Savings To Code: Looking to Whole Systems for Implementing Existing Conditions Baselines

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ABSTRACT

California has some of the most conservative rules for counting energy savings from efficiency measures. Those rules are evolving and adopting new ways to estimate savings has become a top priority. In recognition of the savings potential being left behind in existing buildings by the state's aggressive energy codes and standards, the State Assembly recently passed legislation (AB 802) mandating that the California Public Utilities Commission (CPUC) begin counting energy efficiency savings at existing conditions within a year of the law's passage. This paper offers a readily available pathway for implementing existing conditions baseline for "High Opportunity" measures according to the tight timeline laid out in AB 802. The measure characterization work and implementation recommendations laid out in this paper expand on the concept of "Repair Indefinitely" (RI) savings opportunities—a class of complex equipment and systems that are significantly more likely to be repaired and kept in service than replaced at the end of their estimated useful life. The clear evidence, logical and empirical, for why and how RI systems are kept in service implies that such savings opportunities involve some of the oldest, least efficient equipment in today's grid and are prime candidates, or "High Opportunities," for the existing conditions baseline mandated by AB 802.

Introduction

Building codes and appliance standards have been a cornerstone of energy efficiency in California and the nation since Dr. Art Rosenfeld and others pioneered their use in the 1970s. In California, codes and standards set minimum efficiency levels for individual building components through Title 24 (such as mandating double-pane windows for new constructions) or end use appliance through Title 20 (such as minimum efficiencies in new clothes dryers entering the market). Codes and standards were traditionally used to "bring up the tail" of an individual technology's adoption curve. In other words, a combination of early adopter behavior and utility energy efficiency incentives was expected to reduce the cost of a new efficient technology, leading to increasing mass market adoption; codes and standards mandates were used once the technology was mature and cost-effective enough and only a small percentage of the market lagged behind.

This affects the critical question of what to assume as the baseline for energy efficiency measures, which in turn determines the magnitude of energy savings. This traditional measure adoption dynamic allowed for the use of minimum efficiency mandates in codes and standards as the default baseline for utility energy efficiency programs.[1] Since codes were not introduced until a technology was fairly mature, the regulator could safely assume the mandates were the true counterfactual for the majority of the market—what would have happened in the absence of a utility intervention. However, increasingly aggressive codes and standards adoption in the state changed the nature of codes and standards from a tool to "bring up the adoption tail" to one that sets the highest possible efficiency levels for new construction and significant alterations. This begs the question of what then should the default baseline be for energy efficiency opportunities in *existing* buildings that have not yet triggered code requirements for retrofits?

This paper attempts to answer this question for a particular type of savings opportunities.

Procedural History

Early in the California Public Utility Commission's (CPUC) current Energy Efficiency rule making (R13-11-005), several interveners requested that the Commission revisit its practices on energy efficiency baselines. Program Administrators (PAs) and other interveners argued that the de facto requirement, that customers independently bring existing buildings up to new building efficiency standards before higher efficiency measures could be incentivized, threatened the PAs' ability to capitalize on time-limited funds for energy efficiency in schools. In spite of these arguments, the Commission decided to delay further discussion on the baseline issue until Phase III of the rulemaking in 2016, at which time they expected both Commission Staff and interveners to have compiled sufficient empirical data for the requisite evidentiary record.

In the meantime, the California legislature passed Assembly Bill 802 (Williams), requiring that the CPUC

> *Authorize electrical corporations or gas corporations to provide financial incentives, rebates, technical assistance, and support to their customers to increase the energy efficiency of existing buildings based on all estimated energy savings,*

… instead of only incentivizing savings starting at the Title 24 code baseline.[2] The bill, which was signed into law on October 8th of 2015, mandates that the new existing conditions baseline be in place by January 1st, 2016 for "High Opportunity" measures and September 1st of the same year for all other applicable savings opportunities. This substantially contracted the timeline that the CPUC was expecting to have for discussing, establishing, and implementing existing conditions' baselines.

The California Technical Forum "Savings To Code" Subcommittee

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[1] CPUC rules do allow for Early Retirement (ER) measures that use existing condition baselines for the replaced equipment's Remaining Useful Life. However, the burden of evidence in those cases makes it virtually impossible to pursue ER measures. See *Comments of the Natural Resources Defense Council on the Workshop on Energy Efficiency Baseline and To-Code Incentive Eligibility Issues*, May 2015, p. 1.
[2] AB 802 does not address how the CPUC should count savings from equipment governed by Title 20.

