, based on our discussions with various stakeholders.

3.3 Useful Life, Persistence, and Maintenance

As previously mentioned, there are numerous advantages to IWHs, including their compact sizes, higher efficiency levels, and longer lifespans. According to DOE and manufacturer claims, IWHs have a useful life of approximately 15-20 years whereas the average storage water heater has a useful life of 10-12 years (Schoenbauer, Bohac & Hewett 2012; U.S. Department of Energy 2014). The difference in product lifespans is due to largely to design. However, routine maintenance for any water heater will increase its useful life.

To prolong the useful life of an IWH, the product should be maintained based on manufacturer recommendations. This includes flushing the heat exchanger to prevent scale build-up of lime or calcium (particularly in areas of hard water) and manually draining the water heater when the unit will not be in operation for an extended period of time. Rheem, a water heater manufacturer, recommends periodic inspection (e.g., annual) of the burner, relief valve, air intake filter, water filter, and venting system.

Storage water heaters also require maintenance to prolong their useful lives. American Water Heaters, another water heater manufacturer, recommends draining and flushing the tank every *six* months to remove sediment that may build up during operation for their high-efficiency storage water heaters. With proper maintenance of any water heater, the useful life of the product will surely be extended. However, the need to replace an IWH will not be as frequent as a storage water heater based on the design of the technology.

3.4 Market Impacts and Economic Assessments

3.4.1 Impact on Builders

This particular proposed code change will have little impact on builders. Since the 2013 Title 24 Standards already require the installation of system components that are compatible with gas IWHs, there are no additional installation costs to builders. In addition, the large volume of instantaneous units installed in new construction may result in decreasing costs, as contractors may be able to reduce costs over a large number of installations (Schoenbauer, Bohac & Hewett 2012). Furthermore, builders will still have the option of taking the performance approach as long as the energy budget for the building not exceeded, as well as the other prescriptive options.

3.4.2 Impact on Building Designers

Title 24 is updated on a three-year revision cycle, so acclimating to changes in Title 24 Standards is routine practice for building designers; adjusting design practices to comply with changing code practices is within the normal practices of building designers. This particular revision to the Title 24 water heating standards will not require a departure from standard or common design practices for building designers.

Though water heating design changes are not required, designing for a gas IWH may encourage building designers to explore compact hot water distribution, which is an efficient and effective strategy for increasing energy and water savings as well as user utility. The

energy and water savings associated with compact distribution are not accounted for in this report.

As a whole, the measures being considered for the 2016 code change cycle aim to provide designers with plentiful options on how to comply with the building efficiency standards. The proposed standards do not aim to limit building aesthetics or any particular type of building equipment.

3.4.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Department of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules will remain in place. Complying with the proposed code change is not anticipated to have any impact on the safety or health of occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.

3.4.4 Impact on Building Owners and Occupants

The proposed code change will have a positive impact on building owners and occupants. For building owners, the longer lifespan of IWHs results in fewer water heater replacements over time. Occupants will benefit from an endless supply of hot water and lower utility bills, though the wait time for hot water may increase slightly due to the additional time it takes to heat the water.

3.4.5 Impact on Retailers (including manufacturers and distributors)

The proposed code change will have some impacts on manufacturers, distributors, and retailers. Sales will increase for manufacturers of qualifying IWHs and for retailers and distributors that stock qualifying products. DOE projections indicate roughly a 43% market penetration of IWHs in 2015 in the absence of the recently adopted federal standards. This implies that product availability and adoption will grow at a steady rate each year, thus reducing the likelihood for a lack of available products.

3.4.6 Impact on Energy Consultants

As discussed in Section. 3.5.2 of this report, the changes made to Title 24 may have a positive impact on job growth in the state. Energy consultants may benefit from the overall job growth the standards will generate.

3.4.7 Impact on Building Inspectors

There are no anticipated impacts to building inspectors from the proposed code change. Inspectors will not be required to complete any tasks that they are not already conducting to verify compliance with the 2013 Standards.

3.4.8 Impact on Statewide Employment

The proposed changes to Title 24 are may impact employment. An increase in employment in the water heating sector (e.g., in-state manufacturing, retailers) is expected while a slight employment decrease for installers may result, as IWHs have higher product life expectancies than storage water heaters; the rate of replacement is lower for the former. More impacts to employment are noted below in Section 3.5.

3.5 Economic Impacts

The proposed Title 24 code changes, including this measure, are expected to increase job creation, income, and investment in California. As a result of the proposed code changes, it is anticipated that less money will be sent out of state to fund energy imports, and local spending is expected to increase due to higher disposable incomes due to reduced energy costs.[3] For instance, the statewide life cycle net present value of this measure is $204 million over the 30 year period of analysis. In other words, utility customers will have $204 million to spend elsewhere in the economy. In addition, more dollars will be spent in state on improving the energy efficient of new buildings.

These economic impacts of energy efficiency are documented in several resources including the California Air Resources Board's (CARB) Updated Economic Analysis of California's Climate Change Scoping Plan, which compares the economic impacts of several scenario cases (CARB, 2010b). CARB include one case (Case 1) with a 33% renewable portfolio standard (RPS) and higher levels of energy efficiency compared to an alternative case (Case 4) with a 20 % RPS and lower levels of energy efficiency. Gross state production (GSP),[4] personal income, and labor demand were between 0.6% and 1.1% higher in the case with the higher RPS and more energy efficiency (CARB 2010b, Table 26). While CARB's analysis does not report the benefits of energy efficiency and the RPS separately, we expect that the benefits of the package of measures are primarily due to energy efficiency. Energy efficiency measures are expected to reduce costs by $2,133 million annually (CARB 2008, pC-117) whereas the RPS implementation is expected to cost $1,782 million annually, not including the benefits of GHG and air pollution reduction (CARB 2008, pC-130).

Macro-economic analysis of past energy efficiency programs and forward-looking analysis of energy efficiency policies and investments similarly show the benefits to California's economy of investments in energy efficiency (Roland-Holst 2008; UC Berkeley 2011).

[3] Energy efficiency measures may result in reduced power plant construction, both in-state and out-of-state. These plants tend to be highly capital-intensive and often rely on equipment produced out of state, thus we expect that displaced power plant spending will be more than off-set from job growth in other sectors in California.

[4] GSP is the sum of all value added by industries within the state plus taxes on production and imports.

3.5.1 Creation or Elimination of Jobs

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation estimates that this scenario would result in a 1.1% increase in statewide labor demand in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Tables 26 and 27). CARB's economic analysis also estimates a 1.3% increase in small business employment levels in 2020 (CARB 2010b, Table 32).

3.5.2 Creation or Elimination of Businesses within California

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation (as described above) estimates that this scenario would result in 0.6% additional GSP in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Table ES-2). We expect that higher GSP will drive additional business creation in California. In particular, local small businesses that spend a much larger proportion of revenue on energy than other businesses (CARB 2010b, Figures 13 and 14) should disproportionately benefit from lower energy costs due to energy efficiency standards. Increased labor demand, as noted earlier, is another indication of business creation.

Table 100 below shows California industries that are expected to receive the economic benefit of the proposed Title 24 code changes. It is anticipated that these industries will expand due to an increase in funding as a result of energy efficiency improvements. The list of industries is based on the industries that the University of California, Berkeley identified as being impacted by energy efficiency programs (UC Berkeley 2011 Table 3.8).[5] The list provided below is not specific to one individual code change proposal, but is an approximation of the industries that may receive benefit from the 2016 Title 24 code changes. A table listing total expected job creation by industry that is expected in 2015 and 2020 from all investments in California energy efficiency and renewable energy is presented in the Appendix B of this CASE Report.

