

Draft Research Plan for HVAC Permit and Code Compliance Market Assessment

Identification of Standard Practices and Barriers for Existing HVAC Building Permits and Title 24 Compliance in Residential and Nonresidential Buildings

California Public Utility Commission, Energy Division

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1. Research Plan Introduction

This document presents DNV GL's 2014-2016 research plans to document the current practices associated with permitting and compliance of specific HVAC replacement installations in residential dwellings and nonresidential building markets in California required to meet 2008 Title 24 requirements.

In order to meet CPUC's EM&V objectives, a "roadmap" was developed. The 2013-14 Roadmap¹ set aside a budget of \$1.25M for the 2014-15 year to conduct a HVAC baseline assessment for permitting and compliance. The roadmap was a joint effort developed in 2012 between the CPUC Energy Division and the Investor Owned Utilities. The primary research objective for which funding was allocated stated: *"What are the baselines for California HVAC industry standard practice in obtaining building permits and achieving Title 24 compliance for residential and nonresidential HVAC equipment installations."*

This study was funded to inform policy makers and stakeholders on the current standard practices for HVAC permitting and compliance. The results of this study are expected to be used in future program plans and policy decisions. California's Long-Term Energy Efficiency Strategic Plan has set the goal that 50 percent of HVAC installations in existing buildings comply with codes via permits by 2015 and 90 percent of HVAC systems are installed to code and optimally maintained for systems' useful life by 2020². Achieving these goals is expected to require an HVAC market transformation with a herculean effort to overcome significant barriers and resistance by market actors. Stakeholders must be vigilant, creative, employ cross-cutting methods, and dedicated to impose change. The data collected through this study will provide a baseline performance metric from which it will be possible to measure progress toward achieving the goals set in the Strategic Plan.

This study is prospective in that the outcomes will help establish baseline metrics for evaluating changes in the California market over time. In addition, the perspectives and processes uncovered through this study will inform program design and support resource allocation to programs aimed at HVAC market practice improvements. The objectives are to identify baselines metrics (standard practice) for California residential and nonresidential HVAC in:

- Complying with building HVAC standards and permit requirements,

¹ http://www.cpuc.ca.gov/NR/rdonlyres/B6D32B87-249E-44BB-8083-7139EC4D3B3A/0/20132014_EnergyDivisionEMV_Workplan_v2.pdf

² The California Long-Term Energy Efficiency Strategic Plan; Section 3 Pg. 36
http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

- Attitudes and barriers to permitting and compliance,
- Correlation between permitting and compliance with codes and standards, and
- Effectiveness of Home Energy Rater (HERS) verification processes.

The California Public Utilities Commission (CPUC) Energy Division (ED), its ED Advisors, the investor-owned utilities (IOUs), and the California Energy Commission, have reviewed the Research Plan to ensure the plan contains the correct procedures, and leverages existing resources and knowledge base.

2. Researchable Issues

The HVAC Roadmap included several researchable issues, many of which, have been dropped, revised, or deferred due to limited direct benefit, potential biases, market actor cooperation issues, undemonstrated ability to produce defensible results, and/or the CPUC/IOUs limited ability to influence the permit and compliance landscape. The researchable issues selected and the specific activities to address them include:

- **Estimate the percent of projects that obtained required building permits and comply with building energy efficiency standards (Title 24, Part 6).**

In California, contractors are required by law to pull a permit for HVAC installations. However, the level of compliance with this requirement is believed to be very low; so low that the industry tends to refer to the lack of compliance as the “Underground Economy”³.

In 2008, the California Energy Commission (CEC) published a report that estimated 130 megawatts of additional peak demand reduction could be achieved annually assuming there is 90 percent permitting and proper installation of replacement HVAC equipment⁴. This savings estimate appears to directly coincide with the Strategic Plan’s 90 percent permit and compliance goal. The estimate also assumes a current permitting rate of 10 percent, an often referred rate for residential changeouts, as identified by IHACI and a working group back in August of 2005.

Studies using bottom-up permit rate estimates have found slightly higher predictions but none suggest the state is on track to meet the strategic goals of 50 percent by 2015 and 90 percent by 2020. Furthermore, the evidence to date, although inconclusive due lacking statistical significance and required precision, found less than expected differences for energy-related

³ G. William Pennington, “Underground Economy: Contractors Failure to Pull Permits for Residential HVAC Replacements” Testimony to the Little Hoover Commission, 27 March 2014
<http://www.lhc.ca.gov/studies/activestudies/underground%20economy/March%20Testimony/Pennington%20Testimony.pdf>

⁴ <http://www.energy.ca.gov/2013publications/CEC-400-2013-006/CEC-400-2013-006-D.pdf>; pg.23

metrics between permitted and non-permitted projects^{5, 6}. In order for the state to estimate the savings that can be achieved if the Strategic Plan's goals are met and the actions required to achieve these goals, we must understand the current practice.

This study will therefore attempt to produce a rigorous estimate of the current permitting in the state for HVAC installation in alterations to existing buildings (changeouts); the degree of variance across jurisdictions; reasons for variance; and if there are any lessons to be learned from the differences. In order to answer these questions confidently, this study will utilize larger sample sizes than used in previous research. The results and information collected is expected to be used to estimate the energy and demand savings available by increasing the permitting and compliance rates for HVAC installations.

To determine residential permit rates, we must identify a sample of previous HVAC installation to review and the number of permits associated with those installations. However, finding this sample is a complex undertaking due to various research barriers including but not limited to the lack of HVAC-replacers reporting on permit status and the lack of uniform record keeping, enforcement, and systematic reporting by the 536 city and county building departments. Given the challenges and potential biases, this study will estimate the residential permit rate based on a multi-pronged data collection and analysis approach that will include the following activities:

- **Estimate the HVAC market size.**
 - Examine total sales and/or develop a HVAC equipment replacement model for common equipment types such as central air conditioners, furnaces and heat pumps.
 - Estimate the replacement market versus units sold to new construction.
 - (Optional - Conduct a preliminary assessment of online and used market sales.)
 - The study will review multiple data sources, including but not limited to: an extrapolation of the number of units replaced from saturation studies such as CLASS, RASS, CMST, and/or CSS. Review data from past reports that estimated shipments sent to California from sources such as IHACI or AHRI/DOE or the California Home Building Foundation. Additional data sources will be added if the initial sources are determined to be inadequate.
- **Estimate the number of permits issued.**
 - Estimate the number of units that should have been permitted based on market size.
 - Identify the number of HERS certified HVAC units through the HERS registries.
 - Estimate the number of HVAC changeout permits issued by the 536 California building departments.

⁵ HVAC Permitting: A Study to Inform IOU HVAC Programs; CALMAC Study ID PGE0349.01

⁶ RLW Analytics, Inc. and The Benningfield Group, Residential HVAC Program Evaluation Permit Data & Duct Test Results, March 2008.

The study will review and collect permit data from multiple data sources, including but not limited to past reports that estimated permit rates, units certified through the HERS registry (CalCERTS), the California Home Building Foundation- Construction Industry Research Board (CHB | CIRB) which collects permit data directly from 100's of building departments, sample building departments not reporting to CIRB.

The research focuses on the residential sector; however, it also includes a limited sample of nonresidential HVAC changeouts investigation for the presence of a permit and for compliance requirements. The research will not collect data in the field for commercial projects, without prior CPUC approval, but rather leverage existing data from the Commercial Market Share Tracking Study (CMST) collected in 2012. We anticipate some limitations as it pertains to analysis of this existing data for specific prescriptive and mandatory measures. Early on in the project, results of the previously collected data will be analyzed and presented to the CPUC's Energy Division. The Energy Division will make the final determination on whether additional data is needed to support the findings. If an expansion is decided upon, these sites will need to be identified, recruited and fielded through other means such as the Commercial Saturation Study (CSS), through permits previously filed at building departments, and/or through nonresidential end user surveys.

- **Investigate permitting and compliance separately including whether non-permitted projects are compliant and if permitted projects are compliant.**

It is assumed that increasing the percentage of installations that acquire a permit will result in energy savings. While energy engineering theory shows that adhering to the requirements of Title 24's energy efficiency standards will result in excellent HVAC unit performance, the hypothesis that installations that are not permitted perform worse than permitted installations has not been rigorously tested. This project will test the hypothesis by completing compliance analysis of both permitted and non-permitted installations at residential dwellings. These reviews will identify the differences in recent practice between permitted installations and non-permitted installations. Both installation (permitted and non-permitted) types are expected to have varying levels of compliance for Title 24's mandatory and prescriptive measure requirements such that a permitted project may not be fully compliant and a non-permitted may be fully compliant, herein "compliant" being defined as adhered to Title 24 code requirements absent the permit. This study will aim to validate or refute the conjecture between permit and compliance by investigating these issues separately.

To provide meaningful results, given the sample sizes and complexities, the study will limit the compliance scope as it pertains to building types, installation types and the code cycle will be limited to the 2008 Standards. Limitations are further described in the compliance chapter of the research plan.

The results of this research are expected to be used to create standard practice baseline metrics utilized in future program planning, policy decisions, and impact analysis. The results are also expected to be used to assess the current difference in consumption and demand between permitted and non-permitted installations. To achieve these results, the study will:

- Visit a sample of residential dwellings to determine if the installation complies with building energy efficiency standards, regardless of existence of a permit.
- Assess the compliance of residential installations through onsite performance testing from a subsample of customers recruited from the 2009 Residential Appliance Saturation Study (RASS) databases and (if needed) general population.
- Assess the compliance of nonresidential units by leveraging onsite survey data previously collected from the Commercial Market Share Tracking (CMST) survey. The CMST study collected whole building data and new air conditioning unit data on small commercial units under 65 kBtuh (5-tons).⁷
 - Compliance information garnered from the surveys and from manufacturer nameplate lookups is described in more detail in Section 5. From this dataset we anticipate answering the following types of questions: Was a variable speed drive/variable air volume present (where required)? Was an economizer present (where required)? What percent of outside air did the economizer deliver? (What was the EER, cooling capacity, and maximum fan power? – identified through model number nameplate look up).
 - Compliance information that would not be evaluated from the CMST sample, because it was not collected, includes: Did the setback thermostat, heat pump controls, ductwork insulation, refrigerant piping insulation all meet Title24 (where applicable)?
- At the discretion of the CPUC, additional onsite inspection and/or performance testing of nonresidential projects will be decided upon based on analyzed results of the CMST field data previously collected.

For this study, full compliance with Title 24 will be defined as meeting all mandatory and prescriptive requirements associated with the installation (regardless of the permit status). However, partial compliance can be achieved by meeting some of the requirements. Compliance rates will be evaluated at the measure level.

Commercial Saturation Survey, Section C-1, HVAC_INC

http://energydataweb.com/cpucFiles/pdaDocs/1160/California%20Commercial%20Saturation%20Study_Appendices_Final.pdf

Observers recognize that the variation in compliance may be in part due to varying levels of enforcement. Also of note, many code requirements under the 2008 code were climate zone specific for changeouts. The study will therefore report the permit rate at the statewide level and by climate zone. However, sampling targets for the study were determined based on the targeted relative precision at the statewide level. The climate zone specific permit rates are therefore expected to be less precise than the statewide estimate.

- **Evaluate efficacy of HERS raters and if inspected jobs meet Title 24 requirements. Also, examine barriers and awareness of HERS raters on the code requirements and inspection processes. Identify knowledge gaps where training could help HERS raters to better impact compliance with Title 24 HVAC requirements.**

According to the CEC's HERS Regulatory Handbook, the California Home Energy Rating System (HERS) program was initially implemented to address issues of poorly-performed construction and equipment installations in residential applications. Enforcement of HERS inspections on existing residential projects for HVAC changeouts began in October of 2005 for certain field verification and diagnostic tests (FV&DT) in certain hot climate zones. Since then, FV&DT has expanded to all climate zones and to nonresidential for certain types of systems albeit the emphasis remains on residential projects⁸. Common FV&DT tests for existing systems include air flow, duct test and seal (DTS), and refrigerant charge measurement or (RCM). If/when there are new ducts additional tests include cooling coil airflow (CCA) and fan-watt draw (FWD).

These independent third-party home energy raters are believed to provide quality-assurance services that verify correct HVAC installation and assure excellent HVAC performance. Even though raters have an independent role and are expected to be neutral parties in the installation process, there may be shortcomings in their services due to outside influence from contractors, customers, and building departments - not to mention price pressure from competing raters (rater service fees are not regulated). As a result of these pressures, there is a concern that HERS rater may not perform evaluations with proper rigor and a HERS-certified project may not actually meet HERS requirements or achieve optimal measure performance. To address this concern, this study will:

- Determine whether HERS inspections on HVAC installations produce the intended outcome of a HERS-compliant residence by analyzing inputs from the HERS rater registry.

⁸ <http://www.energy.ca.gov/HERS/> (a small number of nonresidential projects require HERS testing depending upon the systems and ducting present).

- Assess reasons or barriers as to why HERS raters may not perform the work correctly or as thoroughly as necessary by identifying trends in the HERS registry data reviewed and surveys with HERS raters.

2.1 Relevant Code Changes and Policy Decisions

The following recent code changes and policy decisions are relevant to the research study:

Revisions to HERS Regulations

The CEC staff is currently exploring existing and newly identified issues under the Home Energy Raters System Order Instituting Information (OII) Proceeding# 12-1114-6. Commission staff anticipates a revision of the 2008 HERS Regulations through a formal rulemaking process under the Administrative Procedure Act during the 2015 to 2016 period⁹.