The California Technical Forum (Cal TF) is a collaborative of experts who use independent professional judgment and a transparent, technically robust process to peer review technical information related to California's integrated demand side management portfolio.[3] The organization launched its Savings To Code subcommittee in January of 2015 in response to a request by TF Member Armen Saiyan of the Los Angeles Department of Water and Power (LADWP). The concrete goals of the subcommittee were to:

a) Characterize savings "stranded" below Title 24 standards in existing buildings, and
b) Identify which of those "to code" savings would not be captured absent program intervention.

The 12-member subcommittee[4] met 12 times throughout 2015 to brainstorm; discuss analysis performed by other organizations, subcommittee members, and Cal TF staff; draw substantive conclusions; and make recommendations for how to best capture High Opportunity "to code" savings.

Literature Review

The subcommittee's work was rooted in a comprehensive literature review performed by Cal TF staff. This work revealed that, while the various formal evaluations of the IOUs' Codes & Standards programs have been a useful tool in measuring Titles 24 and 20 compliance in new and significantly altered buildings, those studies cannot be used to inform policies for the existing building stock. This is because the literature is heavily skewed towards new construction and is definitely limited to buildings that have received significant alteration permits (DNV GL and Cadmus, 2014). These evaluations ignore un-permitted work, meaning work where a permit should be pulled but is not because the alterations are "behind the wall" such that lack of compliance with permitting requirements is hard to detect. It also ignores a significant portion of permitted alterations, where work is commonly not done consistent with permitting requirements.[5] Finally, and most importantly, it ignores all of the missed opportunities of deferred retrofits and other actions not taken: entirely lawful buildings and equipment that have not been touched since they were constructed, including "Repair Indefinitely" measures (McHugh et al 2010). In fact, Cal TF staff's exhaustive research of the existing literature,

[3] See more, including details on Technical Forum membership and staffing, at http://www.CalTF.org
[4] Subcommittee Co-Champions: Armen Saiyan and Douglas Mahone. Subcommittee Members: Martin Vu, Mary Matteson Bryan, Spencer Lipp, Andrew Brooks, Christopher Rogers, Tom Eckhart, Sherry Hu, Nicholas Dirr (Non-TF – Association for Energy Affordability), Kevin Messner (Non-TF – Association of Home Appliance Manufacturers), Marc Costa (Non-TF – The Energy Coalition).
[5] "PROP Final Report," Benningfield Group, BKi, and ABAG has a helpful discussion about the different types of non-compliance discussed in this paragraph. DNV GL for PGE, 2014 uses existing data to estimate a non-permitted rate as high as 38% for HVAC change-outs. *2011 Vermont Market Characterization and Assessment Study* lists the most frequent cases of under-performance in permitted equipment.

including non-CPUC funded work inside and outside of California, revealed that there are not enough existing statistically significant studies on the subject of savings to code in existing buildings to reliably inform the implementation of AB 802.

Characterization of "To Code" Opportunities

While Cal TF staff's extensive review of the existing literature did not reveal systematically catalogued evidence of "to code" savings potential for existing buildings, the subcommittee did use the compiled literature to create a clear categorization of the different types of "to code" savings opportunities. Figure 1 illustrates this categorization.

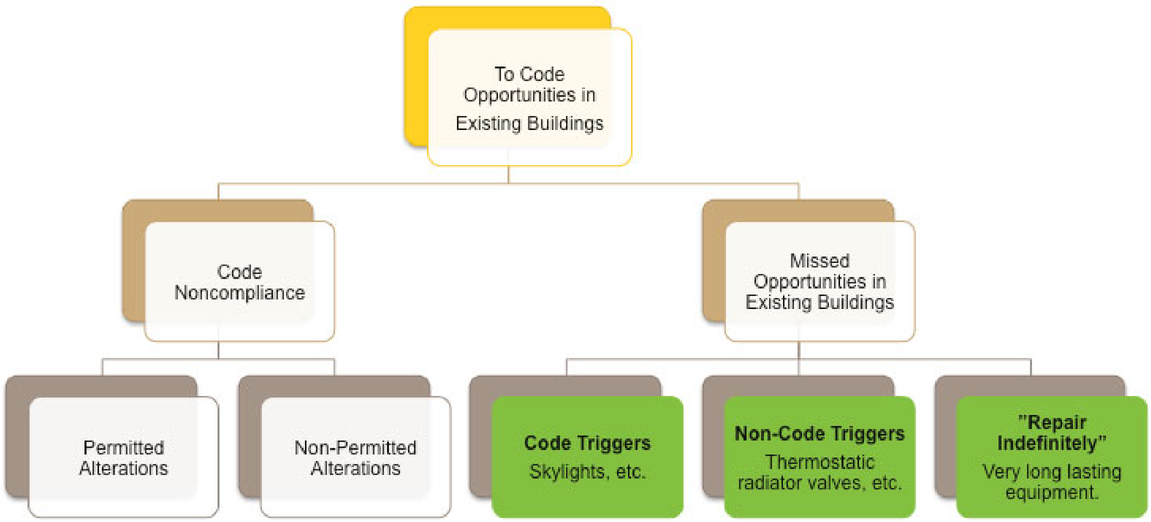


Figure 1. Characterization of "To Code" opportunities in existing buildings.