Table 10: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Residential Building Construction	2361
Nonresidential Building Construction	2362
Roofing Contractors	238160
Electrical Contractors	23821

[5] Table 3.8 of the UC Berkeley report includes industries that will receive benefits of a wide variety of efficiency interventions, including Title 24 standards and efficiency programs. The authors of the UC Berkeley report did not know in 2011 which Title 24 measures would be considered for the 2016 adoption cycle, so the UC Berkeley report was likely conservative in their approximations of industries impacted by Title 24. The Statewide CASE Team believes that industries impacted by utilities efficiency programs is a more realistic and reasonable proxy for industries potentially affected by upcoming Title 24 standards. Therefore, the table provided in this CASE Report includes the industries that are listed as benefiting from Title 24 and utility energy efficiency programs.

Plumbing, Heating, and Air-Conditioning Contractors	23822
Boiler and Pipe Insulation Installation	23829
Insulation Contractors	23831
Window and Door Installation	23835
Asphalt Paving, Roofing, and Saturated Materials	32412
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Industrial Machinery Manufacturing	3332
Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equipment Manufacturing	3334
Computer and Peripheral Equipment Manufacturing	3341
Communications Equipment Manufacturing	3342
Electric Lighting Equipment Manufacturing	3351
Household Appliance Manufacturing	3352
Other Major Household Appliance Manufacturing	335228
Used Household and Office Goods Moving	484210
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Advertising and Related Services	5418
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maintenance	811310

3.5.3 Competitive Advantages or Disadvantages for Businesses within California

California businesses would benefit from an overall reduction in energy costs. This could help California businesses gain competitive advantage over businesses operating in other states or countries and an increase in investment in California, as noted below.

3.5.4 Increase or Decrease of Investments in the State of California

CARB's economic analysis indicate that higher levels of energy efficiency and 33% RPS will increase investment in California by about 3% in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b Figures 7a and 10a).

3.5.5 Incentives for Innovation in Products, Materials, or Processes

Updating Title 24 standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings.

3.5.6 Effects on the State General Fund, State Special Funds and Local Governments

The Statewide CASE Team expects positive overall impacts on state and local government revenues due to higher GSP and personal income resulting in higher tax revenues, as noted earlier. Higher property valuations due to energy efficiency enhancements may also result in positive local property tax revenues. The Statewide CASE Team has not obtained specific data to quantify potential revenue benefits for this measure.

3.5.6.1 Cost of Enforcement

Cost to the State

State government already has the budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24 standards, including updating education and compliance materials and responding to questions about the revised standards, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

Cost to Local Governments

All revisions to Title 24 will result in changes to Title 24 compliance determinations. Local governments will need to train permitting staff on the revised Title 24 standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2016 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining. For example, the California utilities offer compliance training such as "Decoding" talks to provide training and materials to local permitting departments. As noted earlier, though retraining is a cost of the revised standards, Title 24 energy efficiency standards are expected to increase economic growth and income with positive impacts on local revenue.

The proposed prescriptive standard would revise an existing measure without significantly affecting the complexity of this measure. Therefore, on-going costs are not expected to change significantly.

3.5.6.2 Impacts on Specific Persons

The proposed changes to Title 24 are not expected to have a differential impact on any of the following groups relative to the state population as a whole:

- Migrant Workers
- Persons by age
- Persons by race
- Persons by religion
- Commuters

We expect that the proposed code changes for the 2016 Title 24 code change cycle will reduce energy costs and could put potential first-time homeowners in a better position to afford mortgage payments. On the other hand, homeowners may experience higher first costs to the extent that builders pass-through the increased costs of Title 24 compliance to home buyers. Some financial institutions have progressive policies that recognize that home buyers can better afford energy efficiency homes (even with a higher first cost) due to lower energy costs.[6]

Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed-through from landlords. Renters who do not pay directly for energy costs may see more of less of the net savings based on how much landlords pass the energy cost savings on to renters.

On average, low-income families spend less on energy than higher income families, however lower income families spend a much larger portion of their incomes on energy (Roland-Holst 2008). Thus it seems reasonable that low-income families would disproportionately benefit from Title 24 standards that reduce residential energy costs

4. METHODOLOGY

This section describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. The Statewide CASE Team calculated the impacts of the proposed code change by comparing existing conditions to the proposed if the code change is adopted. This section of the CASE Report goes into more detail on the assumptions about the existing and proposed conditions, prototype buildings, and the methodology used to estimate energy, demand, cost, and environmental impacts.

To assess the energy, demand, costs, and environmental impacts of the proposed measure, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements. Since the existing Title 24 Standards cover domestic water heating systems, including water heaters, the existing conditions assume the base case is a building that complies with the 2013 Title 24 Standards.

4.1 Existing Conditions

To assess the energy, demand, costs, and environmental impacts, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements. Since the existing Title 24 Standards cover the domestic hot water system in residential buildings, the existing conditions assume a building complies with the 2013 Title 24 Standards.

[6] Refer to US EPA's Energy Star website for examples: http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=CA.

As described in Section 2, the existing Title 24 Standards include requirements for domestic gas water heating systems for newly constructed and existing single-family and multi-family buildings. The current prescriptive Standards for residential new construction allow for the installation of a gas storage water heater (75,000 BTU or less), a gas IWH (200,000 BTU or less), or an electric storage or electric IWH as part of a solar hot water system in new residential construction (including multi-family buildings with dedicated water heaters for each individual dwelling unit).

As described in Section 3, many builders are frequently including gas IWHs as part a building's hot water distribution design. In fact, IWHs are now more commonly found in the design plans for new homes in Southern California, based on our discussions with various stakeholders.

4.2 Proposed Conditions

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, the proposed code change will change the prescriptive baseline from a 50-gallon gas storage water heater to a gas IWH (meeting federal minimum standards). In other words, compliance via the performance path will be based on meeting a water heating energy budget based on the energy performance of a gas IWH that meets the federal minimum standard (EF = 0.82 in 2015). See Section 2 and Section 6 of this report regarding the proposed code language. The Statewide CASE Team used IWH for savings estimates in our analyses.

In addition, since the alternative prescriptive option will be equivalent to or better energy performance than gas IWHs at 0.82 EF, it will be designed so it results in similar energy savings.

4.3 Prototype Building

CEC provided guidance in the Residential ACM Reference Manual on the type of prototype building that must be modeled. According to CEC, the prototypical single-family residential building is 2,500 square-feet and two-stories, based on typical floor plans provided by the Davis Energy Group (DEG). Table 11 presents the details of the prototype building used in the analysis. Since the proposed measure only applies to residential buildings with dedicated water heaters for each individual dwelling unit, the proposed single-family residential prototype building was used as a proxy for the multi-family buildings affected by the proposed standards. Multi-family buildings with central water heating systems are outside the scope of this proposal, and therefore, were not modeled.

Table 11: Prototype Single Family Residential Buildings used for Energy, Demand, Cost, and Environmental Impacts Analysis

	Occupancy Type (Residential, Retail, Office, etc.)	Area (Square Feet)	Number of Stories
Two-story Prototype	Residential	2,500	2

4.4 Climate Dependent

The Statewide CASE Team modeled energy and cost savings in every climate zone using statewide TDV factors. For each climate zone, the cold water supply temperature is assumed to be the same as ground temperatures and the hot water supply temperature is 135 degrees Fahrenheit (^{o}F), as stated in the Residential ACM Reference Manual.