2013 Title 24, Section 6 Building Code Change - D#12-BSTD-01

Every three years the California Energy Commission (CEC) updates its Building Energy Efficiency Standards. The 2013 code change went into effect July 1, 2014. The 2013 Standards continue to improve upon the previous 2008 Standards for new construction of, and additions and alterations to, residential and nonresidential buildings.¹⁰ Researchers will exclude 2013 projects given small samples, the recent effective date of the current code and learning curve from both contractors and code officials to adopt the code. If the study encounters 2013 projects, through the data collection processes, these will be documented for future reference. The results of the study will therefore be an assessment of recent practice under the previous standard which we believe to be the appropriate methodology since it eliminates the influence of delayed uptake on the results and focuses more on the actions taken by market actors operating under a known code.

Senate Bill 454 ¹¹ (SB 454) (YR: 2011)¹²

SB 454 authorizes the CEC to assess civil or administrative penalties for violating California Energy Code efficiency appliance standards for manufacturers or sellers of appliances. It further prohibits (SEC. 7. Section 399.4, 2b) *“Any rebates or incentives provided by any public utility for energy efficiency improvements and installation of energy efficient components,*

⁹ http://www.energy.ca.gov/HERS/12-HERS-01/documents/2012-10-31_OII_12-HERS-01.pdf and http://www.energy.ca.gov/HERS/12-HERS-01/documents/comments/Second_Comments_from_Michael_E_Bachand_CalCERTS_2013-01-25_TN-69293.pdf

¹⁰ 2013 Title 24 Section 6 Code Changes: <http://www.energy.ca.gov/title24/2013standards/index.html>

¹¹ Senate Bill 454: http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0451-0500/sb_454_bill_20110216_introduced.pdf

¹² http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1918

equipment, or appliances in buildings shall be provided only if required building permits are obtained.” Currently, the enforcement and interpretation of the law varies by IOU program. Some IOU programs have not implemented any kind of permit requirement prior to payment (nonresidential Upstream rebate) while other programs may only require self-certification by homeowners or contractors to having pulled a permit (which maybe false), and some program may only require the permit be pulled (Quality Install) but never require proof of permit closure. The whole house retrofit programs allegedly required evidence, but appear to be substantially missing permit information in the job file¹³. The current study recognizes utility program requirements could have a role in increase permitting due to these loose requirements but the extent of this has not been evaluated for all programs and will not be an area of research for this study due to competing objectives.

2.2 Project Coordination and Data Sharing with Research Studies and IOU Programs

Research in the area of HVAC permitting and compliance has become increasingly important to policy makers and stakeholders. A number of activities are underway to understand what factors drive permitting and compliance barriers and to implement methods that would reduce those barriers

Currently there are several programs and studies being directed by the CPUC Energy Division, the CEC and IOUs. Table 1 lists pilot programs, rebate programs, and research studies that are possible sources of coordination, information and activities aimed at influencing permitting. DNV GL is open to directly accounting for non-IOU program impacts if the data associated with these programs is shared with the research team. However there would be limits on the direct application given the study period is focused on 2008 compliance.

¹³ Conversation with CEC, William (Bill) Pennington, response to Research Plan, 12/2/2014

Table 1: Overlapping Rebate, Pilot Programs, and Research Studies

Type	Program Name	Program Description	Potential Influence
Residential Pilot Program (Jan. 2014 – Ongoing)	IOU HVAC Code Compliance Incentive Program Pilot	The program provides incentives for HVAC distributors and homeowners to voluntarily participate in conjunction with contractors in the tracking of the sale, permitting and installation of residential HVAC change-outs in compliance with the 2013 Standards.	Given study’s focus on 2008 code project, no actual influence on results is expected. May influence future 2013 code permit and compliance rates and code officials’ and contractors’ knowledge of Title 24, permits, and compliance in the city implemented. Any study of 2013 code projects should directly account for participants claimed through the program (via data requests) but spillover effects could not be estimated. If the study performs a general population survey, to identify permit and compliance rates, it will be necessary to exclude customers touched by the program. As of late 2014 the programs were just launching we anticipate these will still be in their early development stages during the time customers are contacted (early to mid-2015). As the program matures the program expects permit rates to increase in areas influenced by the program (City & Co. of Fresno, the Coachella Valley, and the inland San Diego County) and may spillover to the surrounding jurisdictions that contractors touched by the program serve.
Pilot Program (2013- 2017)	Cool Comfort Financing – HVAC Permit Compliance Pilot sponsored by CEC and implemented by CCSE ¹⁴	The program will provide low interest financing for high efficiency HVAC equipment changeouts with assurance that permits are pulled and installations comply with Standards requirements. Financing is offered to 500 customers in the County of Los Angeles and throughout San Diego. The Compliance Pilot is also developing a best practices survey that contains input from 54 building departments in Southern California to streamline the permit process. And collaboration with building departments to reduce barriers that cause contractors to not comply with permit requirements, including the development of approaches to streamline permit processing and to encourage the establishment of online permitting systems.	May influence the permit and compliance rates and may influence code officials’ and contractor knowledge of the 2013 Title 24 code, permits, and compliance in the cities and counties where implemented. We can directly account for IOU programs but there will be uncertainly around non-IOU programs due to limited ability to collect information the program claims. May influence permit and compliance rates under the 2013 code, no impact under the 2008 code.

¹⁴ <http://energycenter.org/sites/default/files/docs/nav/buildings/contractors/cool-comfort/Cool%20Comfort%20Financing%20Webinar%20Slides%20BQ%26A%2011-5-13.pdf>

Type	Program Name	Program Description	Potential Influence
Pilot Program (Summer 2014 - Ongoing)	Ambassador Program	CSLB in collaboration with the Energy Commission plans a pilot program to encourage contractors to pull building permits and comply with Standards requirements. CSLB will provide incentives to homeowners, whose contractors did not pull permits for change-outs that are required after July 1, 2014 to comply, to cover the cost of HERS rater verification for those projects.	Given study's focus on 2008 code project, no actual influence on results is expected. However, future research activities should consider program accomplishments and activities.
Pilot Program (2013-2014)	BayREN PROP (Permit Resource Opportunity Program) ¹⁵	The program reached out to 109 BD and 17 choose to participate in the auditing process. Reviewing auditing code inspection (50-100 projects) and review processes for 17 local government BayREN members. Estimating compliance at 3 junctures – as submitted, approved and constructed. Recommendations will address compliance gaps, and best practices. Conducting a Code & Standards survey targeted to code officials. ¹⁶	Program is not expected to influence research results. Pilot focus is on new construction, not changeouts in existing buildings and is not isolated to HVAC but rather all measures. A Codes and Standards study completed in 2013 offers results that can be used to inform the HERS interview guides/surveys. A report will be out in the early 2015 The study does not disclose participants or building departments.
Rebate Program (Ongoing)	IOU's Upstream Distributor HVAC Rebate Program ¹⁷	Pays rebates to wholesale distributors for the sale of high efficiency HVAC products. Does not require evidence of a permit for rebated projects.	The program represents a significant share of units sold to the replacement market. Wholesale distributors participating in the program may be contacted to collect sales estimates. Permit rates for these program participants is relatively easy to study and the same market actors distribute a majority of the non-program units for commercial customers.
Financing Program through local governments and PACE	Home Energy Renovation Opportunity (HERO) Financing Program	Provides financing for home improvements, requires permits.	Provides residential and commercial financing for energy saving projects including HVAC replacements. May influence permit and compliance rates under the 2013 code, no impact under the 2008 code.

¹⁵ <https://www.bayren.org/>

¹⁶ BayREN Code & Standards Survey for Bay Area Code Officials: https://www.surveymonkey.com/s/BayREN_Energy_Code

¹⁷ Upstream Program from Program Implementer: <http://energy-solution.com/index.php/case-studies/upstream-hvac/>

Type	Program Name	Program Description	Potential Influence
Research Study (13/14 Evaluation Cycle)	IOU's (SCE Study Mgr.) HVAC Residential and Small Nonresidential Customer Decision-Making Study	Cross coordination—identify where HVAC replacements occur in the residential market. “Will identify the drivers behind QI/QM/high efficiency customer purchasing decision-making across various market sectors. Will identify how the benefits of HVAC industry standards based quality maintenance and installation, and equipment efficiency are perceived by market actors. Will identify market intervention strategies for increasing customer understanding of the QM/QI value proposition to increase their receptiveness to contractor QM/QI offerings and eventually proactively demand QM/QI.”	May influence sample size of known HVAC replacements in non-participant population and will inform QI/QM IOU residential impact programs.
Compliance Improvement (Ongoing) CPUC	Codes & Standards Compliance Improvement Sub-program	Program provides education, training, and other activities targeting building departments and other industry actors responsible for compliance with Building Energy Code and Appliance Standards requirements. Activities may include development of “best practices tools” and other infrastructure elements that serve multiple compliance improvement objectives. http://energycodeace.com/	The efforts are not focused solely on HVAC. Tools (http://energycodeace.com/), education and outreach includes support for building departments, energy consultants, contractors, the general public and other involved parties. Certain training modules are focused entirely on HVAC replacement issues.
Organizations (Ongoing)	Western HVAC Performance Alliance (WHPA)	Cross coordination - to keep informed of studies aimed at improving compliance and activities underway such as online permitting and batch permitting. Networking with market actors.	Will provide insight/feedback from stakeholders.

3. Detailed Scope of Work

This section provides DNV GL’s scope of work per task for addressing the Researchable Issues discussed above.

4. Estimate the HVAC Permitting Rate

The study will take two separate approaches to estimate the percent of projects permitted; using a bottom-up and top-down method. The bottom-up method has the advantage of providing specific information on permitting but has a disadvantage of potential responses bias. The top-down method has the advantage of eliminating response bias with the disadvantage of lack of detailed site-specific information. Both methods will extrapolate final results back to their

respective populations to estimate an overall permitting rate. For this study, the permitting rate in its simplest form is defined as:

$$\text{Permitting Rate} = \frac{\text{No. of Permits Completed}}{\text{No. of Permits Expected}}$$

4.1 Equipment Types Eligible for the Study

Developing a sample design that yields the most accurate reliable data in a cost-effective manner is critical to successful research efforts. This study will focus on the 2008 Standards for HVAC replacements in order to clearly assess permitting practices free from the complexities of new construction, renovation, and changes to the new code. Furthermore, performance based impact evaluation studies from 2006-08 and 2010-12 revealed single-family compliance rates were 120 percent better in the 06-08 cycle and 400 percent better in the 10-12 cycle for nonresidential low rise new construction.¹⁸ There is also the opinion that new construction compliance rates tend to be better because of the level of rigor employed through the plan review steps.

The study will not focus on new construction or additions. The study will capture permit practices for the following installations:

- Entirely new or completed replacement space conditioning systems and
- Altered space conditioning-systems.

There are numerous heating and cooling equipment types. The team anticipates encountering the following types in residential and nonresidential installations (this is not an exhaustive list):

- Central heating and cooling systems (gas, electric, or propane)
- Furnaces
- Heat pumps
- Single phase (residential) and three phase (commercial) packaged rooftop and split systems
- Water-sourced heat pumps & evaporative cooled air conditioning

¹⁸ California Investor Owned Utilities' Codes and Standards Program Evaluation for Program Years 2006 - 2008, available at (http://calmac.org/publications/Codes_Standards_Vol_III_FinalEvaluationReportUpdated_04122010.pdf)

Statewide Codes and Standards Program Impact Evaluation Report For Program Years 2010 -2012, available at http://calmac.org/publications/CS_Evaluation_Report_FINAL_10052014-2.pdf

4.2 Estimate the Permitting Rate using a Bottom-up Method

This approach is a complex undertaking due to the incomplete information on the total number of installations, the whereabouts of those installations, and the total number of permits issued. The general consensus is that the vast majority of installations are unpermitted even though permitting has been required since October 1, 2005.

The bottom-up method will estimate the permitting based on individual occurrences and then extrapolate those estimates back to the population. All alterations occurring January 1st 2010 through June 30th 2014 qualify for participation in the study. All of these replacements required a mechanical permit under the 2008 Title 24 Standards. On July 1, 2014, the 2013 Title 24 requirements took effect which significantly changed the permit requirements for HVAC replacements. Currently the plan excludes all projects governed by the 2013 code.

4.2.1 Data Collection Processes for the Bottom-up Method

For the bottom-up method, we will investigate individual permit records at the building department associated with each sample point and produce outcomes for each unit the study identifies within the RASS and CMST population. Researchers assigned to the task of independently investigating permits will be trained to ensure that assessments are performed systematically. There will be three possible dispositions for each search performed. These dispositions will include:

- Mechanical permit found
- Mechanical permit not found
- Inconclusive

The disposition “inconclusive” will be assigned only when there is not enough evidence to verify that a permit on record is associated with an HVAC replacement. The team anticipates that between 1 to 5% of building permit records will contain insufficient information to determine whether a permit on record is associated with an HVAC changeout. This is more likely to occur in applications that undergo a build out or retrofit where multiple permits are filed simultaneously. Records flagged as inconclusive will be reviewed in an attempt to resolve occurrences of this disposition. One additional reference could be used to resolve issues is the (residential) HERS registry. However, a project’s existence in the registry does not guarantee that a permit was also completed as some building departments may not actively support or check for HERS verification

The permit search process will begin with an online search using the local building departments online search engine (where they exist). Accela Citizen Access® is one online platform used by

building departments in California. If no online permit history is available, researchers will contact local building departments by telephone. In a recent permit investigation study managed by PG&E and performed by DNV GL, researchers found the majority of building departments were able to provide permit records either by email or by mail at a later date. Only a small sample of building departments in the Bay Area and in metropolitan Los Angeles required an in-person visit as data was stored only on microfiche or paper.