4.5 Time Dependent Valuation (TDV)

The TDV of savings is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during different times of the day and year. The TDV values are based on long-term discounted costs (30 years for residential measures). The TDV cost impacts are presented in 2016 present value dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBTUs" so that the savings are evaluated in terms of energy units and measures with different periods of analysis can be combined into a single value.

This is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

The TDV energy impacts based on the current TDV values are presented in Section 5.1.1 of this report, and the statewide TDV cost impacts are presented in Section 5.1.2.

4.6 Energy Impacts Methodology

The Statewide CASE Team calculated per unit impacts and statewide impacts associated with all new residential construction during the first year that buildings begin complying with the 2016 Title 24 Standards (effective 2017).

The Statewide CASE Team updated the energy savings analysis performed in the 2013 Title 24 Residential High Efficiency Water Heater Ready CASE Report (2011), in which the energy savings per household are calculated by comparing annual natural gas consumption of the

federal minimum efficiency for IWHs to the baseline storage equipment. The 2015 federal residential water heater standard was used as the baseline for energy savings estimates, since it will be in effect starting April 2015, well in advance of the 2016 Title 24 effective date (January 1, 2017).

The Statewide CASE Team will be evaluating the impacts of the electricity use associated with gas IWHs and will include the results in the next version of the CASE Report submitted to CEC in Fall 2014.

The Statewide CASE Team used the current CEC hourly hot water draw schedule, which was updated in 2013, and distribution loss multipliers that are in the Title 24 Residential ACM Reference Manual, Appendix E and inputted into a Microsoft Excel spreadsheet tool developed by the Statewide CASE Team. As previously stated, the prototype building is a 2,500 square-foot, two-story, single family home.

4.6.1 Per Unit Energy Impacts Methodology

The Statewide CASE Team estimated the natural gas savings associated with the proposed code change. The energy savings were calculated on a per building basis. The Statewide CASE Team updated the energy savings analysis performed for the 2013 Title 24 High Efficiency Water Heater Ready CASE effort (2011) and calculated the energy savings per household by comparing the annual natural gas consumption of the baseline case (50-gallon storage water heater at the federal minimum efficiency level of 0.60) and the measure case (gas IWH at the 2015 federal minimum efficiency level of 0.82 EF).

The Statewide CASE Team will be evaluating the impacts of the electricity use associated with gas IWHs and will include the results in the next version of the CASE Report submitted to CEC in fall 2014.

Analysis Tools

An Excel-based spreadsheet tool was developed to perform hourly hot water heating energy consumption and savings calculations.

Key Assumptions

Based on the six typical single family building floor plans presented in the 2008 Public Interest in Energy Research (PIER) Study, the prototype building is a single family home with 2,517 square-feet of conditioned floor area and a corresponding daily hot water demand is 56.5 gallons (LBNL 2008) .[7] The Statewide CASE Team considered other estimates of daily hot water use, and assuming the building has two stories, the distribution loss multiplier is calculated to be 1.163, as indicated in the Title 24 Residential ACM Reference Manual Appendix E. The total water heater demand is 56.5 × 1.163 = 65.7 gallons/day.

[7] The Title 24 Residential Alternative Calculation Method Reference Manual assumes a 2,500 square foot residential buildings use 38.4 gallons per day. However, the Statewide CASE Team believes Davis Energy Group's assumption of 56.5 gallons per day is a more accurate depiction of actual hot water use in an average single family home in California.

For each climate zone, the cold water supply temperatures are assumed to be the same as ground temperatures and the hot water supply temperature is 135^{o} F, according to the Residential ACM Reference Manual. Hourly hot water draw was determined using the hot water draw schedule defined by CEC.

The present values of hot water heating energy use were calculated using the residential 30-year natural gas TDV values and corresponding conversion factors.

To determine energy savings between the baseline and measure cases, the Statewide CASE Team used the 2015 federal minimum standard EF ratings for a gas storage water heater (50-gallon) and gas IWH. The EF rating for gas IWHs was multiplied by 92% to account for the *potential* increase in hot water consumption (discussed in Section 4.8.2) as instructed by the Residential ACM Reference Manual, Appendix E. The Statewide CASE Team believes that discounting the EF rating in this way addresses stakeholder concerns and is a reasonable estimate given limited field studies (Hoeschele et al. 2011). This approach of discounting the EF rating was also used in the 2013 Title 24 High Efficiency Water Heater Ready CASE Report (2011) and the energy savings results will be somewhat conservative due to the discounted EF. The key assumptions used for the per unit Energy Impacts Analysis are shown in Table 12.

Table 12: Key assumptions for per unit Energy Impacts Analysis

Parameter	Assumption	Source
Prototype building	2,500 square feet	Residential ACM Reference Manual
Daily hot water demand per HH	56.5 gallons	LBNL (2008) PIER Study
Distribution Loss Multiplier	1.163	Residential ACM Reference Manual
Total water heater demand	56.5 ×1.163 = 65.7 gallons/day	LBNL (2008) PIER Study and Residential ACM Reference Manual
Cold water inlet temperature	Same as ground temperature	Residential ACM Reference Manual
Hot water supply temperature	135° F	Residential ACM Reference Manual
Base case	50-gallon gas storage water heater (federal minimum efficiency)	Residential ACM Reference Manual; United States Department of Energy
Measure case	Gas IWH (federal minimum efficiency)	United States Department of Energy
Potential hot water increase multiplier for IWH	92%	Residential ACM Reference Manual

4.6.2 Statewide Energy Impacts Methodology

First Year Statewide Impacts

The Statewide CASE Team estimated statewide impacts for the first year that buildings begin complying with the 2016 Title 24 Standards (2017) by multiplying per unit savings estimates by the 2017 statewide construction forecasts.[8] The statewide energy savings depend on the number of IWHs that are installed if the proposed measure was adopted. To demonstrate the scale of energy savings, the Statewide CASE Team assumed that a gas IWH will be installed in every new single-family home and multi-family unit with a dedicated water heater in every climate zone.

4.7 Cost-effectiveness Methodology

This measure proposes a modification to the prescriptive requirement for domestic water heating in residential new construction. As such, a lifecycle cost (LCC) analysis is required to demonstrate that the measure is cost effective over the 30-year period of analysis.

CEC's procedures for calculating lifecycle cost-effectiveness are documented in the LCC Methodology. The Statewide CASE Team followed these guidelines when developing the Cost-effectiveness Analysis for this measure. CEC's guidance dictated which costs were included in the analysis: incremental equipment and maintenance costs over the 30-year period of analysis. TDV energy cost savings from natural gas savings were also considered. Each of these components is discussed in more detail below.

Design costs and the incremental cost of verification were not included in the Cost-effectiveness Analysis as there are none associated with the proposed code change.

4.7.1 Incremental Cost Methodology

Incremental Construction Cost Methodology

Since the 2013 Title 24 Standards residential water heating standards require new homes to be equipped for the installation of high-efficiency water heaters, such as gas IWHs, there are no assumed incremental construction costs between the baseline case and the proposed measure case.

Incremental Equipment Cost Methodology

The incremental equipment costs were obtained from the rulemaking documents published by the DOE in 2010 and cost data from popular online retailers. DOE conducted extensive studies of costs for water heaters and its methodologies and findings were published as rulemaking supporting documents that were thoroughly vetted by participating stakeholders. These documents represent the most comprehensive data source for residential water heater costs.

[8] CEC's 2017 construction forecast used for the proposed measure was revised by TRC Energy Services.

The Statewide CASE Team also confirmed and updated DOE's costs by researching current water heater prices among the top retailers (Home Depot, Lowe's Home Improvement, and Sears) and found the incremental equipment cost to be similar; non-condensing gas IWHs are on average approximately $500 more than non-condensing gas storage water heaters.

According to DOE, the average lifespan of a gas storage water heater is approximately 13 years and approximately 20 years for a gas IWH. Based on this information, the Statewide CASE Team factored in approximately 2.3 times the storage water heater equipment costs and 1.5 times the IWH equipment costs for the 30-year LCC analysis. In calculating incremental installation costs over a 30-year period, we assumed a total of three installations over 30 years for storage equipment and two installations of IWHs equipment for a building. Key assumptions used to derive costs are presented in Table 13.

Table 13: Key Assumptions for Per Unit Incremental Cost

Parameter	Assumption	Source	Notes
Incremental Equipment Cost	~$500	United States Department of Energy 2010 Final Rule; Home Depot; Sears; Lowes	Lowes has an incremental cost difference of approximately $185 (Lowes.com)
Storage Water Heater			
Equipment Life	13 years	United States Department of Energy 2010 Final Rule	
Equipment Cost (30 Years)	$1,964	Calculation	Retail Price * (30 Years/Equipment Life)
Installation Costs – New Construction	$428	Title 24 2013 High Efficiency Water Heater Ready CASE Report 2011	
Installation Costs – Replacement	$487	Title 24 2013 High Efficiency Water Heater Ready CASE Report 2011	
Number of Replacement Installations Over 30 Years	2	Calculation	
30 Year Installation Cost	$1,402	Calculation	Installation Cost (NC) + (Installation Cost (Replacement)* Number of Replacement Installations)
Instantaneous Water Heater			
Equipment Life	20 years	United States Department of Energy 2010 Final Rule	
Equipment Cost (30 Years)	$1,945	Calculation	Retail Price * (30 Years/Equipment Life)
Installation Costs – New Construction	$428	Title 24 2013 High Efficiency Water Heater Ready CASE Report 2011	
Installation Costs – Replacement	$487	Title 24 2013 High Efficiency Water Heater Ready CASE Report 2011	
Number of Replacement Installations Over 30 Years	1	Calculation	
30 Year Installation Cost	$915	Calculation	Installation Cost (NC) + (Installation Cost (Replacement)* Number of Replacement Installations)

Incremental Maintenance Cost Methodology

Though water heaters require a level of maintenance to prolong their useful life, there is a lack of information pertaining to the costs of maintenance for both storage and IWHs. Hoeschele and Weitzel (2012) assert that the issue is not currently well understood. Further, respondents in a high-efficiency water heater study conducted by Hoeschele et al. (2011) reported little to no maintenance of their IWHs. Given the uncertainty around typical maintenance activities and associated costs, the Statewide CASE Team has assumed there is no incremental cost for maintenance. As such, we did not include the incremental maintenance cost into the LCC analysis, which is consistent with assumptions made in the development of the 2013 Title 24 water heating standards. The maintenance requirements as recommended by water heater manufactures are described in Section 3.3 of this report.

4.7.2 Cost Savings Methodology

Energy Cost Savings Methodology

The present value of the energy savings was calculated using the method described in the LCC Methodology (CEC 2014b). In short, the hourly energy savings estimates for the first year of building operation were multiplied by TDV cost values to arrive at the present value of the cost savings over the period of analysis. This measure is climate sensitive, so the energy cost savings were calculated in each climate zone using TDV values for each unique climate zone.

The Statewide CASE Team performed the energy savings analysis for the proposed code change using the updated model we developed for the 2013 Title 24 water heating standards. That analysis involved calculating energy savings per household by comparing the annual natural gas consumption of different water heater options to the federal minimum efficiency baseline. For this measure, we compared the energy use of a gas IWH that meets the 2015 federal minimum efficiency standard to a 50-gallon storage water heater that meets the 2015 federal minimum standard. In addition, we updated the equipment costs and included installed costs over the lifetimes of a gas IWH and a gas storage water heater.

The hourly hot water draw schedule and distribution loss multipliers were obtained from Appendix E of the 2013 Title 24 Residential ACM Reference Manual and inputted into an Excel spreadsheet tool developed by the Statewide CASE Team. For each climate zone, the cold water supply temperatures are assumed to be the same as ground temperatures and the hot water supply temperature is 135^{o} F, according to the calculation method in the Reference Manual.

As described in Section 4.3 of this report, the prototypical building used in the model is a 2,500 square-foot, two-story, single-family home, as specified in the Reference Manual. Since the proposed measure only applies to residential buildings with dedicated water heaters for each individual dwelling unit, the proposed single-family residential prototype building was used as a proxy for the multi-family buildings affected by the proposed standards. Multi-family buildings with central water heating systems are outside the scope of this proposal, and therefore, were not modeled.

4.7.3 Cost-effectiveness Methodology

The Statewide CASE Team calculated cost-effectiveness using the LCC Methodology. According to CEC's definition, a measure is cost effective if it reduces overall lifecycle cost from the current base case (existing conditions). The LCC Methodology clarifies that absolute lifecycle cost of the proposed measure does not need to be calculated. Rather, it is necessary to calculate the change in lifecycle cost from the existing conditions to the proposed conditions.

If the change in lifecycle cost is negative then the measure is cost effective, meaning that the present value of TDV energy savings is greater than the cost premium, or the proposed measure reduces the total lifecycle cost as compared to the existing conditions. Propane TDV costs are not used in the evaluation of energy efficiency measures.

The Planning Benefit to Cost (B/C) Ratio is another metric that can be used to evaluate cost effectiveness. The B/C Ratio is calculated by dividing the total present value TDV energy cost savings (the benefit) by the present value of the total incremental cost (the cost). If the B/C Ratio is greater than 1.0 (i.e. the present valued benefits are greater than the present valued costs over the period of analysis), then the measure is cost effective.

The Statewide CASE Team leveraged the Cost-effectiveness Analysis completed for the 2013 Title 24 water heating standards in which gas IWHs were determined to be cost effective in all climate zones across California (though they were not included as a prescriptive requirement in the 2013 Standards). The calculation was based on CEC's LCC methodology.[9] The cost values used in the calculation were updated for the current Cost-effectiveness Analysis.

4.8 Environmental Impacts Methodology

4.8.1 Greenhouse Gas Emissions Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

The Statewide CASE Team calculated avoided greenhouse gas (GHG) emissions assuming an emission factor of 353 metric tons of carbon dioxide equivalent ($MTCO_2e$) per gigwatt-hours (GWh) of electricity savings. As described in more detail in Appendix A: Environmental Impacts Methodology, the electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the state meets the Renewable Portfolio Standard (RPS) goal of 33% renewable electricity generation by 2020. Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

[9] The Life Cycle Cost (LCC) Methodology report for the 2013 standards can be viewed at: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/2011-01-14_LCC_Methodology_2013.pdf.

Greenhouse Gas Emissions Monetization Methodology

The TDV cost values include the monetary value of avoided GHG emissions, so the Cost-effectiveness Analysis presented in Section 5.2 of this report does include the cost savings from avoided GHG emissions. The monetization for the TDV values includes permit (retail) cost of avoided GHG emissions, but it does not include the social costs of avoided emissions. As evident in the results of the Cost-effectiveness Analysis, the value of avoided GHG emissions is aggregated into the total TDV cost savings and the contribution of GHG emissions is not easily discernible. To demonstrate the value of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the overall TDV cost savings value. The Statewide CASE Team used the same monetary values that are used in the TDV factors.