There are a number of pilot studies working with local governments to implement an online permitting system, one example is the “Green it Forward Imperial Valley Program” which aims to expand to other local governments and the SoCalREN is piloting a program in Huntington Beach. To ensure timely cooperation with BDs we will develop a permit official notification letter that outlines the purpose of the study. We will use the letter to authenticate the requests as needed.

4.2.2 Residential Sample for the Bottom-up Method

The initial residential recruitment sample will be based on information obtained on residential dwellings from study participants in the 2009 Residential Appliance Saturation Study (RASS)¹⁹ and if needed supplemented with general population customers. The RASS database is the best available data set for this study due to its size and its impact on the study’s cost. The RASS database reduces the cost of the study by providing researchers with a set of building stock known to have HVAC equipment with a high potential for a recent replacement. We therefore expect a higher incident rate of replacements leading to a lower study cost compared to using only the general population. For initial recruitment, we will target RASS-respondent homes with heating and/or cooling units nine years old or older in 2009.

Table 2 contains the age of main heating (all fuel types) and central cooling units from the RASS study²⁰ by electricity provider, excluding non-response, not applicable and master-metered electric service. Overall, 17,072 main heating and central air conditioning units in IOU service territory (excludes LADWP) were reported to be 9 -13 years, 14 to 30, or greater than 30 years old. We will use this sub-population of dwellings, from the three equipment age bins (9-13, 14-

¹⁹ The 2009 RASS study was implemented as a mail survey with an option for respondents to complete it online. The survey requested households to provide information on appliances, equipment, and general consumption patterns. Data collection was completed in early 2010.
<http://energy.ca.gov/appliances/rass/index.html>

²⁰ The RASS data set comes from IOU and LADWP customer accounts active in 2008. The final survey data set contained 24,464 individually-metered electric customers who responded to a mail or online survey. The sample strata included electric service provider, presence of electric heat and energy forecasting zone.

30 and 31+ years) as our initial residential recruitment population. The results from the homes recruited will be the basis for the residential bottom-up permit baseline. We anticipate some overlap of customers from the two categories of heating and cooling. The final recruitment population is therefore expected to be smaller than what is reflected in the table.

Table 2: RASS Data Un-weighted results on Age of Heating and Cooling Units by Electricity Provider

Main Heating System							
Electric Utility	LESS THAN 1 YR OLD	1-3 YRS	4-8 YRS	9-13 YRS	14-30 YRS	31 + YRS	Total
PG&E	229	868	1,592	1,133	1,900	846	6,568
SDG&E	121	414	758	540	1,062	494	3,389
SCE	344	1,373	2,065	1,405	2,582	1,332	9,101
LADWP	73	305	440	326	539	464	2,147
Total	767	2,960	4,855	3,404	6,083	3,136	21,205
Central Cooling							
Electric Utility	LESS THAN 1 YR OLD	1-3 YRS	4-8 YRS	9-13 YRS	14-30 YRS	31 + YRS	Total
PG&E	153	641	1,037	721	799	131	3,482
SDG&E	87	302	539	398	486	61	1,873
SCE	357	1,311	1,827	1,205	1,659	318	6,677
LADWP	73	278	374	246	312	66	1,349
Total	670	2,532	3,777	2,570	3,256	576	13,381

Table 3 contains the age of main heating units (all fuel types) by gas provider. The counts are non-weighted; exclude non-response, not applicable and master-metered electric service. Households with electric service provided by SCE and LADWP primarily overlap with SoCalGas.

Table 3: RASS Data Un-weighted results on Age of Heating Units by Gas Provider

Gas Utility	LESS THAN 1 YR OLD	1-3 YRS OLD	4-8 YRS OLD	9-13 YRS OLD	14-30 YRS OLD	OVER 30 YRS OLD	Total
PG&E	197	702	1,295	924	1,550	730	5,398
SDG&E	98	328	600	414	808	386	2,634
So Cal Gas	325	1315	2,062	1,474	2,499	1,310	8,985
Other	13	72	108	60	119	68	440
Total	633	2,417	4,065	2,872	4,976	2,494	17,457

Residential customers recruited for this research will be utilized to calculate the bottom-up permitting rate and to measure compliance. We will utilize a two stage recruitment strategy. The first stage of recruitment is a qualifier to screen down to only homes that have recently replaced their HVAC equipment. The second stage of recruitment is to secure an onsite visit to perform compliance testing. Researchers acknowledge the study may not attract participation or responsiveness to the survey among customers who previously hired an unlicensed contractor and as a result the bottom-up method could undercount these units. The study attempts to control for this by asking about a host of measures and avoid emphasizing HVAC only measures. To minimize respondent bias, we will not discuss the subject of permitting and compliance with respondents. To further minimize respondent bias, we will ask customers about a short list of energy-saving improvements made to their home. The main question for identifying a replacement occurrence will be:

Within the past five years (since 2010) have you completed renovations to your home that involved any of the following ...

- A. Added insulation?
- B. Replaced a central air conditioner or furnace?
- C. Replaced windows?
- D. Added a new central air conditioner or furnace?
- E. Purchased a new appliance?
- F. Purchased a new water heater?
- G. Completed a renovation or addition to your existing home?
- H. None of these.

Prior to fielding the survey, the team will consider editing or adding to the list other measures that may support other CPUC research objectives. If the respondent self-reports B or D we will ask a series of follow-up screening questions to understand if the new equipment was installed as part of an addition or renovation to the home and when the installation occurred. If the respondent passes all screening questions, we will later request their participation in an onsite inspection.

DNV GL will follow up with all interested respondents in the second phase of recruitment to schedule a visit for the code compliance review. We may also call non-interested respondents who replaced HVAC equipment to manage our sample frame. On-site scheduling will prioritize the most recent installations (still occurring before 7/1/2014) as much as is reasonably possible. To reduce bias and not compromise the study's results, any discussions with participants

regarding permitting will be completed only after the permit status has been independently verified and/or on-site compliance data collection has been completed.

During our onsite inspection, we will also ask respondents about the age of the unit removed. This information will be used to assess if there is any correlation between the age of the unit and the permitting rate.

We acknowledge that the usefulness of saturation study results may be affected by the age of the data and how knowledgeable are the respondents. Residential utility accounts were originally selected in 2008 to complete the 2009 study. If the data has a high rate of disconnected or wrong numbers, we may need to develop a separate sample of the general population.

If a general population sample is required, the age of the accounts will be taken into consideration. The team will prepare and distribute a sample methodology memo for the CPUC to approve. Sample from the RASS study will be exhausted before a general population is explored. The general population customers will be “supplemental”, (unless the RASS data does not produce any results) due to the time-intensive process of identifying a replacement since the effective lifetime of a residential unit is between twenty and thirty years, the assumed replacement rate is 3-5 percent per year, and considering a proportion of the population does not have central ducted systems and would not be qualified for the study.

4.2.3 Nonresidential Sample for the Bottom-up Method

A similar methodology for nonresidential customers will be applied. We will first leverage customers from the previously conducted saturation study (CMST). Unlike RASS, new units purchased in 2009-2013 (since January 2009) are identified in CMST. If there are any necessary additions to the sample, with CPUC’s approval we will either leverage CSS samples (262 CSS sites were labeled as new installations from 2010-2012 and 342 for 2009-2012), or use building department permit data, and/or select samples of small-to medium-sized businesses in each of the IOUs service territory. We will prepare a memo outlining the sampling methodology should additional sample be required.

The CMST study identified and collected whole building information on packaged or split units at or under 65kBtu (5-tons). The same concerns also apply to residential customers and their ability to accurately report the age of their unit.

shows the business types associated with the units identified through CMST. No participant recruitment is therefore required. The research team does not intend to make contact with these CMST participants unless information critical to the compliance analysis is deemed

necessary. The same concerns also apply to residential customers and their ability to accurately report the age of their unit.

The table also documents the poor quality of information collected using a telephone survey of nonresidential participants when trying to identify the presence of newly replaced units. As illustrated in the column “Total Sites with New HVAC” and “Sites with new HVAC (HVAC not ID’d on Phone Survey)” a total of 197 sites were identified as having new HVAC units. Of which, 78 or 40 percent were not identified through the telephone screening process that was intended to capture this information, but rather identified when the onsite data was collected for the whole building analysis. This information indicates only 60 percent of the respondents with a new unit correctly reported that a new unit was installed; should the current study telephone another population of nonresidential customers such those in the CSS study or the general population we may find similar discrepancies among end-users self-reported information on system replacement. The same concerns also apply to residential customers and their ability to accurately report the age of their unit.

Table 4: HVAC Sample Leveraged from CMST Study²¹

Business type	Recruited CMST-HVAC Sites	Phone Survey CMST-HVAC On-Sites Completed	Phone Survey CMST-HVAC Recruits & Onsite HVAC Found	Share of Phone Survey CMST-HVACs Sites Found HVAC Onsite	Sites with new HVAC (HVAC not ID’ d on Phone Survey)	Total sites with new HVAC
College	2	0	0	0%	1	1
Food/Liquor	26	15	6	40%	7	13
Health/Medical Clinic	31	18	11	61%	10	21
Health/Medical - Hospital	6	1	1	100%	0	1
Hotel	8	5	3	60%	0	3
Industrial	16	8	4	50%	1	5
Miscellaneous	96	47	20	43%	12	32
Office	83	57	23	40%	11	34
Restaurant	27	14	8	57%	5	13
Retail	36	22	13	59%	12	25

²¹ Commercial Market share Tracking, Prepared by Itron Final Report 18 July 2014, Table 8-2: CMST HVAC On-site Distribution by Business Type*, Section 8-4, [http://energydataweb.com/cpucFiles/pdaDocs/1158/California%20Commercial%20Market%20Share%20Tracking%20Study_Report%20and%20Appendices_Final%20\(1\).pdf](http://energydataweb.com/cpucFiles/pdaDocs/1158/California%20Commercial%20Market%20Share%20Tracking%20Study_Report%20and%20Appendices_Final%20(1).pdf)

Business type	Recruited CMST-HVAC Sites	Phone Survey CMST-HVAC On-Sites Completed	Phone Survey CMST-HVAC Recruits & Onsite HVAC Found	Share of Phone Survey CMST-HVACs Sites Found HVAC Onsite	Sites with new HVAC (HVAC not ID'd on Phone Survey)	Total sites with new HVAC
School	61	37	21	57%	9	30
Warehouse	30	19	9	47%	10	19
Total	422	243	119	49%	78	197

4.2.4 Extrapolation Bottom-up Results to the Population

RASS participants have an unknown number of units replaced while participants of the CMST study have at least 145 eligible units. The final results will be extrapolated back to their respective populations, using case weights from the original sample design, to estimate a permitting rate. We will provide a sample extrapolation memo to the CPUC documenting our suggested extrapolation procedure and sample point weights once the final data set is acquired.

The extrapolation process will create some challenges, some of which are yet to be identified. These challenges and their proposed resolution will be discussed at length with the Energy Division and its stakeholders. Identified extrapolation challenges include the following:

- The characteristics that determined each premise’s 2007 strata and weights will have changed for many of the participants. New weights may need to be developed to account for these changes
- Many RASS participants have moved
- Current occupants and renters may not know what is the change out status of a unit

The team will consult with DNV GL statisticians that specialize in sampling and survey research to recommend the best way to address these challenges to the Energy Division and the IOUs. In particular, the team has access to Dr. Miriam Goldberg. Dr. Goldberg developed the sample design that was utilized in the 2009 RASS and is a leading authority in sampling and statistical analyses in the energy industry.

The permitting rate estimated using this bottom-up methodology is limited as the estimates will only represent replacements within the territories served by the IOU’s that participated on the saturation studies: PG&E, SCE, SDG&E and SCG, not all replacements statewide. It will not

represent the population of customers that are served by Energy Load Service Entities (LSE) or Publicly Owned Utilities (POU)²². Additionally, not all IOUs²³ will be represented. The following IOU-owned providers will be excluded: (PacifiCorp, Bear Valley Electric Service, and Liberty Energy). As previously noted some LADWP customers may be captured in the study if the furnace was recently replaced and if SCG is the service provider. Given the anticipated low frequency of these replacements the study will not aim to extrapolate permit rates in LADWPs service territory.

4.3 Estimating the Permit Baseline using a Top-Down Method

The top-down method will estimate the total number of HVAC permits issued by building departments and then compare the estimate to an estimate of the total number of units sold in the state to applicable projects and/or by using a replacement model. The top-down method results in a less granular permitting rate estimate but has the advantage of eliminating response bias. Unlike the bottom-up method, the top-down method will represent unit sales and permit activity occurring statewide. The building departments researched will not be limited to the IOUs. This method will estimate the total number of HVAC permits pulled during a particular time period such as 2014 and then extrapolated to the California population.

4.4 Estimating the Number of Permits Issued

DNV GL intends to purchase HVAC changeout permit data from the California Homebuilding Foundation (CHB) Construction Industry Research Board (CIRB) as a source to estimate the number of permits issued. This data does contain some known limitations, many building departments are missing and the data relies on local jurisdictions reporting which may lack in uniform definition for changeouts, but is believed to be the consistent source of statewide permitting activity that is readily available.