4.8.2 Water Use Impacts Methodology

The Statewide CASE Team also considered the potential water use impacts associated with the proposed measure, such as a potential increase in hot water usage and longer hot water delivery times. According to a study conducted by the Davis Energy Group (2011) that looked at the associated water use of high-efficiency water heaters installed in 18 California single family homes, IWHs were found to influence water usage behavior to a degree. The sites retrofitted with IWHs showed an increase in average hot water draw volume from 1.40 to 2.09 gallons per draw, which was counteracted by an average 23% reduction in the daily number of draws (Hoeschele et al. 2011). In other words, there was essentially no change in the hot water recovery load with the conversion of a storage water heater to an IWH.

A study by the Minnesota Center for Energy and Environment provided an in-depth study of storage and IWHs in Minnesota homes. The report addressed the impact of the water heater on the amount of hot water used and any behavioral impacts from switching from a storage water heater to IWH. Based on the data collected from each monitoring site, the study determined that there was no statistical difference in hot water usage with the storage water heater and the tankless water heater. In fact, the study found that replacing a storage water heater with an IWH resulted in a 37% savings in water heating energy per household, as well as acceptable service at a reduced monthly cost without increasing total hot water consumption (Schoenbauer & Bohac 2013).

In terms of the time it takes for hot water to arrive at the tap, respondents in both studies reported an increase in wait time ranging from 5 to 60 seconds for hot water. However, 80% of study respondents were satisfied overall with their IWH, particularly with the consistent hot water temperatures during each draw and many of the respondents adjusted their behavior to account for the wait time, including not using hot water for shorter tasks (Hoeschele 2011; Schoenbauer & Bohac 2013). Furthermore, the 2013 Title 24 water heating standards require pipe insulation in new construction, which will reduce the amount of heat loss as the hot water travels from the water heater to the tap. Moreover, designing the hot water distribution system in a manner that minimizes pipe distance by placing the water heater closer to the points of use will further reduce heat loss and decrease the amount of time it takes hot water to reach the tap.

Given the findings of the abovementioned studies and that hot water delay is a function of several water heating variables (e.g., pipe length, pipe size, faucet flow rate, inlet and outlet water temperatures, pipe insulation, and type of water heater), the Statewide CASE Team has determined that the potential water use impacts of the proposed measure are not significant enough to include in the overall analysis. In order to provide a conservative estimate and address stakeholder concerns (as described in the Section 4.6.1), we discounted the gas savings associated with this measure to account for the potential increase in hot water draw.

4.8.3 Material Impacts Methodology (Optional)

The Statewide CASE Team did not develop estimates of material impacts.

4.8.4 Other Impacts Methodology

There are no other impacts from the proposed code change.

5. ANALYSIS AND RESULTS

Results from the energy, demand, cost, and environmental impacts analyses are presented in this section.

Statewide CASE Team Note: At this time, all results are preliminary until we finalize all the inputs based on stakeholder feedback and TDV values are finalized by CEC.

5.1 Energy Impacts Results

5.1.1 Per Building Energy Impacts Results

Per building energy and demand impacts of the proposed measure by Climate Zone are presented in Table 14. Per building savings for the first year are expected to be 50 therms/year.

It is estimated that the per building TDV savings over the 30-year period of analysis will be 8,095 kBTU,

Table 14: Energy Impacts per Building

Climate Zone	Per Unit First Year Savings[1]			Per Unit First Year TDV Savings[2]		
	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Savings (kBTU)	TDV Natural Gas Savings (kBTU)	Total TDV Savings (kBTU)
Climate Zone 1	0	0	55	0	8,796	8,796
Climate Zone 2	0	0	53	0	8,423	8,423
Climate Zone 3	0	0	52	0	8,392	8,392
Climate Zone 4	0	0	52	0	8,245	8,245
Climate Zone 5	0	0	52	0	8,363	8,363
Climate Zone 6	0	0	50	0	8,021	8,021
Climate Zone 7	0	0	49	0	7,763	7,763
Climate Zone 8	0	0	49	0	7,871	7,871
Climate Zone 9	0	0	48	0	7,787	7,787
Climate Zone 10	0	0	48	0	7,795	7,795
Climate Zone 11	0	0	50	0	8,059	8,059
Climate Zone 12	0	0	51	0	8,198	8,198
Climate Zone 13	0	0	48	0	7,739	7,739
Climate Zone 14	0	0	50	0	8,066	8,066
Climate Zone 15	0	0	42	0	6,747	6,747
Climate Zone 16	0	0	57	0	9,249	9,249

1. Savings from one prototype building for the first year the building is in operation.
2. TDV energy savings for one prototype building for the first year the building is in operation. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity and natural gas.
3. Site electricity savings. Does not include TDV of electricity savings.

5.1.2 Statewide Energy Impacts Results

First Year Statewide Energy Impacts

The statewide energy impacts of the proposed measure are presented in Table 15. During the first year that buildings complying with the 2016 Title 24 Standards are in operation, the proposed measure is expected to reduce natural gas use by approximately 5.4 million therms (MMtherms).

Table 15: Statewide Energy Impacts

	First Year Statewide Savings[1]			TDV Savings[2]		
	Electricity Savings[3] (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings (Million kBTU)	TDV Natural Gas Savings (Million kBTU)	TDV Energy Savings (Million kBTU)
Proposed Measure	0	0	5.4	0	862	862
TOTAL	0	0	5.4	0	862	862

1. First year savings from all buildings built statewide during the first year the 2016 Standards are in effect.
2. First year TDV savings from all buildings built statewide during the first year the 2016 Standards are in effect. Calculated using CEC's 2016TDV factors and methodology but will be updated to the 2016 TDV values when they are made finalized by CEC.
3. Site electricity savings.

All assumptions and calculations used to derive per unit and statewide energy and demand savings are presented in Section 4.4 of this report.

5.2 Cost-effectiveness Results

5.2.1 Incremental Cost Results

The incremental cost of the proposed measure, relative to existing conditions, is presented in Table 16. The total incremental cost includes the incremental cost during initial installation, the replacement cost of the equipment, and the present value of the incremental maintenance cost over the 30-year period of analysis. Based on assumed lifetimes, storage equipment are expected to be replaced 2 times and IWH replaced once over 30 years. Each of these components of the incremental cost is discussed below.

Table 16: Incremental Cost of Proposed Measure 2016 Present Value Dollars[1]

Condition	Initial Equipment Cost[2]		Incremental Present Value of Maintenance Cost[5]	Total Cost[6]
	Current[3]	Post Adoption[4]		
Existing Conditions	$3,366	$3,366	$0	$3,366
Proposed Conditions	$2,860	$2,860	$0	$2,860
Incremental[1]	-$506	-$506	$0	-$506

1. Incremental costs equal the difference between existing conditions and proposed conditions. Negative values indicate the Proposed Conditions are less expensive than Existing Conditions.
2. Equipment cost includes cost of equipment (water heater) plus the installation cost for original equipment and all replacements that are installed within 30 year period of analysis.
3. Initial construction cost using current prices; ΔCI_C.
4. Initial construction cost using estimated prices after adoption; ΔCI_{PA}.
5. Present value of maintenance costs over 30 year period of analysis; ΔCM.
6. Total costs equals incremental cost (post adoption) plus present value of maintenance costs; $\Delta CI_{PA} + \Delta CM$.

Incremental Construction Cost Results

Since the 2013 Title 24 Standards for domestic water heating requires new single-family homes and multi-family buildings with dedicated water heaters for each individual dwelling unit to be equipped with the components to accommodate the installation of IWHs, there are no incremental construction costs as a result of the proposed code change.