4.4.1 HVAC Permit Data

Since January 2014, the California Homebuilding Foundation (CHB) Construction Industry Research Board (CIRB) has been attempting to collect HVAC changeout permit activity from all 536 building departments. CHB|CIRB data can be purchased monthly and represents permit activity for residential and nonresidential construction statewide. CHB|CIRB began collecting

²²Electric Utility Service Areas:

http://www.energy.ca.gov/maps/serviceareas/electric_service_areas.html;

²³ Electric Load Service Entities: <http://energyalmanac.ca.gov/electricity/utilities.html>

the data as a result of request from their clients for HVAC changeouts and photovoltaic installations which both require permits. One known limitation of the data is the reports do not separate residential from nonresidential construction and permit issuance totals reported by CHB|CIRB do not distinguish between filed vs. final and only reflect filed status.

Although permit activity is requested statewide, not all BDs are reporting to CHB|CIRB; 37 percent of the BDs did not report any HVAC changeout permits from January through August 2014. While there is imperfect information, (namely, not all BDs are reporting, and the reports lack in granularity by building type) the data collection performed by CHB|CIRB is respected due to their extensive effort in parsing out the reports from building departments that lack uniformity. Additionally, CHB|CIRB has gained cooperation and follow-through to routinely obtain this data from BDs which is otherwise considered a significant barrier. Lastly, the research will need to account for the non-reporting BDs by either scaling the permitting numbers up to the entire state or the installation numbers down to the specific set of departments reporting.

DNV GL purchased a custom CHB|CIRB report to improve our understanding of the data recorded and assess its use for this study. From January through August of 2014 only 19,052 changeout permits were pulled and CHB|CIRB reported a significant drop (~700) in July 2014 when the 2013 code went into effect. By organizing the CHB|CIRB permit data by the greatest number of permits issued, we found the City of Sacramento contained the highest number of permits throughout the state (6% of the total population for this period). The Sacramento Municipal Utility District has taken considerable effort to ensure HVAC units in their service territory are permitted; for example, they require evidence of finalized permits to be submitted for units eligible for their rebate program²⁴. Another city served by a municipal, Modesto Irrigation District (MID) had the second-highest permit activity for HVAC changeouts²⁵. MID also requires rebated units to have permits.

If there are compelling arguments presented to not use CHB|CIRB data due to limitation concerns or other reasons then the research team will sample building departments to acquire our own data. Most likely the team will sample the 37% of building departments that are not reporting to CIRB due to duplicity and cooperation barriers. For this scenario we will target BDs

²⁴ <https://www.smud.org/en/residential/save-energy/rebates-incentives-financing/documents/HVAC-Heatpump-Rebate-Application.pdf>

²⁵ http://www.mid.org/rebates/home/documents/HomeApplication_002.pdf

with the largest populations and use a 90/10 sampling precision calculator. The research team will solicit support from the CEC with the expectation their support will improve response rates.

4.4.2 Permit Status Filed vs. Final

An additional area of interest for the study is to assess the rate at which filed permits reach the quality and final inspection process. Since October 1, 2005, the issuance of a permit is required for HVAC replacement or new installations in residential settings. Also required is an independent assessment by a certified Home Energy Rating System (HERS) rater to verify the quality of the installation. Once a permit is issued, an inspection must be scheduled and completed as the final stage in the permit approval process. According to building inspectors, permits often fail to reach final stage for approval when customers responsible for arranging the final inspection fail to do so. Where possible, we will collect data on the status of the permit (filed vs. final). However, there are uncertainties surrounding the task of parsing out filed vs. final permits. Not all building departments retain incomplete permits, and the retention period varies between jurisdictions. Additionally, the team does not know how detailed the permit data records will be; in some cases it may not be possible to distinguish between finalized and incomplete permits. For residential projects, the status of a completed HERS submission in the registry will be a source of comparison and a proxy for a finalized permit. But since there are limited HERS requirements for nonresidential projects this cross comparison will not be a viable option. One additional compliance problem is some building departments do not actively support HERS verification. Through HERS rater interviews the research aims to identify and measure the extent of this problem. As previously noted, several building departments in the State are in the process of adopting an online permit system.

4.5 Estimating the Number of Units Sold

DNV GL will review multiple data sources and develop multiple estimates of the units sold to applicable projects in the state. None of the sources are expected to provide perfect information and therefore cannot be expected to provide a perfect estimate. The final estimate of statewide sales is expected to be based on the estimates from each data source. DNV GL will document its methodology for determining the final estimate in a memo to the Energy Division. The initial data sources that will be investigated for use in this study are public data from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) and shipment data the Institute of Heating and Air Conditioning Industries (IHACI). In addition to estimating the number of units sold based on industry sales data, DNV GL will consider an estimate from a stock replacement

model that estimates the number of equipment alterations that are occurring in the state each year.

One alternative the team did investigate was obtaining shipment data from the Heating Air Conditioning Refrigeration Distributors International + D&R (HARDI). Due to the limited ability to represent the wholesale market, the high cost of purchase, and the effort and negotiation necessary to obtain the exact data desired, the team decided against the use of HARDI data.

4.5.1 Optional Wholesale HVAC Distributor Interviews

If the estimate of statewide sales from the initial data reviewed is determined to be inadequate, the research team may interview all distributors participating in the 2013-14 HVAC Upstream program and solicit input from non-participant distributors as well. However, based on recent attempts to collect sales data from non-participating Upstream distributors we anticipate cooperation would be very limited. This activity is currently not budgeted for and will only be completed after approval is provided. The information gathered through these interviews would be used to refine the initial statewide sales estimates.

While there are recognized drawbacks with the top-down methods outlined here; the evaluation team believes that this approach is more robust and less susceptible to selection bias than the bottom-up method. We also believe this approach allows development of a more defensible estimate of total permit counts.

4.5.2 Optional Preliminary Assessment of Online Market Sales

The evaluation team assumes that nearly all HVAC equipment sales in California occur through wholesale distributors. However, some brands (Amana, GE, Goodman, etc.) and sellers offer central system products for purchase online. There are two online market channels - sales of new units from online retailers such as the “The AC Outlet” and sales of used units through online community websites such as Craig’s List® or eBay®. One question to be researched is the volume of online sales for new or second-hand units. The research team may develop a limited preliminary assessment to understand the scope of new and second-hand equipment sold through Craig’s List. The decision to explore this area of research will be dependent upon sources used to estimate overall sales of the market. If the study relies on AHRI data or a stock replacement model then this area of research will be necessary.

We anticipate that the community websites, particularly Craig’s List, will likely offer used equipment and this equipment will not meet minimum efficiency requirements. The actual presence of these sales has already been verified but the frequency has not. We may develop a

framework to capture sales of units through secondary market newsfeeds that will inform the scope. However, it should be noted that the newsfeeds collected will not confirm if a sale occurred, only that equipment has been offered. The method will also fail to capture sales that occur via personal referral or other methods. We will write a newsfeed script in Outlook for Craig's list postings to track sales for a limited period of time. Once the overall volume of postings is assessed we will report back to the CPUC to determine if a more robust effort is required.

4.6 Analysis of Permit Data & Tables Planned for Reporting

Multiple data points will be included to inform the number of permits (numerator) and number of HVAC changeouts (denominator) in the top-down and bottom-up permit rate calculations. The current best estimates of the number of HVAC change-outs are based on the latest saturation studies that indicated three to five percent replacement rate - for residential and five to nine percent for nonresidential depending on utility. This estimate is based on AHRI's year-to-date shipments and what proportion reaches California's market (the CMST study assumed 10 percent of all sales). The calculations from this study will also need to account for a variety of factors such as:

- A representative population,
- Unit type and sizes examined under the study when extrapolating back to the population,
- Type of units that require a permit (the study may not capture all through the bottom-up sample),
- Nonresidential units that are exempt from a local building department permit processes (e.g. government buildings and public schools),
- Total number of units sold for new construction projects,
- Estimated purchases from wholesale distributors – the markets they serve and their service territories,
- Estimated secondary market sales that do not go through wholesale distributors in California and “off-the-truck” used market sales (that are likely illegal),
- Estimated number of permits filed by non-reporting/non-responsive building departments,
- Estimated unit sales by climate zone and by IOUs (for reporting benefit).

We expect to produce the following permit rate estimates for the top-down and/or bottom-up calculations. Total estimate using a top-down method:

- Total estimate using a bottom-up method for both residential and nonresidential, and
- Total estimate using a bottom-up method at a regional or CZ level.

The results will estimate permit rates at a regional level using the bottom-up methodology for both residential RASS and nonresidential CMST sample sources. The geographic regions, the study will report is displayed in **Error! Reference source not found.** (residential) and Table 6 (nonresidential). The climate zone regions clusters are consistent with the 2010-12 Statewide Codes and Standards (C&S) study²⁶. The sample sizes by region are study variables; the estimates as shown were based upon the C&S percent of new construction by region. The coefficient of variation (CV) for permit rates is assumed as 0.5 due to building department variation not climate conditions. Due to small populations the study does not anticipate a sample for changeouts in CZ16.

Table 5: Distribution of Sample by Climate Region & Bottom-up Permit Rate, Residential

Ref.	Climate Region	CEC Climate Zones (s)	Sample Size	Estimated 90% CI Precision
A	North / Central Coastal	1, 2, 3, 5	42	13%
B	South Coastal	6, 7, 8, 9, 10	98	8%
C	Central Valley	4, 11, 12, 13	46	12%
D	Desert	14, 15	14	22%
E	Mountains	16	0	N/A
Total			200	

Table 6: Distribution of Sample by Climate Region & Bottom-up Permit Rate, Nonresidential

Ref.	Climate Region	CEC Climate Zones (s)	Sample Size	Estimated 90% CI Precision
A	North / Central Coastal	1, 2, 3, 5	30	15%
B	South Coastal	6, 7, 8, 9, 10	70	10%
C	Central Valley	4, 11, 12, 13	34	14%
D	Desert	14, 15	11	25%
E	Mountains	16	0	N/A
Total			145	

The results will compare the final permit rate based on the two methodologies (top-down and bottom-up). Table 7 displays the format we will present the information for the two methods.

²⁶ http://calmac.org/publications/CS_Evaluation_Report_FINAL_10052014-2.pdf; Section: Gross Savings and Compliance, Table 28, pg. 40

Table 7: Distribution of Sample by Permitting Rate Methodology

Top-down Rate	Top-down Precision 90% CI	Bottom-up Rate	Bottom-up Precision 90% CI
%	N/A	%	10%

Table 8 will require assumptions to generate a top-down permit rate by sector and will be most accurate overall. The top-down rate will be an estimate with unknown precision while the bottom –up rate will have a precision based on the sample for residential and nonresidential.

Table 8: Distribution of Sample by Building Type & by Estimated Top-Down Permit Rate

Building Type	Top-down Rate	Bottom-up Rate	Estimated 90% CI Precision
Residential	% **	%	10%*
Nonresidential	% **	%	10%*
Total	%	%	10%

**Assumptions will be built in to make these estimates.

Table 9 displays the total number of permits issued versus the number finalized through HERS. The study will compare the total number of permits issued to the total number of permits in the HERS registry. This table is intended to be residential only, but we will work with the HERS registry owners to identify if their database tracks the limited share of nonresidential projects that go into the registry. We will produce similar tables that provide baseline information such as: the estimated number of units sold according to AHRI vs. the total number of units purchased according to wholesale distributors. And the total number of statewide permits issued and number of permits by climate zone regions.

Table 9: Estimated number of Residential Permits in HERS Registry vs. Total Number of Permits Pulled, % of Final Permits

Total Submittals in HERS Registry	Total No. of Permits Pulled	% of Permits Final
#	#	%

4.6.1.1 Key Activities and Deliverables:

Key activities and deliverables associated with estimating the HVAC permit baseline includes the following:

- Acquire data sources for consideration in the study CMST/CSS, RASS data
 - Acquire reports estimating total sales volume and parse out sales for California and numerous variables, AHRI, DOE data and/or IHACI.
 - Acquire permit counts from CHB|CIRB data and directly from building departments.
 - Acquire HERS registry data to compare permit totals and compliance results.
 - Pending approval, acquire general population residential and IOU data on small/medium size commercial customers
-
- Acquire current estimate of statewide utility customers

4.6.1.2 Develop Sample Frame and Telephone Surveys (if required)

- Develop sample design methodology memo
- Apply sample design to the populations (residential and nonresidential)
- Draft and finalize customer surveys
- Conduct customer surveys on an ongoing basis to identify replacements
- Draft and finalize Permit Official notification letter

Deliverables:

- Non-participant sample design methodology memo
- Customer identification of HVAC replacement survey
- Results from individual permit sources.

4.6.1.3 Conduct CATI Surveys to Identify HVAC Replacements

- Coordinate with CATI vendor to implement sample and surveys
- Conduct CATI surveys
- Weekly data extract of identified replacements
- Monitoring of progress

4.6.1.4 Conduct Permit Search

Permit data, or the absence thereof, for projects in the sample will be used to determine the frequency of permitting. Only sites where a known HVAC replacement occurred will be used to develop the permit rate. Researchers will be trained on the process and will conduct permit searches for all populations.

4.6.1.5 Permit Search Analysis and Reporting

We will summarize and report permit rates using a bottom-up and top-down methodology.