Incremental Maintenance Cost Results

Though water heaters require a level of maintenance to prolong their useful life, the lack of information pertaining to the costs of maintenance for both storage and IWHs has led the Statewide CASE Team to assume there is no incremental cost for maintenance. As such, we did not include the incremental maintenance cost into the LCC analysis, which is consistent with the methodology used for the 2013 Title 24 water heating standards. The maintenance requirements associated with the code change proposal, relative to existing conditions, are described in Section 3.3 of this report.

5.2.2 Cost Savings Results

Energy Cost Savings Results

The per unit TDV energy cost savings over the 30-year period of analysis are presented in Table 17. The analysis shows the per household gas savings for each climate zone. The proposed measure results in positive cost savings in every climate zone.

Given data regarding the new construction forecast for 2017, the Statewide CASE Team estimates that TDV energy cost savings (30-year) of all buildings built during the first year the 2016 Title 24 Standards are in effect will be approximately $132 million.

As noted, this is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

Table 17: TDV Energy Cost Savings Over 30-Year Period of Analysis - Per Unit

Climate Zone	TDV Cost Savings (2016 PV $)[1]
Climate Zone 1	$1,523
Climate Zone 2	$1,459
Climate Zone 3	$1,453
Climate Zone 4	$1,428
Climate Zone 5	$1,448
Climate Zone 6	$1,389
Climate Zone 7	$1,344
Climate Zone 8	$1,363
Climate Zone 9	$1,349
Climate Zone 10	$1,350
Climate Zone 11	$1,396
Climate Zone 12	$1,420
Climate Zone 13	$1,340
Climate Zone 14	$1,397
Climate Zone 15	$1,168
Climate Zone 16	$1,602

1. All cost values presented in 2013 dollars. Cost savings are calculated using 2013 TDV values and will be updated to the 2016 TDV values when they are made publicly-available by CEC.

5.2.3 Cost-effectiveness Results

The proposed measure results in cost savings over the 30-year period of analysis relative to the existing conditions due to the longer life of IWHs and their lower energy demand (i.e. lower utility bills). In sum, the proposed code change is cost effective in every California climate zone. The negative values listed under the "Change in Lifecycle Cost" column indicate that the proposed measure is cost effective. The results of the per unit lifecycle Cost-effectiveness Analyses are presented in Table 18.

Table 18: Cost-effectiveness Summary[1]

Climate Zone	Benefit: TDV Energy Cost Savings + Other Cost Savings[2] (2016 PV $)	Cost: Total Incremental Cost[3] (2016 PV $)	Change in Lifecycle Cost[4] (2016 PV $)	Benefit to Cost Ratio[5]
Climate Zone 1	$1,523	-$506	-$2,029	3.01
Climate Zone 2	$1,459	-$506	-$1,965	2.88
Climate Zone 3	$1,453	-$506	-$1,959	2.87
Climate Zone 4	$1,428	-$506	-$1,934	2.82
Climate Zone 5	$1,448	-$506	-$1,954	2.86
Climate Zone 6	$1,389	-$506	-$1,895	2.75
Climate Zone 7	$1,344	-$506	-$1,850	2.66
Climate Zone 8	$1,363	-$506	-$1,869	2.69
Climate Zone 9	$1,349	-$506	-$1,854	2.67
Climate Zone 10	$1,350	-$506	-$1,856	2.67
Climate Zone 11	$1,396	-$506	-$1,902	2.76
Climate Zone 12	$1,420	-$506	-$1,926	2.81
Climate Zone 13	$1,340	-$506	-$1,846	2.65
Climate Zone 14	$1,397	-$506	-$1,903	2.76
Climate Zone 15	$1,168	-$506	-$1,674	2.31
Climate Zone 16	$1,602	-$506	-$2,108	3.17

1. Relative to existing conditions. All cost values presented in 2016 dollars. Cost savings are calculated using 2013 TDV values and will be updated to the 2016 TDV values when they are finalized by CEC.
2. Present value of TDV cost savings equals TDV electricity savings plus TDV natural gas savings; $\Delta TDV\$ = \Delta TDV\$E + \Delta TDV\$G$. Cost savings are calculated using 2013 TDV values and will be updated to the 2016 TDV values when they are finalized by CEC.
3. Total incremental cost equals incremental construction cost post adoption) plus present value of incremental maintenance cost; $\Delta C = \Delta CI_{PA} + \Delta CM$.
4. Negative values indicate the measure is cost effective. Change in lifecycle cost equals cost premium minus TDV energy cost savings; $\Delta LCC = \Delta C - \Delta TDV\$$.
5. The Benefit to Cost ratio is the TDV energy costs savings divided by the total incremental costs; $B/C = \Delta TDV\$ \div \Delta C$. The measure is cost effective if the B/C ratio is greater than 1.0.

Given the 2017 construction forecast published by CEC's Demand Analysis Office, the Statewide CASE Team estimates that that lifecycle cost savings 30-year) of all buildings built during the first year that the 2016 Title 24 Standards are effective will be approximately $204 million.

5.3 Environmental Impacts Results

The greatest environmental impact of the proposed measure is the expected emissions reduction due to reduced natural gas use for water heating.

5.3.1 Greenhouse Gas Emissions Results

Table 19 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year the 2016 Title 24 Standards are in effect the proposed measure will result in avoided GHG emissions of 28,476 $MTCO_2e$, which has a value of $1,361,103. The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) for each hour of the year and thus included in the Cost-effectiveness Analysis presented in this report.

Table 19: Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions[1] ($MTCO_2e$/yr)	**Monetary Value of Avoided GHG Emissions[2] (2016 $)**
Proposed Measure	28,476	$1,361,103
TOTAL	28,476	$1,361,103

1. First year savings from buildings built in 2017; assumes 5,303 $MTCO_2e$/MMTherms.
2. Monetary value of carbon is included in cost effectiveness analysis. Will update to 2016 TDV values when they are finalized by CEC.

5.3.2 Water Use Impacts

Given the findings of the abovementioned studies and that hot water delay is a function of several water heating variables e.g., pipe length, pipe size, faucet flow rate, inlet and outlet water temperatures, pipe insulation, and type of water heater), the Statewide CASE Team has determined that the potential water use impacts of the proposed measure are not significant enough to include in the savings analyses.

Impacts on water use and water quality are presented in Table 20.

Table 20: Impacts of Water Use and Water Quality

	On-Site Water Savings[1] (gallons/yr)	Embedded Energy Savings[2] (kWh/yr)	Impact on Water Quality Material Increase (I), Decrease (D), or No Change (NC) compared to existing conditions			
			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	NC	NC
Per Unit Impacts[3]	n/a	n/a	n/a	n/a	n/a	n/a
Statewide Impacts (first year)	n/a	n/a	n/a	n/a	n/a	n/a
Comment on reasons for your impact assessment	n/a	n/a	n/a	n/a	n/a	n/a

3. Does not include water savings at power plant
4. Assumes embedded energy factor of 10,045 kWh per million gallons of water.
5. Unit means per prototype building. For description of prototype buildings refer to section 4.3.

5.3.3 Material Impacts Results (Optional)

The material impacts of the proposed code change on material use were not evaluated.

5.3.4 Other Impacts Results

There are no other impacts of the proposed code change.

6. PROPOSED LANGUAGE

The proposed changes to the 2013 Title 24 Standards, Residential ACM Reference Manual, and Compliance Manual are provided below. Changes to the 2013 documents are marked with underlining new language) and ~~strikethroughs~~ deletions).

6.1 Standards

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR NEWLY CONSTRUCTED RESIDENTIAL BUILDINGS

c) **Prescriptive Standards/Component Package.** Buildings that comply with the prescriptive standards shall be designed, constructed, and equipped to meet all of the requirements for the appropriate Climate Zone shown in TABLE 150.1-A. In TABLE 150.1-A, a NA not allowed) means that feature is not permitted 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 C, or D.

~~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 that meets the tank insulation requirements of Section 150.0j) and the requirements of Sections 110.1 and 110.3 shall be installed. For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.~~

~~B.~~ A. 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 storage tank, and that meets the requirements of Sections 110.1 and 110.3 shall be installed. For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.

B. *see note below*

C. For systems serving multiple dwelling units, a central water-heating system that includes the following components shall be installed:

i. Gas or propane water heaters, boilers or other water heating equipment that meet the minimum efficiency requirements of Sections 110.1 and 110.3; and
ii. A water heating recirculation loop that meets the requirements of Sections 110.3c)2 and 110.3c)5 and is equipped with an automatic control system that controls the recirculation pump operation based on measurement of hot water demand and hot water return temperature and has two recirculation loops each serving half of the building; and

EXCEPTION to Section 150.1c)8Cii: Buildings with eight or fewer dwelling units are exempt from the requirement for two recirculation loops.

iii. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.20 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.35 in Climate Zones 10 through 16. The solar savings fraction shall be determined using a calculation method approved by the Commission.

D. For systems serving individual dwelling units, an electric-resistance storage or instantaneous water heater may be installed as the main water heating source only if natural gas is unavailable, the water heater is located within the building envelope, and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.

Note: a proposed alternative option for meeting the prescriptive requirement for gas water heating will be included as part of the code change proposal in the next version of the CASE Report that is submitted to CEC in Fall 2014. The Statewide CASE Team is currently developing a prescriptive alternative to enable stakeholders to comply with the Title 24 Standards prescriptively without having to install a gas IWH in the design of the building.

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.3 ACM Reference Manual

Chapter 2 of the Residential ACM Reference Manual will need to be revised. See proposed changes below.

Section 2.10 Domestic Hot Water (DHW)

Standard Design

Individual dwelling units: The standard design is based on §150.1c)8. For single-family dwellings or dwelling units served by a dedicated water heating system, each dwelling unit has one ~~small storage < 75000 Btu), 50 gallon gas storage~~ instantaneous water heater, meeting minimum federal Energy Factor standard ~~0.575 in 2014, 0.60 in 2015)~~ 0.82 in 2015) or electric ~~0.904 in 2014,~~ 0.945 in 2015) if natural gas in not available. The distribution type is either standard or, if a recirculating system is shown in the proposed design, a recirculating system with manual controls.

6.4 Compliance Manuals

Chapter 5 of the Residential Compliance Manual will need to be revised. See proposed changes below.

5.4 Prescriptive Water Heater and Distribution System Requirements

5.4.1 Single Dwelling Units

150.1c) 8

The ~~conventional~~ approach ~~to~~ for meeting the prescriptive requirements of ~~Package~~ option A for systems serving individual dwelling units, is that the system ~~would~~ be designed to use ~~either a small storage or~~ a gas instantaneous ~~gas~~ water heater as prescribed in the water heater Section 5.1. The distribution type options for a complying system would include either a conventional trunk and branch system or an on-demand recirculation system with manual controls. Both distribution systems must meet all of the mandatory requirements previously mentioned in this chapter. Other distribution system types do not meet the prescriptive requirement.

The other option under the prescriptive compliance method is to use the performance method for water heating only as defined in §150.1b)1 and which is discussed in full in the performance compliance section later in this chapter. This path requires inputting the building square footage and detailing the water heater and distribution system information into the building performance compliance tool.

§150.1c) 8

With the changes in the ~~2013~~ 2016 standards there are actually three prescriptive options for domestic hot water heating in single family residences depending upon whether natural gas service is available at the site.

~~1. A system with a single gas or propane storage type water heater must have:~~

~~a) A gas input rating < 75,000 Btu/h,~~

~~b) If the water heater's efficiency only meets the minimum federal efficiency standards, the tank must be wrapped with an R-12 water heating blanket [a mandatory requirement in §150.0j)1].~~

~~c) If the system uses a trunk and branch distribution system then all pipes from the water heater to the kitchen must be insulated and all pipe with a diameter equal to or greater than ¾ of an inch must be insulated.~~

~~d) If this system has a recirculation pump then the control must be demand based with manual controls pump only runs upon user direct activation until water temperature equals temperature setpoint). All portions of the distribution system that recirculate water must be insulated.~~

~~e) All applicable mandatory requirements in Section 110.3 and 150.0j,n) must be met~~

~~2~~ 1. A system with a single gas or propane instantaneous water heater without a storage tank must have:

a) A gas input rating < 200,000 Btu/h,

b) No supplemental storage tank is installed,

c) Uses a trunk and branch distribution system then all pipes from the water heater to the kitchen must be insulated and all pipes with a diameter equal to or greater than ¾ of an inch must be insulated.

d) All applicable mandatory requirements in Section 110.3 and 150.0j,n) must be met

e) No recirculation systems can be installed.

~~3~~ 2. An electric resistance storage or instantaneous water heater can be used if all of the following conditions are met:

a) Natural gas is unavailable at the site

b) The water heater is located within the building envelope

c) For storage electric and instantaneous a trunk and branch distribution system must have all pipes from the water heater to the kitchen and must be insulated and all pipes with a diameter equal to or greater than ¾ of an inch must be insulated.

d) All applicable mandatory requirements in Section 110.3 and 150.0 must be met

e) A solar water heater is installed which is designed to provide a solar fraction of 50% provides 50% of the heating load) and is installed as specified in the Reference Residential Appendix RA4. The details of the solar water heating prescriptive requirements are in described in more detail in Section 5.6.1 later on in this chapter.

e) No supplemental storage tank is installed

g) No recirculation system can be installed with electric instantaneous water heaters.

3. An alternative to the primary prescriptive option that does not include instantaneous water heaters is currently being developed for this code change proposal.

If a water heater is installed in combination with a booster heater used to either eliminate cold surges when an instantaneous water heater is the primary system, or used to reheat water in a portion of the system the booster heater must be included in compliance. All booster heaters must be treated as separate electric instantaneous water heaters. To comply, performance compliance must be used to demonstrate the installed system uses no more energy than what is allowed under the standards.

7. REFERENCES AND OTHER RESEARCH

[CARB] California Air Resources Board. 2008. "Climate Change Scoping Plan Appendices, Volume I." http://www.arb.ca.gov/cc/scopingplan/document/appendices_volume1.pdf.

__.2010a. “Proposed Regulation for a California Renewable Electricity Standard Staff Report: Initial Statement of Reasons Appendix D.” http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf..

__. 2010b. “Updated Economic Analysis of California’s Climate Change Scoping Plan: Staff Report to the Air Resources Board.” http://www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf.

__. 2011a. California Air Resources Board. “Appendix C: Cost Effectiveness Calculation Methodology.” http://www.arb.ca.gov/msprog/moyer/guidelines/2011gl/appc_3_10_11.pdf.

__. 2011b. “Emission Reduction Offsets Transaction Cost Summary Report for 2011.” http://www.arb.ca.gov/nsr/erco/erco.htm.

__. 2012. “Emission Reduction Offsets Transaction Cost Summary Report for 2012.” http://www.arb.ca.gov/nsr/erco/erco.htm.