5. Determine Rate of Compliant Units

Studies have shown that the success of energy saving depends not only on a stringent code but also on robust code enforcement and its rate of compliance. Effective code compliance and code enforcement helps achieve all intended energy savings, reduces operating costs, and increases building resale value and healthy built environment with minimum impact on the environment. The objective of task is to investigate compliance separate from permitting. This involves determining; 1) if non-permitted installations meet the Title 24 HVAC code requirements; and 2) if permitted installations meet the Title 24 HVAC code requirements; for both residential and nonresidential HVAC replacement changeouts.

A compliance evaluation refers to a set of processes and procedures where information is provided, assessed, and checked to determine whether mechanical systems effectively meet applicable energy code requirements. This compliance assessment will consist of onsite inspections and testing to determine if Title 24 mandatory and prescriptive requirements were met for the inspected unit. The assessment will also entail onsite inspections of equipment nameplates to determine if code-compliant equipment was installed, as well as a review of HERS rater compliance test results (where available). Researchers will rate compliance based on field observations and test results. Where applicable, researchers will compare onsite data to HERS compliance forms.

While it may appear on the surface that compliance is an either/or determination, in reality, it is complex. A changeout unit can be viewed as fully, partially, or not compliant. Full compliance is indicated when all requirements are met, partial compliance when some are met, and not compliant is when none are met, e.g. second hand unit.

Researchers will produce a memo on the compliance analysis methodology and share methods with stakeholders. Currently we plan to estimate compliance rates for each verifiable mandatory and prescriptive measure. A method will be required to combine the measure level compliance into an overall compliance rate that accounts for partial compliance. This effort can also be used to determine the potential energy impact of the estimated level of compliance. We plan to use the DEER (Database for Energy Efficient Resources) existing construction prototype model input with field collected data to establish the measure-weights that can be assigned to the prescriptive and mandatory measures to develop a single partial compliance rate. The DEER prototype approach is both cost effective and beneficial to estimate IOU program impacts targeted toward HVAC compliance and installation. Additionally, we will collect whole building level data on a small sample of homes (10) providing researchers the ability to develop a site-specific energy model and efficiency estimate accounting for interactive effects of measures.

We will also provide analyses of performance metrics for measures with a numerical target such as duct leakage tests.

The following section describes the verifiable mandatory and prescriptive measures for Title 24 HVAC installations. We will indicate whether measures are:

- **(VO)** Verifiable onsite or through data collected onsite,
- **(NV)** Not verifiable given the limitations of this study rigor, or
- **(VTN)** Verifiable through nameplate

5.1 California Energy Code Requirements

California Energy Code sets requirements that are dependent on the type of HVAC system components installed in existing buildings. These requirements for low-rise residential buildings are specified in sections 152(a) and (b) of the 2008 Standards. The requirements can be categorized into the following:

- HVAC installations in alterations to existing buildings (within study scope)
- HVAC installations in additions to existing buildings (out of study scope)

Mandatory requirements are requirements that must be met in every project no matter which compliance path is chosen. Prescriptive requirements are requirements that either must be met by every project, or if the requirement is not met, a tradeoff must be made to “make up” for not meeting that requirement. The space-conditioning systems of all nonresidential, shall be designed, constructed and installed in accordance with either: (a) Performance approach—to use no more time dependent valuation energy from depletable sources than the energy budget, calculated or (b) Prescriptive approach—in accordance with all the applicable requirements.

5.2 2008 Title 24 Residential Measures²⁷

Mandatory Requirements

There are mandatory requirements that apply to any equipment that is installed – these are requirements are stated in Sections 111 and 112(b) and (c), and Section 150(h), 150(i), 150(j)² of the Standards. Mandatory requirements that are solely about equipment efficiency certification are stated in Sections 112(b) and (c), 120, 121, 122, 123, 124, 125, 128, and 129 additional detail that goes beyond the efficiency requirements given are in Sections 110-111.

- **(VTN)** Certification by Manufacturers- HVAC equipment must be certified by the manufacturer to meet specific efficiency requirements. (Section 112). They must comply with

²⁷ 2008 Building Energy Efficiency Standards: Residential Compliance Manual, August 2009, California Energy Commission

applicable federal and industry efficiency certifications and ratings requirements that are adopted by the Title 24 Standards.

- **(VO)** Thermostats – All unitary heating and/or cooling systems that are not controlled by a central energy management control system shall have a setback thermostat. Heating systems shall be equipped with thermostats that meet the setback thermostat requirements of Section 112(c). All thermostats shall have a clock mechanism that allows the building occupant to program the temperature points for at least 24 hour period. Some exceptions apply examples include: non-central electric heaters, decorative gas appliances, stoves, room air conditioner; etc.
- **(VO)** Building cooling and heating loads - must be calculated in accordance with a method based on any one of the following ASHRAE Handbook, SMACNA Res. Manual, or ACCA Manual J. The cooling and heating loads are two of the criteria that shall be used for equipment sizing and selection. Section 150(h)1 requires that the heating and cooling loads be determined but does not require submittal of the load calculations to enforcement agencies, and does not specify an equipment sizing method that would use the load calculations. Section 150(h)2 requires design conditions for load calculation that may differ from the design conditions given in the ASHRAE, ACCA, and SMACNA methods²⁸.
- **(VO)** Cooling system line insulation- Section 150(j)2 –cooling system lines shall be thermally insulated. The insulation shall have a minimum thickness as calculated by Equation 150-A.
- **(VO)** Unless ducts are enclosed entirely in conditioned space, the minimum allowed duct insulation value is R-4.2.
- **(VO)** Installer must ensure that indoor air quality and mechanical ventilation requirements are met. Minimum airflow rate of 300 cfm per nominal ton is required for the refrigerant charge verification procedure. Minimum airflow rate of 300 cfm per nominal ton is required for the refrigerant charge verification procedure. HERs verification of refrigerant charge was required (both for newly constructed buildings and for alterations to existing buildings) only in CZ 2, and CZ's 8-15. Verifying mechanical ventilation compliance, other than to attempt to show that ventilation occurs through the introduction of outside air, is beyond the scope of this study.

²⁸ Standards Section 144(b) requires heating and cooling system design loads to be determined in accordance with the procedures described in the ASHRAE Handbook, Fundamentals Volume, or as specified in a method approved by the Commission. Indoor design temperature and humidity conditions for general comfort applications shall be determined in accordance with ASHRAE Standard 55 or the ASHRAE Handbook, Fundamentals Volume, Chapter 8, except that winter humidification and summer dehumidification shall not be required. Outdoor design conditions shall be selected from Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X. Heating design temperatures shall be no lower than the Heating Winter Median of Extremes values. Cooling design temperatures shall be no greater than the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

Prescriptive Approach

Prescriptive approach – must meet each of the applicable requirements in Sections 150.2(b)1C, D, E, F of the 2008 Energy Code.

For some requirements described in this section the following limitation clause applies: “*The requirement is applicable only to newly constructed buildings, and to completely new or replacement HVAC systems where all components of the system, including all ducts, are replaced in altered existing buildings.*”

- **(VO)** According to the standards proper refrigerant charge must be confirmed through field verification (HERS) and diagnostic testing in accordance with procedures set forth in the Reference Residential Appendix RA3.2 or have a Charge Indicator Display. A HERS rater must verify that split system air conditioners and heat pumps have the correct refrigerant charge. HERS verification of refrigerant charge was required (both for newly constructed buildings and for alterations to existing buildings) only in CZ 2, and CZ's 8-15. Minimum airflow rate of 300 cfm per nominal ton is required for the refrigerant charge verification procedure.
 - There are two methods to test refrigerant charge one is referred to as “*refrigerant charge diagnostic testing*” the other is “*weigh-in*” testing. Factory shipped residential HVAC units do not contain refrigerant charge. The R-410A refrigerant is installed at the installation. To verify proper refrigerant, the Title 24 approved method is to perform refrigerant charge diagnostic testing, which is an indirect assessment of charge amount. Only C-20 contractors can use the more rigorous weigh-in approach to specifically assess the amount of refrigerant present and compare that to manufacturer specifications for the unit based on length of lines between the condenser and evaporator. This method cannot be used by HERS raters to verify compliance. However the weigh-in method is considered the most accurate. Because of the cost, process, and risk of damage to the unit or contamination or accidental release of the refrigerant, field staff will limit the number of units with the weigh-in testing to approximately 10 for the entire study. The refrigerant charge diagnostic testing will occur in climate zones 2 and 8-15.
- **(VO)** The installer must provide Temperature Measurement Access Holes (TMAH) Saturation Temperature Measurement Sensor (STMS) or Permanent Install Static Pressure Probe (PSPP)-(CZ 10-15) in the plenum on either side of the evaporator coil to allow non-intrusive measurement of supply and return air temperature and humidity. (The above limitation clause applies to this requirement.)
- **(VO)** A Charge Indicator Display (CID) may be used as an alternative to the refrigerant charge requirement, provided it is verified by a HERS rater.
- **(VO)** (CZ 10-15) Central forced air cooling system fans must maintain airflow greater than 350 CFM per nominal ton of cooling capacity. (The above limitation clause applies to this requirement.)

- **(VO)** (CZ 10-15) Central forced air cooling system fans must have a supply fan watt draw of less than 0.58W per measured CFM. (The above limitation clause applies to this requirement.)
- **(VO)** (CZ 10-15) The installer must provide either a hole in the supply plenum for the placement of a static pressure probe or a permanently-installed static pressure probe. The installer must provide either a hole in the supply plenum for the placement of a static pressure probe or a permanently-installed static pressure probe. (The above limitation clause applies to this requirement.)
- **(VO)** Depending on Climate Zone, duct insulation must have a minimum R-value from 4.2 to 8.0.
- **(VO)** (CZ 2, 9-16) If the replacement or installation involved the replacement or addition of more than 40 feet of ductwork in unconditioned space, the ducts must be tested and sealed so that leakage is no more than 15% of nominal system airflow. However, if the entire duct system is replaced, it must meet the same 6% leakage requirement as new construction. The option to seal the ducts to no more than 15% of nominal system airflow is only one of four possible choices that a contractor can choose to show compliance. The compliance documentation (if it exists) will show which option the contractor chose. Any option is completely satisfactory for showing compliance.
- **(VO)** (CZ 2, 9-16) when a space-conditioning system is altered by the installation or replacement of space-conditioning equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, cooling or heating coil, or the furnace heat exchanger) the duct system that is connected to the new or replacement space-conditioning equipment shall be sealed, as confirmed through field verification and diagnostic testing. Targets for compliance: 15% total pressurization, or 10% leakage to outside, or 60% measured improvement, or compliance using smoke test and sealing all accessible leaks. Section 152(b)E

Additional Requirements:

Entirely new or replacement space-conditioning systems - (all HVAC equipment and ducts replaced) – installed as part of an alteration, shall include all the system heating or cooling equipment (e.g. condensing unit and cooling or heating coil for split systems; or complete replacement of a package unit); plus entirely new or replacement duct system (Section 150.2(b)1Diia); plus a new or replacement air handler²⁹. Meet the requirements of Sections 150(h) (load calculations), 150(i) (thermostat), 150(j)2 (cooling line insulation), 151(f)7 (refrigerant charge in some climate zones depending on package chosen – refrigerant charge

²⁹ <http://energycodeace.com/site/custom/public/reference-ace-2013/index.html#!Documents/section1502energyefficiencystandardsforadditionsandalterationsin.htm>

testing requires minimum 300 CFM airflow; airflow at minimum 350 CFM and fan watt draw and static pressure probes in fewer climate zones depending on package chosen .)_

Altered space conditioning – mechanical cooling (commonly termed “changeout”) – install setback thermostat, meet refrigerant charge requirements in 151(f)7 climate zones, including minimum 300 CFM airflow for refrigerant charge testing in those CZs (minimum 350 CFM airflow and fan watt draw and static pressure probes not required in any CZ).

Altered space conditioning – duct sealing

- *Entirely new duct system* – meet applicable requirements of section 150(m) and duct insulation requirements of section 151(f)(10), in specific climate zones duct leakage less than 6 % of system fan flow and minimum 300 CFM airflow
- *Altered duct system* (40 feet or more of replaced ducts) – meet applicable requirements of section 150(m) and in certain climate zones, meet one of 4 choices for duct sealing (see the compliance documentation to determine what choice to be met) (no airflow requirements)
- *Altered mechanical equipment* (commonly termed “changeout”) – meet one of 4 choices for duct sealing (see the compliance documentation to determine what choice to be met) (no airflow requirements if just heating system alteration)
- *Ventilation* – no ventilation requirements apply to installation of residential HVAC equipment except in the unusual case that the central HVAC system is designed to provide ventilation subject to section 151(f)(11).

5.3 2008 Title 24 Nonresidential Measures

- **(VO)** - verifiable onsite or through data collected onsite,
- **(NV)** - not verifiable given the limitations of this study rigor, or
- **(VTN)** - verifiable through nameplate

Nonresidential Mandatory Measures

- **(VTN)** HVAC equipment must meet efficiency requirements and must be certified by the California Energy Commission. Most of the 2008 mandatory measure requirements are met by using equipment with CEC certification³⁰ and are not discussed further.
- **(NV)** Installer must ensure that indoor air quality and mechanical ventilation requirements are met. Verifying mechanical ventilation compliance, other than to attempt to show that ventilation occurs through the introduction of outside air, is beyond the scope of this study.

³⁰ CEC Appliance Efficiency Database: <http://www.energy.ca.gov/appliances/database/>

- **(VO)** Thermostatic controls must be provided and must have the following characteristics:
 - When used to control heating, the thermostatic control must be adjustable down to 55°F or lower.
 - When used to control cooling, the thermostatic control must be adjustable up to 85°F or higher.
 - When used to control both heating and cooling, the thermostatic control must be adjustable from 55°F to 85°F and also provide a temperature range or dead band of at least 5°F. When the space temperature is within the dead band, heating and cooling energy must be shut off or reduced to a minimum. (A dead band is not required if the thermostat requires a manual changeover between the heating and cooling modes.)
- **(VO)** Most piping that conveys either mechanically heated or chilled fluids for space conditioning must be insulated in accordance with §123.
- **(VO)** Portions of duct systems that are outdoors or are enclosed in unconditioned space must be insulated. The minimum allowed duct insulation value is R-8.0.
- **(VO)** Portions of supply-air ducts ductwork that are in indirectly conditioned space shall be insulated to a minimum installed level of R-4.2 (or any higher level required by CMC Section 605).
- Insulation is not required for portions of duct enclosed in directly conditioned space.

Nonresidential Prescriptive Measures

- **(VO)** The Standards require that mechanical heating and cooling equipment (including electric heaters and boilers) is the smallest size available, within the available options of the desired equipment line that meets the design heating and cooling loads of the building or spaces being served. The heating and cooling system design loads must be calculated in accordance with the procedures described in the ASHRAE Handbook, Fundamentals Volume, Chapter 30, and Table 1. Other load calculation methods, e.g. ACCA, SMACNA, etc., are acceptable provided that the method is ASHRAE-based.
- **(VO)** Maximum fan power is regulated in individual fan systems where the total power of the supply, return and exhaust fans within the fan system exceed 25 bhp at design conditions. For fan systems exceeding 25hp, the total fan power index at design conditions shall not exceed 0.8 W/CFM of supply air for a constant velocity fan system and 1.25 W/CFM for a Variable Air Volume system.
- **(VTN)** An economizer must be fully integrated and must be provided for each individual cooling space-conditioning system that has a design supply capacity over 2,500cfm and a total cooling capacity over 75,000 Btu/h. Depending on the cooling capacity of the unit an

economizer must be present, but there's no direct requirement that it be operational after the occupancy permit is granted³¹.

(NV) Ducts on small single zone systems with portions of the ductwork either outdoors or in uninsulated or vented ceiling spaces are required to be sealed and leak tested as specified in Reference Nonresidential Appendix NA1. Researchers will typically be unable to verify duct leakage rates in nonresidential installations due to the disruptive nature of the testing.

- **(NV)** 150.0(m)1 requires minimum R-6.0 for ducts that are not enclosed entirely in directly conditioned space.
- **(NV)** 150.0(m)12 provides new air filtration requirements that include: filter grills shall be designed to accommodate the clean-filter pressure drop of the filter media; Air filter devices (return grilles) shall be labeled to disclose the design airflow rate and pressure drop such that the label information will enable the system owner to purchase the correct replacement air filter media.
- **(NV)** - 150.0(m)15 provides new requirements for zoned ducted cooling systems for verification of fan watts and airflow rate in all zonal control modes for some zoned cooling system types.
- **(VN)** All unitary air conditioning equipment and air-handling units with mechanical cooling capacity at ARI conditions greater than or equal to 110,000 Btu/hr that serve single zones shall be designed for variable supply air volume with their supply fans controlled by 2-speed motors, variable speed drives, or equipment that has been demonstrated to the Executive Director to use no more energy. The supply fan controls shall modulate down to no more than two thirds of the full fan speed at low cooling demand.
- **(NV)** Space conditioning zone controls – each zone shall have controls that prevent reheating, recooling; simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems. Section 144(d)
- **(NV)** Before an occupancy permit is granted the following equipment and systems shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the applicable acceptance requirements in NA7. Section 125 This requirement is applicable only to newly

³¹ Initial research shows that Nonresidential Title 24 for both 2008 and 2013 suggests that the only requirements for economizer testing are at building commissioning. Title 24 uses the phrase “construction inspection” to refer to this requirement, but doesn’t define “construction inspection” to include retrofits or changeouts. While it does state construction inspections and acceptance tests are to be completed prior to granting an occupancy permit this permit would not be applicable for changeouts. There may be an indirect requirement – if the economizer is responsible for part or all of the space’s required ventilation.

constructed buildings and to completely new or replacement HVAC systems where all components of the system, including all ducts, are replaced in altered existing buildings. Also, an alternative to measuring airflow rate and fan watts is available for compliance with Section 150(m)13 through the installation of a return duct system that conforms to the requirements in Table 150.0-C or D.

5.4 Installations Subject to Compliance Assessment

5.4.1 Nonresidential Sample for Compliance Analysis

The nonresidential compliance sample will come from site audits previously performed in the CMST study. CMST identified and collected whole building information on packaged or split units at or under 65kBtu (5-tons) installed in 2009-2013³². According to the CMST report, extensive information on HVAC systems, with a focus on air conditioning systems, specifically direct expansion (DX) space cooling systems was collected.

5.4.2 Exemptions from Local Building Dept. Permit Processes & State Compliance Requirements

A relatively significant portion (52 of 197) of the nonresidential CMST sample currently considered for this study is not subject to local building department permit requirements and will therefore not be included in the permit nor compliance analysis due to the unique requirements and inspection processes. As a result of these exempt buildings, the total sample of 197 potential sites is reduced to 145. When developing the permit rate (top-down approach) exemptions must be considered in the permit rate calculation as a number of bonds in California have been approved to replace air conditioning units in public schools.

Buildings exempt from local BD's permit processes for HVAC changeouts include public schools, hospitals, historic, and government buildings. Not all of these buildings are exempt from compliance with the California Energy Code however enforcement is complex issue. Enforcement is overseen by:

State and local government building compliance is enforced by the Department of General Services (DGS) or other state agencies. Federal buildings need not comply with state code requirements.

³² CMST study cites very few surveys were collected in 2013 and installations from 2013 were included in the 2012 samples.

The Division of the State Architect (DSA) serves as the enforcement agency for schools but according to DSA officials, the DSA is not required to review energy-saving projects such as HVAC changeouts. Furthermore, the decision to submit an HVAC changeout in a like-with-like application is at the discretion of school districts (limitations are described in DSA form PR 14-02³³).

The Office of Statewide Health Planning and Development (OSHPD)³⁴ oversee hospitals and medical buildings they do not expressly enforce the requirements for the hospitals and medical buildings that are under their jurisdiction.

There is also an exception for historic buildings. In most cases compliance with HVAC requirements are not exempted for historic buildings, and are enforced by building departments. (It does not appear from the CMST building department categories that any of the building types are historic buildings.)

If data relevant to compliance was not collected at CMST sites, even though site forms indicate placeholders for the data, or if additional sample is needed to inform the studies permit and compliance rates then we will defer to alternate samples from the CSS. The CSS study collected, among other data, the age of mechanical systems. Applying the same methods as RASS, we will contact the CSS survey respondents and inquire about the condition of the HVAC system. The CSS study like CMST should identify non-permitted and permitted projects. If the Energy Division decides to expand to the study to include field inspection then we would proposed to complete 100 onsite field inspections and would expect the samples shown in Table 10 based on random recruitment.

Table 10: Planned Nonresidential Sample, random sampling (if required)

Code Year	Installation Type	Estimated Variation	Sample Size	Estimated 90% CI Precision
N/A	Non-permitted Installations	1.0	80	18%
2008	Permitted Installations	0.7	20	26%
	Total	1	100	16%

³³ DSA Exception Occurrences: PR 14-02 http://www.documents.dgs.ca.gov/dsa/pubs/PR_14-02.pdf According to interviews with the DSA they have limited enforcement capabilities for alterations, there appears to be no method to ensure compliance for projects not submitted to DSA and identifying past projects in general could be difficult to track with discretionary filing practices. And projects submitted to DSA compliance and the ability to enforce it appears limited and based on good faith that contractors will perform services correctly.

³⁴ OSHPD <http://www.oshpd.ca.gov/fdd/>

If neither CMST nor CSS identifies sufficient samples of permitted projects, anticipating these will be low, then we will mine the CHB| CIRM permit counts and contact building department (BDs) to collect installation addresses. This BD effort may be worthwhile if turns out the CMST and/or CSS identify very few permitted units.

Once the data is gathered, we will analyze compliance based on the data collected from the 145 units and overlay the sites with the permit rate. The results of these findings will drive future project decisions and whether additional sample is necessary.

Once we identify a changeout, its equipment type, and approximate changeout date, we will request the survey respondent to participate in an onsite inspection. We will not disclose study objectives (measuring permits and compliance) to participants; but instead, we will inform customers the intent of the study is to understand how much energy newly installed units save. Regardless of the survey respondent's willingness to participate in the inspection, the status of a permit and HERS certification will be sought out.

While the types of equipment will vary, we anticipate that the most common equipment types we will come across will be central natural gas-fired furnaces and central split-system or packaged air conditioners. Equipment types that will not be included are window or portable air conditioners.

5.5 Residential Installations Subject to Compliance Analysis

The California Energy Code sets requirements that are dependent on what HVAC system components are being installed in existing buildings.

Building Types: The study will be limited to low-rise residential installations and will exclude high-rise.

Installation Types: The study will be limited to altered space conditioning – mechanical cooling (commonly termed “changeout”), entirely new or replacement space-conditioning systems (all HVAC equipment and ducts replaced). If the entirely new HVAC equipment includes an addition and/or renovation to an existing building the dwelling will be excluded as this type of change introduces the possibility of a compliance trade-off approach.

Code Cycle: Additionally, the code cycle will also be restricted to projects that complied with or should have complied with the 2008 Standards and will exclude projects under the 2013 Standards or previous code cycles.

The residential compliance sample goal is 200 units tested and inspected. The sample sources will likely include self-reported changeouts from RASS, and possibly the general population or units identified through building departments. For each compliance site we will independently verify the permit outcome and seek to obtain information on the HERS status. Any site that is not found in the HERS registry will be treated as non-fully compliant.

Sampling will occur in two phases, we will re-assess the residential sample after 100 completes to determine if oversampling is needed in specific areas to improve the expected relative precision of any metric of interest.

Table 11 shows the number of installations we anticipate reviewing based on if the unit was permitted. The samples sizes by permit and non-permit and by code are estimates. For this plan, we have assumed that 20 percent of all units reviewed will have permits. We also assume an annual change out population of 337,500 units, an annual permit rate of 60,000 units. These assumptions are based on the results of previous work, reports made available to the research team, and AHRI shipment data from 2011, and extrapolated CIRB permit data, and our expectations of the market.

Table 11: Planned Residential Sample, random sampling

Code Year	Installation Type	Estimated Variation	Sample Size	Estimated 90% CI Precision
N/A	Non-permitted Installations	0.8	160	10%
2008	Permitted Installations	0.6	40	16%
	Total	0.8	200	9%

Table 12 displays the anticipated sample points and relative precision for each code required measure to evaluate. The table matches the format we anticipate providing for the study results.

There are several types of variation that we do not currently know about the population, such as regional variation in enforcement and the frequency in which each measure applies to a given replacement. In these calculations we continue to assume overall variation is higher than the variation for a specific mandatory or prescriptive measure. The variation estimates used for sampling are based on the research team’s experience and standard evaluation assumptions. The relative precision of the study’s results may be different if the variation in the observed sample differs from the assumptions. We currently don’t have categories for grouping individual building departments since the variation isn’t that neighboring BD’s are similar, thus we cannot target BD’s to oversample until we complete a significant amount of the planned data collection.

The variables used to inform, the fields include estimates made: annual change out population, estimated permit rate, annual permit population, annual non-permit population, and placed sample co-efficient variation.

Table 12: Planned Compliance Reporting Template, Residential Sample

Code Year	Measure	Mandatory (M)/ Prescriptive (P)	Sub-sample Proportion	CV By Measure (0.5 for Yes/No, 0.6 if measured target)	Energy Weight - TBD	Total Sample Size	Total Compliance Rate	Total 90% CI Precision	Permitted Sample Size	Permitted 90% CI Precision	Non-Permitted Sample Size	Non-Permitted 90% CI Precision
2008	Meets Minimum Efficiency Requirements	M	100%	0.50	N/A - Mandatory	200	X%	6%	40	13%	160	7%
	Loads calculated per standards	M	100%	0.50	N/A - Mandatory	200	X%	6%	40	13%	160	7%
	Thermostats	M	100%	0.50	N/A - Mandatory	200	X%	6%	40	13%	160	7%
	Unconditioned ductwork >= R-4.2	M	100%	0.50	N/A - Mandatory	200	X%	6%	40	13%	160	7%
	Mandatory Measures		100%	0.8		200	X%	9%	40	21%	160	10%
	Refrigerant Charge (CZ 2, 8-16)	P	60%	0.60	TBD	120	X%	9%	24	20%	96	10%
	Temperature Measurement Access	P	95%	0.50	o but EM&V Value	190	X%	6%	38	13%	152	7%
	Airflow > 350CFM/Ton (CZ 10-15)	P	40%	0.60	TBD	80	X%	11%	16	25%	64	12%
	Supply fan watt draw < 0.58 W/CFM	P	40%	0.60	TBD	80	X%	11%	16	25%	64	12%
	Static pressure probe or probe hole	P	95%	0.50	o but EM&V Value	190	X%	6%	38	13%	152	7%
	All ductwork R-4.2 – R-8.0 (CZ-dependent)	P	50%	0.60	TBD	100	X%	10%	20	22%	80	11%
	DTS (CZ 2, 9-16)	P	50%	0.60	TBD	100	X%	10%	20	22%	80	11%
	Prescriptive Measures		100%	0.8		200	X%	9%	40	21%	160	10%

5.5.1 Recruitment for Residential Onsite Compliance Inspections & Testing

We will recruit both permitted and non-permitted sites for onsite inspections. In past studies requiring onsite inspections we used customer notification letters to authenticate the study and financial incentives to compensate customers for their time. We anticipate using both letters and financial incentives in this phase of the study. Follow up telephone calls will be placed to customers who are non-responsive to the notification letter and post-card reply mail.