__. 2013a. “Mail-Out #MSC 13-09.” http://www.arb.ca.gov/msprog/mailouts/msc1309/msc1309.pdf.

__. 2013b. “California Air Resources Board Quarterly Auction 3, May 2013 – Summary Results Report.” http://www.arb.ca.gov/cc/capandtrade/auction/may-2013/results.pdf.

[CEC] California Energy Commission. 2009. “Residential Appliance Saturation Survey.” http://www.energy.ca.gov/appliances/rass/

__. 2014a. “Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2016 Time Dependent Valuation (TDV) Data Sources and Inputs.” July 2014. http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/Title24_2016_TDV_Methodology_Report%20v3.docx. Accessed July 2014.

__. 2014b {placeholder for CEC 2016 Lifecycle Cost Methodology Report}

California Utilities Statewide Codes and Standards Team. 2011. “Title 24 2013 High-Efficiency Water Heater Ready CASE Report.” http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_WH2.WH5_WaterHeaterReady-10.28.2011.pdf.

Hoeschele et al. 2011. “California Field Performance of Advanced Residential Gas Water Heating Technologies.” Davis Energy Group.

Hoeschele, M. & E. Weitzel. 2012. “Water Heating Design Guide.” Prepared for California Energy Commission by Davis Energy Group and Gas Technology Institute. http://www.energy.ca.gov/2013publications/CEC-500-2013-126/CEC-500-2013-126.pdf.

KEMA. 2010. “Residential New Construction Programs: Impact Evaluation – Volume I.

California Investor-Owned Utilities' Residential New Construction Program Evaluation for Program Years 2006-2008." Prepared for California Public Utilities Commission – Energy Division. http://www.calmac.org/publications/RNC_Final_Evaluation_Report.pdf.

[LBNL] Lawrence Berkeley National Laboratory. 2008. "Water Heaters and Hot Water Distribution Systems." Public Interest Energy Research Program. Prepared for California Energy Commission. http://eetd.lbl.gov/sites/all/files/water_heaters_and_hot_water_distribution_systems.pdf.

[NEEA] Northwest Energy Efficiency Alliance. 2006. "Residential Water Heater Market." Prepared by KEMA.

http://neea.org/docs/reports/assessmentoftheresidentialwaterheatermarketingnwc6f59c4d2eeb.pdf.

__. 2012. "2011 Water Heater Update." Prepared by Verinnovation Inc. http://neea.org/docs/reports/2011waterheatermarketupdatea273dbb87ca3.pdf.

[PG&E] Pacific Gas and Electric Company. 2012. "Market-Focused Program Design to Accelerate Penetration of ENERGY STAR Water Heaters." Prepared by Navitas Partners. http://www.etcc-ca.com/reports/market-focused-program-design-accelerate-penetration-energy-star-water-heaters.

Rodgers, K. & J. O'Donnell. 2009. "A Market Transformation Strategy for Gas-Fired Domestic Hot Water Heaters." Consortium for Energy Efficiency. http://aceee.org/files/proceedings/2008/data/papers/9_248.pdf.

Roland-Holst, David. "Energy Efficiency, Innovation, and Job Creation in California." October 2008. http://are.berkeley.edu/~dwrh/CERES_Web/Docs/UCB%20Energy%20Innovation%20and%20Job%20Creation%2010-20-08.pdf .

Schoenberger, B., D. Bohac & M. Hewett. 2012. "Tankless Water Heaters: Do They Really Save Energy?" Minnesota Center for Energy and Environment. http://www.mncee.org/getattachment/1ef50130-fd3a-4a5c-beb9-1ea806c26785/.

Schoenberger, B. & D. Bohac. 2013. "Actual Savings and Performance of Natural Gas Tankless Water Heaters." http://mncee.org/Innovation-Exchange/Projects/Past/Actual-Savings-and-Performance-of-Natural-Gas-Tank/.

[U.S. DOE] United States Department of Energy. 2014. "Final Rule: Standards, Federal Register, 75 FR 20112 April 16, 2010)."

http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27.

U.S. EPA] United States Environmental Protection Agency. 2011. "Emission Factors for Greenhouse Gas Inventories." http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

[UC Berkeley] 2011. University of California Berkeley Donald Vial Center on Employment in the Green Economy. "California Workforce Education and Training Needs Assessment for Energy Efficiency, Distributed Generation, and Demand Response" http://www.irle.berkeley.edu/vial/publications/WET_Part1.pdf.

APPENDIX A: ENVIRONMENTAL IMPACTS METHODOLOGY

Greenhouse Gas Emissions Impacts Methodology

The avoided GHG emissions were calculated assuming an emission factor of 353 metric tons of carbon dioxide equivalents $MTCO_2e$) per GWh of electricity savings. The Statewide CASE Team calculated air quality impacts associated with the electricity savings from the proposed measure using emission factors that indicate emissions per GWh of electricity generated.[10] When evaluating the impact of increasing the Renewable Portfolio Standard RPS) from 20% renewables by 2020 to 33% renewables by 2020, California Air Resources Board CARB) published data on expected air pollution emissions for various future electricity generation scenarios CARB 2010). The Statewide CASE Team used data from CARB's analysis to inform the air quality analysis presented in this report.

The GHG emissions factor is a projection for 2020 assuming the state will meet the 33% RPS goal. CARB calculated the emissions for two scenarios: 1) a high load scenario in which load continues at the same rate; and 2) a low load rate that assumes the state will successfully implement energy efficiency strategies outlined in the AB32 scoping plan thereby reducing overall electricity load in the state.

To be conservative, the Statewide CASE Team calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 was considered a representative year for this measure.

Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

Greenhouse Gas Emissions Monetization Methodology

The 2016 TDV cost values used in the LCC Methodology includes the monetary value of avoided GHG emissions based on a proxy for permit costs not social costs and the Cost-effectiveness Analysis presented in Section 5.2 of this report does include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated value of avoided GHG emissions from the other

[10] California power plants are subject to a GHG cap and trade program and linked offset programs until 2020 and potentially beyond.

economic impacts. The Statewide CASE Team used the same monetary values that are used in the TDV factors.

APPENDIX B: JOB CREATION BY INDUSTRY

Table 21 shows total job creation by industry that is expected from all investments in California energy efficiency and renewable energy (UC Berkeley 2011, Appendix D). While it is not specific to codes and standards, this data indicates the industries that generally will receive the greatest job growth from energy efficiency programs.

Table 21: Job Creation by Industry

NAICS	Industry Description	Direct Jobs	
		2015	2020
23822	Plumbing, Heating, and Air-Conditioning Contractors	8,695	13,243
2361	Residential Building Construction	5,072	7,104
2362	Nonresidential Building Construction	5,345	6,922
5611	Office Administrative Services	2,848	4,785
23821	Electrical Contractors	3,375	4,705
551114	Corporate, Subsidiary, and Regional Managing Offices	1,794	3,014
54133	Engineering Services	1,644	2,825
5418	Advertising and Related Services	1,232	2,070
334413	Semiconductor and Related Device Manufacturing	1,598	1,598
541690	Other Scientific and Technical Consulting Services	796	1,382
23831	Drywall and Insulation Contractors	943	1,331
3334	Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equipment Manufacturing	453	792
3351	Electric Lighting Equipment Manufacturing	351	613
926130	Regulation and Administration of Communications, Electric, Gas, Other Utilities	322	319
23816	Roofing Contractors	275	277
54162	Environmental Consulting Services	151	261
484210	Used Household and Office Goods Moving	137	239
23835	Finish Carpentry Contractors	120	120
23829	Other Building Equipment Contractors	119	113
3352	Household Appliance Manufacturing	63	110
Other	Other	454	547
	Total	**35,788**	**52,369**