Respondents who express interest in the onsite component during the screening survey will be placed on a waiting list. We will schedule site visits once a reasonable number of residential customers agree to the onsite portion of the study and prioritize customers with newer units. Past research has found this two-stage recruitment approach is the most cost effective, but some respondents will drop out even when previous interest was expressed.

5.5.2 Field Data Comparison to HERS Documentation

To evaluate HERS raters' ability to ensure inspected jobs are compliant with Title 24 measures, DNV GL will request site documentation (e.g., Certificates of Field Verification and Diagnostic Testing) from the HERS registry maintained by CalCERTS, Inc.³⁵ and U.S. Energy Raters Association (USERA).³⁶ With the documentation, we will compare DNV GL onsite test results to Title 24 requirements and the verified values from the HERS verification reports, and report on the percent of projects that met the requirements. For changeouts under 2008 Title 24 we will specifically focus on climate zones (CZs) within California where duct testing was required (CZ 2 and 9 through 16), and where measuring refrigerant charge was required (CZ 2 and 8 through 15) and we will factor in where the bottom-up permit and compliance samples fall to be sure those are captured.

Title 24 HERS rater measures include verifying a system airflow of at least 350 CFM per nominal ton of cooling capacity and duct leakage of less than 15 percent of system airflow (unless the entire duct system has been replaced, in which case duct leakage must be below 6 percent of system airflow).

5.5.2.1 Key Activities and Deliverables:

Key activities and deliverables associated with the compliance task include the following:

³⁵ CalCERTS, Inc. <https://www.calcerts.com/>

³⁶ U.S. Energy Raters <http://www.usenergyraters.com/>

5.5.2.2 Compile Sources and Coordinate with Research Studies

- Acquire the original population from the IOUs for the 2009 RASS study. Compare this to customer data to identify new occupants.
- Acquire the original population CMST study from the IOUs.
As needed:
- Acquire the original population CSS study from the IOUs.
- Acquire general population data to develop sample frame once saturation studies have been exhausted.
- Acquire permitted projects from building departments.
- Acquire permitted projects documentation from HERS registry.

5.5.2.3 Preparation of Onsite Surveys

Instruments

- Prepare customer recruitment surveys
- Prepare onsite data collection survey data collection forms
- Prepare onsite data field database
- Prepare compliance analysis tool for measures analyzed
- Prepare onsite notification letter
- Purchase onsite incentive cash gift cards, and prepare gift card distribution and tracking protocols

Deliverables

- Onsite data collection instruments
- Customer notification letters
- Compliance analysis tool
- Database data dictionary

5.5.2.4 Recruit and Perform Onsite Inspections

The following activities will occur over the course of the study:

- Train recruitment staff on both recruitment process and procedures and onsite inspection
- Recruit customers for field inspections once self-reported units have been identified.

5.5.2.5 Compliance Analysis & Reporting

The objective for this task is to perform analysis on compliance rates for each of the prescriptive and mandatory categories listed below. Ideally, we would establish through visits to all sample sites, a complete list of Title 24 HVAC compliant measures. Because of budget and resource limitations this approach is not feasible. The team will, instead, investigate using verifiable key measures for each sample site to serve as proxies so we can place each site along a gradient from non-compliance to full compliance. These key verifiable measures might include, among others:

- Filed permits,

- HERS documentation,
- Finalized permits,
- Compliance documents,
- Refrigerant charge (CZ limitations),
- Airflow,
- Fan watt draw, and
- Duct test (CZ limitations).

Before the team develops a detailed data collection plan and after we review CMST and RASS data, we will work with stakeholders to develop this approach. Researchers will summarize and report compliance rates in a draft and then a final report.

6. Evaluate Efficacy of HERS Documentation & Raters

6.1 Overview

As described in the introduction, even though raters have an independent role and are expected to be neutral parties in the installation process, there may be shortcomings in their services due to outside influence from contractors, customers, and building departments - not to mention price pressure from competing raters (rater service fees are not regulated). As a result of these pressures, a HERS rater may not perform evaluations with proper rigor and a HERS-certified project may not actually meet HERS requirements or achieve optimal measure performance. This study will determine whether HERS inspections on HVAC installations produce the intended result of a HERS-compliant residence. To inform the question of why HERS raters may not perform the work correctly or as thoroughly as necessary, researchers will conduct exploratory semi-structured interviews; online or mail survey with raters across different California climate zones; and evaluate comprehensiveness of HERS submitted documentation.

6.1.1 Policy Decisions:

As indicated in Section 2.1 the Energy Commission staff are currently exploring existing and newly identified issues under the Home Energy Raters System Order Instituting Information (OII) Proceeding# 12-1114-6.

The HERS Rater Program has it's an internal quality assurance procedure. There is currently a requirement for HERS registry-provider CalCERTS to conduct a quality assurance (QA) program evaluation for all Raters. The QA entails an independent re-test verification performed by CalCERTS. Only one percent of a Raters projects are required to be verified. If the Rater

projects (1%) fail the QA review increases to two percent for the next six months. The percent of projects reviewed is currently part of the OII proceeding. In this proceeding there are ongoing discussions to increase the QA level to 2 percent regardless of the failure status. This change is being supported by the CEC.

6.1.2 Key Activities

Evaluate the Comprehensiveness of HERS Documentation: To complete this step, we will conduct a thorough review and analysis of the documentation available in the HERS registry. This is assuming we can have access to the HERS registry (see discussion in Section 3.3.3 for more details.) The data content and formats desired include acquiring (or constructing) a data set of individual Title 24 2008 compliance CF-4R³⁷ and the Title 24 2013 compliance CF3R³⁸ HERS rater data collection forms or access to other key variables found in HERS rater registries.

With the above data we will perform data analysis that will include, but is not limited to, the following:

- Identify the frequency of rater submitted test results that indicate a system did not pass or was out of compliance with Title 24 requirements.
- Determine what percent were resubmitted with a passing rate and what percent were not.
- Review HERS provider companies³⁹ (CalCERTS/USERA) quality control/quality assurance audit test results that were drawn from a sample of audited homes.
- Assess the percentage of HERS raters that may only do a subset of the required verification activities.
- Identify if there are any trends associated with any particular climate zones, building departments, raters or contractors where verification activities are systematically not performed.

For this analysis we will request a large volume of QA/QC test (i.e., two years' worth) to measure the frequency of errors found. The frequency of errors will then be extrapolated to the population of unaudited units to estimate the overall percent of projects that may be non-compliant. With only two in seven units tested, a review of a larger volume of data would allow

³⁷ http://www.energy.ca.gov/title24/2008standards/residential_manual.html#HVAC-Alt
<http://www.energy.ca.gov/title24/2008standards/changeout/>

³⁸ http://www.energy.ca.gov/title24/2013standards/res_compliance_forms/CF3R/

³⁹ <http://www.energy.ca.gov/HERS/providers.html>

us to estimate how many out of the populations that were not tested were likely also out of compliance.

Semi-structured Interviews with HERS Raters: Once the rater registry evaluation is complete we will conduct interviews with HERS raters to explore systematic issues found in the registries to identify problems that may be present in certain climate zones, building departments, hiring contractors, under the two T24 code periods (2008 and 2013), or by raters themselves. We will examine the awareness of HERS raters on the HVAC replacement/retrofit code requirements and inspection processes, and identify knowledge gaps where training could help to better enforce compliance requirements and barriers to compliance. In particular, we will ask HERS raters about the barriers identified and their relative importance from the perspective of each type of market actors. Based on our previous research, we will build on the following knowledge or awareness gaps previously identified:

- Inconsistent enforcement of Title 24 requirements between jurisdictions
- Inconsistent enforcement of Title 24 requirements between individuals in the same jurisdictions
- Lack of control to enforce Title 24 requirements
- Contractors unwilling to pay for Title 24 requirements
- Code constantly changing, both processes/procedures and measures, making it hard to keep up with requirements
- Affordable access to training/certification
- Impressions on the rater industry and competitors performing the services correctly.
- We will probe on cities where low and high compliance exists
- What barriers do HERS raters face when performing jobs as well as seeking future work?
- What barriers do raters face when their tests reveal a system is not in compliance with Title 24 standards?
- Determine to what extent building departments in all 16 climate zones are aware of the latest Title 24 requirements for HERS testing.

We will begin with exploratory semi-structured interviews with a few raters to ensure the topics of great importance are identified. We will focus the online or mail survey questions to ensure responses are measureable. Given the potential sensitivity of the issues, using the online or mail survey will allow raters to provide feedback with a certain amount of anonymity where they may possibly disclosed information they would not otherwise do in an interview. Once the all interviews are completed, we will rank the issues in order of magnitude.

Deferred Case Studies

The team anticipates the findings from compliance document review may identify optimal rater case-study interview candidates. If raters report barriers to performing work correctly with certain cities or counties we will look for any evidence in the data obtained from the HERS

providers to validate or refute such claims. Conversely, if raters report positive factors in a particular region, we will look to the data to support the rater's feedback. In essence anytime the survey feedback is consistent for a particular issue or region, we will analyze the provider's records to identify if there is data to support the claims. Follow up case studies are not currently considered due to budget constraints but may be re-introduced depending on budget status and findings.

6.1.3 HERS Data Acquisition Planning Assumption

The HERS rater evaluation has some inherent limitations; namely, residential alteration compliance documents, and the registry itself are not public records and the ability to obtain the volume of information desired to characterize rater effectiveness will be subject to approval by the HERS provider companies that govern those documents. A thorough assessment will require efficient access to numerous compliance documents and, while customers may retain their individual copies, the volume that can be obtained directly from customers will not be sufficient. We will identify the necessary provisions to gain access to residential alteration compliance documents from the two accredited HERS provider companies (CalCERTS, Inc. and USERA). Based on previous conversations, researchers expect a legal confidentiality agreement such as a memorandum of understanding (MOU) will be needed, and the providers may request compensation for their employees' time to collect and transfer the number of documents requested or require a fee for the test results.

6.1.4 Data Collection Methods

6.1.4.1 Literature Review

For the literature review, we will review Title 24 Section 6 on mechanical alteration requirements; Title 20 Section 1670 code of regulation requirements; and HERS rater-training manuals; and compliance forms CF-1R -Certificate of Compliance, CF-4R - Certificate of Field Verification & Diagnostic Testing and CF-6R Installation Certificate. The purpose of the literature review is to identify the 2008 code and the California climate zones that require these measures. Through the initial literature review process we anticipate additional documents will become relevant and also reveal specific areas of interest to consider in the analysis.

6.1.4.2 Sampling & Recruitment

To the extent possible, we will seek a balanced sample of HERS raters from each of the 5 climate zone groups (CZ 2, 3, 4 & 5; CZ 11 & 16; CZ 12 & 13; CZ 14, 15, 16; and CZ 8, 9, & 10). We will target the interviews with raters that have extensive experience applicable to HVAC replacements and among raters with specific licenses (Alterations Residential and Alterations Nonresidential). We will identify the list of raters primarily through the CalCERTS and USERA. We will complete a few semi-structured targeted interviews with HERS raters and then develop questions to serve a larger audience via an online or email survey. While there are specified

completion goals, the online surveys will target all raters for which we can obtain email or mail addresses. We will use follow up calls to reduce non-response to ensure minimum sample goals are achieved. Some sample may be retained for later in the study to ensure projects under the 2013 code are captured particularly in climate zones where significant changes now apply. HERS raters will be offered a modest incentive to participate in an interview (and possibly a survey), balancing the need to attract respondents without biasing the sample. The specific value and form of the incentives will be determined later.

Using the free online CalCERTS search engine we identified statewide 605 unique HERS rater companies providing services for “alterations-residential” and “alterations-nonresidential”⁴⁰. The vast majority of raters serve multiple counties and multiple rater services. Table 13 shows the number of HERS survey completes required with 10 percent relative precision at 90 percent CI. The expected population size was expanded to account for raters that may be associated with USERA.

Table 13: HERS Rater Survey Size

Expected Population (N)	Sample (n)	Coefficient of Variation	90% CI Precision
650	57	0.5	10%

6.1.4.3 Human Subject and Data Protection Plan

Given the sensitive nature of much of the data to be collected for this study, it is very important to create and maintain processes and procedures for safeguarding people and their data. DNV GL’s subcontractor UC Davis will apply for approval, of relevant sections of the research plan by the Institutional Review Board at UC Davis⁴¹. The IRB process was previously characterized as a very lengthy process taking months to complete but has since been streamlined to a couple of weeks. Each member of the research team will adhere to standard protocols for the protection of human research subjects and follow established internal protocols for de-identifying data, preserving anonymity, and controlling access to data.

6.1.5 Key Activities and Deliverables:

- Purchase data and set up legal agreement for data transfer with HERS provider companies (CalCERTS and USERA)

⁴⁰ Estimates were collected in October 2014.

⁴¹ Institutional Review Board (IRB) Administration at UC Davis: <http://research.ucdavis.edu/c/cs/hrp>

- Complete compliance registry documentation review
- Complete informative phase telephone inquiries with a few HERS raters to better inform questionnaire for larger audience of raters
- Prepare final HERS rater questionnaire
- Implement surveys
- Survey analysis
- Report results
- Conduct HERS rater case studies (time and budget permitting)

7. Deliverables, Timeline and Budget

This section defines the deliverables timeline and budget for each of the tasks. The budget and scope will undergo a critical review and decision making assessment in April of 2015. At this time we anticipate a review of nonresidential data collection activities to determine the interest in expanding the scope to include onsite field inspections.

7.1 Progress Report Meetings

We will report progress on the project on a monthly basis through the HVAC Program Coordination Group (PCG) and as needed at Market Assessment PCG conference calls. These meetings provide the researcher team, stakeholders, ED consultants, and IOU representatives the opportunity to discuss project status, methodologies, survey instruments, preliminary and final data collection findings, and discuss general topics relevant to the research study and cross-cutting studies.

7.2 Reporting & Presentation of Results

The researcher team will prepare a draft report for the ED to review and we will produce task completion memos at the major task milestones. Planned milestone memos and anticipated due dates are described in **Error! Reference source not found..**

Memos will be circulated to ED and their Advisors, and, at ED's discretion to IOUs and the CEC. Preliminary results will be regularly shared at PCG meetings. Once comments have been received a draft will be circulated to ED consultants and IOUs for comments. Once comments have been received from all stakeholders the research team will deliver the Final Report and a presentation of the results. The results will first be presented to ED, CEC and IOUs. A separate public presentation of the results will be conducted in a public meeting or webinar, with the aim of scheduling that at a time convenient for WHPA members.

DNV GL commits that it will submit task memos, draft and final reports in a timely fashion as requested to the CPUC. In addition, the research team will only present documents to CPUC for

review following in-house DNV GL editing to ensure the documents adhere to professional level of quality in organizational structure, labeling of tables and graphs, and technical and narrative writing.

Deliverables: The deliverables for this task will be:

- **Task Completion Memos** at major task milestones, for circulation to ED, and at ED’s discretion, to the CEC and IOUs (as described in Table 14).

Table 14: Estimated Project Deliverables Timeline 2014-16

Deliverables	Approx. Date/Year
Finalize Research Plan	February 2015
Memo # 1 Proposed methodology for determining partial compliance and weighting of prescriptive measures (following stakeholder meeting).	April 2015
Memo # 2 Results from CMST Nonres permit and compliance analysis	May 2015
(Pending Approval) Memo on achieved nonres sample by strata at 25% completion (45) identified projects. Sample methods to achieve remaining sample goals.	August 2015
Memo # 3 Residential permit & compliance rate at 50% completion. And sampling disposition update and assessment of the need for additional data.	August 2015
Memo #4 Define variables of interested in HERS registry. Participant’s permit rate (from HERS) and HERS interviews.	October 2015
	2016
Draft preliminary report	April 2016
Energy division review	May 2016
Preliminary report release	June 2016

(Deliverables Continued...)

- **Outline of the draft report** for review and approval by ED representatives.
- **Prepare a draft report** for review by ED, CEC and IOUs.
- **Document and respond** to ED, CEC, IOU and stakeholder comments. DNV GL will review ED, CEC, IOU and stakeholder comments on the draft and prepare a matrix of proposed responses and revisions. We will review the response matrix with ED representatives and consultants and arrive at accepted revisions to be made to the document.
- **Revise the Draft Final Report.** DNV GL will implement the agreed-upon revisions in the Draft Final Report.

- **Public Presentation of Results.** DNV GL will prepare and deliver a PowerPoint presentation of the key findings and recommendations of the study to stakeholders through a Webinar or public meeting in convened by Energy Division.

7.3 Project Timeline

A number of research activities are dependent on access to data and field activities require identification of eligible sample for the on-sites can begin. The success of locating these units will impact other activities such as the permit verification, compliance testing, and analysis of permit rate, and compliance data. Upon research plan approval, identification surveys will promptly begin and such activities may be continuous throughout the study.

Table 15: Project Tasks Timeline 2014-16

Task No.	Task Descriptions	Estimated Completion
1	Project administration	3Q2016
2	Finalize research plan	February 2015
3	Training and survey pilots	May 201
4	Nonres. Permit & Compliance Analysis-Only Method	May 2015
5	*Nonres. Compliance Analysis w/option for additional onsite* Optional	January 2016
6	Phase1: Res. Compliance Testing and Permit Analysis Qty. 100 units	August 2015
7	Phase2: Res. Compliance Testing and Permit Analysis Qty. 100 units	November 2015
8	Phase3: Res. RCA Testing Weigh-in Method on Subsample	November 2015
9	Develop Bottom-up Permit Rate	January 2016
10	Develop Top-down Permit Rate	January 2016
11	HERS Rater Interviews	October 2015
12	Evaluate Efficacy of HERS Rater Submittals	December 2015
13	Project Milestone Memos	See Table 14
14	Present and deliver final report	June 2016

7.4 Proposed Budget

This research plan has a budget of \$1,450,000. The current budget exceeds the contract amount by \$200,000. Funding originally reserved for the Quality Installation evaluation will be shifted to this study.

The research team anticipates priorities under this study will continue to evolve. Should additional changes be made this will free up funds that were previously deferred for other research activities such as a more comprehensive assessment of online market sales and/or customer interviews on barriers to permitting and compliance or case studies with HERS raters. There are numerous research topics of interest that could be reevaluated; the CPUC has been provided a supplemental document with additional scope that may be considered for deferred research topics. The budget and scope will undergo a critical review and decision making in April of 2015.

The following includes proposed saving opportunities for the project:

- The current budget assumes reliance on 100 nonresidential field inspections with an emphasis on nameplate data and visual verification. By starting with the proposed nonresidential CMST compliance analysis from the data previously collected, and no additional field inspections, there may be a significant savings in excess of \$210,000 due to the reduced costs associated with finding eligible sample, recruitment, travel, incentives and project management, etc. The current budget assumes a reasonable number, excess of 100 customers from the RASS study will be identified and will participate in the study.

Additional study plan considerations that impacts the proposed budget includes:

- This budget assumes efficient access to RASS, CMST, and CSS data.
- This budget assumes efficient access to HERS registry data. Under the HERS Rater tasks a budget has been set aside for registry owners to perform export data and run queries.

The consolidated budgets (49%) show the vast majority of the budget is allocated to residential compliance which includes identifying, recruiting, performing site testing, inspections and analysis; some 18% is allocated to nonresidential permit and compliance which includes the same set of tasks as residential with fewer units evaluated, 8% is for identifying the permit rate which includes both top-down and bottom-up, 7% is for evaluating the role of HERS rates - barriers, the registry and efficacy of raters. The remaining 18% is assigned to project administration, coordination, the development of the research plan and addendum (as needed) to the 2015 plan, training, reporting, and presenting the results.

Table 16: High-Level Project Budget by Task

Task No.	Task Descriptions	Budget
1	Project administration	65,000
2	Develop research plan	90,000
3	Training and survey pilots	30,000
4	Nonres. Permit & Compliance Analysis-Only Method	55,000
5	*Nonres. Compliance Analysis w/option for additional onsite* Optional	210,000
6	Phase1: Res. Compliance Testing and Permit Analysis Qty. 100 units	660,000
7	Phase2: Res. Compliance Testing and Permit Analysis Qty. 100 units	
8	Phase3: Res. RCA Testing Weigh-in Method on Subsample	50,000
9	Develop Bottom-up Permit Rate	55,000
10	Develop Top-down Permit Rate	60,000
11	HERS Rater Interviews	50,000
12	Evaluate Efficacy of HERS Rater Submittals	50,000
13	Project Milestone Memos	30,000
14	Present and deliver final report	45,000
	Total	\$1,450,000

8. Appendices

8.1 Project Contact List

Organization	Name	Role	Address	Email	Phone
DNV GL - Energy	Jarred Metoyer	Project Sponsor	155 Grand Ave. Ste. 500 Oakland, CA	jarred.metoyer@dnvgl.com	(510) 891-0446 Ext. 44156
DNV GL - Energy	Amber Watkins	Project Manager	155 Grand Ave. Ste. 500 Oakland, CA	amber.watkins@dnvgl.com	(707) 820-4400
Western Cooling Efficiency Center University of California, Davis	Kristin Heinemeier, Ph.D., P.E., Principal Engineer	Subcontractor Principal in Charge	215 Sage St #100, Davis, CA 95616	kheinemeier@ucdavis.edu	(617) 284-6230 Ext. 6
Energy Division, California Public Utilities Commission	Paula Gruendling	Regulatory Analyst, CPUC Project Manager	505 Van Ness Avenue San Francisco, CA 94102	Paula.gruendling@cpuc.ca.gov	(415) 703-1925

8.2 Acronyms and Abbreviations

AC	Air Conditioning
ACCA	Air Conditioning Contractors of America
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
BD	Building Department
CalCERTS	California Certified Energy Rating & Testing Services, Inc.
CAC	Central air conditioners and heat pumps
CATI	Computer Assisted Telephone Interviewing
CFM	Cubic Feet per Minute
CI	Confidence Interval or “confidence level”
CHB CIRB	CA Homebuilding Foundation and CHF CIRB Construction Industry Research Board
RASS	Residential Appliance Saturation Study
CSS/CMST	Commercial Saturation Study (performed for the CPUC) & (sub-sample of CSS sites) Commercial Market Share Tracking
CLASS	California Lighting Appliance Saturation Study (study conducted by CPUC in 2005 & 2012)
CPUC	California Public Utilities Commission
DOE	U.S. Department of Energy
DST	Duct Test and Seal
CEC	California Energy Commission
ED	Energy Division a Department of the California Public Utilities Commission
HERS	Home Energy Rating System
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility (includes PG&E, SCE, SCG and SDG&E)
kWh	Kilowatt-Hour
LADWP	Los Angeles Department of Water and Power
NV	Not verifiable given the limitations of this study rigor
PCG	Project Coordination Groups
PG&E	Pacific Gas and Electric Company
QI	Quality Installation
RASS	Residential Appliance Saturation Study
RCA	Refrigerant Charge and Air Flow
SB	Senate Bill
SCE	Southern California Edison
SCG	Southern California Gas
SDG&E	San Diego Gas & Electric

SMUD	Sacramento Municipal Utility District
Title 24	Reference to California Energy Code Regulation Applies to Energy Requirements under Title 24, Part 6
Upstream	Refers to an IOU rebate program that pays incentives to HVAC distributors
USERA	US Energy Raters Association
VO	Verifiable onsite or through data collected onsite
VTN	Verifiable through nameplate
WHPA	Western Heating Performance Alliance

8.3 2013 Title 24 Requirements

2013 Title 24 Residential Measures⁴²

The 2013 Title 24 includes some changes and enhancements to 2008 Title 24. These changes and enhancements are described here for the reader's information. No site visits are planned to projects governed by this code. Items not specifically mentioned below are unchanged from 2008 Title 24.

Changes to Residential Mandatory Measures from 2008

- **(VO)** When duct sealing is required, the requirement extends to all CZs, not just CZs 2 and 9-16.
- **(VO)** The 2008 prescriptive requirements for airflow (350 CFM/nominal cooling capacity) and fan watt draw (0.58W/CFM) are now mandatory requirements. (Section 150.0(m)13)

Changes to Residential Prescriptive Measures from 2008

- **(VO)** When duct sealing is required, the requirement extends to all CZs, not just CZs 2 and 9-16.
- **(VO)** Duct insulation – Raise minimum from R-4.2 to R-6.0 in climate zones 6-8.
- **(VO)** Night ventilation – Whole-house fan as a minimum in CZs 8-14; central-fan-integrated ventilation systems may be used as alternatives.

2013 Title 24 Nonresidential Measures⁴³

Changes to Nonresidential Mandatory and Prescriptive Measures

- **(VTN)** Heat pumps with supplementary electric resistance heaters shall have controls that prevent supplementary heater operation when the heating load can be met by the heat pump alone, and in which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.
- **(VO)** All unitary heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat with a clock mechanism that allows the building occupant to program the temperature set-points for at least four periods within 24 hours.
- **(VTN)** Each unitary cooling fan system with a design total mechanical cooling capacity over 54,000 Btu/hr shall include an air economizer capable of supplying 100 percent of the design supply air quantity as outside air. (Section 140.4(e))
- **(VO)** All newly installed air-cooled unitary direct-expansion units, equipped with an economizer and with mechanical cooling capacity at AHRI conditions of greater than or

⁴² Op. cit.

⁴³ Op. cit.

equal to 54,000 Btu/hr, shall include a Fault Detection and Diagnostics (FDD) system. The following temperature sensors shall be permanently installed to a controller to monitor system operation: outside air, supply air, and when required for differential economizer operation, a return air sensor. The controller shall have the capability to display the value of each sensor and shall provide system status by indicating the following conditions:

- Free cooling available
- Economizer enabled
- Compressor enabled
- Heating enabled
- Mixed air low limit cycle active

The FDD controller shall manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified. Faults shall be reported to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats. The FDD system shall detect the following faults:

- Air temperature sensor failure/fault
- Not economizing when it should
- Economizing when it should not
- Damper not modulating
- Excess outdoor air
- The FDD System shall be certified by the Energy Commission as meeting relevant requirements.

- Section 140.4(e) provides new requirements for economizers. Each cooling fan system that has a design total mechanical cooling capacity over 54,000 Btu/hr shall include either: An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or a water economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

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