As shown, there are two main types of savings potential "stranded" below California standards: Code non-compliance types and "missed opportunities" in existing buildings. "Missed opportunities" involve savings that could result from voluntary retrofits to existing buildings. These are not mandated for existing buildings by law since the general principle in building codes is that they only apply to existing buildings when the owner initiates work. Given the lack of readily available data, and unanswered policy questions surrounding the use of ratepayer dollars to fund actions required by law,[6] the subcommittee focused the bulk of its work on the "missed opportunities" type.

There are three sub-categories of "missed opportunities:"

1. Code Triggers are voluntary building upgrades that, when initiated, trigger energy code compliance and thereby increase the cost (and savings) of installing the upgrade. Fenestration and day lighting are good examples of this type of activity.
2. Non-Code Triggers are additions or changes in existing buildings where owners are voluntarily initiating an upgrade, where program incentives or other program

[6] The appropriateness of using ratepayer dollars to bring existing buildings up to code where the code has already been triggered was still being debated at the CPUC as of the writing of this paper.

activity could encourage them to upgrade, and where no code is triggered. Good examples of this type are an aerator added to an existing faucet or a thermostatic radiator valve to a radiator.

3. "Repair Indefinitely" (RI) describes equipment that customers already own and typically repair rather than replace, so that it continues in operation well past its deemed expected useful life.[7] This old equipment is typically less efficient than new equipment.

The subcommittee concluded that RI measures hold some of the greatest, most easily achieved below code potential that could be substantiated with readily available data. The subcommittee also believed that programs could feasibly be designed to capture RI savings while minimizing the expenditure of ratepayer funds on free rider behavior. The following section discusses the data sets that allowed the subcommittee to reach this decision.

Repair Indefinitely (RI) Measures

Definition

RI measures involve equipment that is less prone to catastrophic failure than a typical measure,[8] can be repaired long after its "official" effective useful life, and is operationally and logistically costly to replace in its entirety. Large multifamily and commercial boiler systems are examples of an RI opportunity. For instance, data from a recent project to upgrade an existing boiler at the San Francisco War Memorial Veterans Building indicated that the boiler had been installed and was operating since 1932, over eighty years. According to current CPUC equipment lifetime assumptions, the 1930s system would have been retired several times over in the last century. However, the budget-constrained city government was unable to begin capturing this significant savings opportunity until it was able to raise capital for seismic improvements by issuing bonds.[9] The unnecessary carbon emissions from this RI equipment could have been curtailed decades ago if incentives had sufficiently reflected the savings from the retrofit. Savings should have been calculated based on the difference between existing system efficiency and the efficiency of a new boiler. The assumption of an artificial Title 24 baseline compared to the new boiler efficiency produces a much smaller savings potential, and hence a much reduced economic incentive to make the upgrade.

The subcommittee identified several other initial RI measures for which it believed data were available to reliably calculate savings. Lighting systems for small commercial uses, window systems in multifamily buildings, rooftop HVAC units, and industrial air compressors can also be qualified as RI opportunities. All of them have sub-

[7] Repair Indefinitely measure category first presented in McHugh et al.

[8] The term "catastrophic failure" is used in reference to equipment that cannot be repaired and brought back to service once it fails. RI equipment and systems are composed of many individual components, some of which can fail but be repaired or replaced to keep the entire piece of equipment functioning.

[9] New high efficiency Aerco hot water boilers were installed to serve the Veterans Building. The 1930s steam boilers continue to serve the Opera House but the load on them has been reduced dramatically: http://www.sfdpw.org/index.aspx?page=1611.

components that can fail without causing the system to break down (a single broken window pane or burnt out lamp in a liquor store), can be repaired without needing to replace the entire system (a new fan motor or cooling coil in a rooftop HVAC unit), and would be much more costly and disruptive to replace in its entirety (a plant that must stop or slow production to replace an expensive air compressor).

Deemed Implementation Recommendations

Based on the above definition, there are three criteria that a measure must meet before it can be qualified as RI for deemed[10] programs:

1. The type of equipment or system to be retrofitted must not have a catastrophic failure mode;
2. It must have a documented history of repair rather than replace; and
3. It must be less costly to repair than to replace.

The satisfaction of these three requirements can be documented with existing, not project-specific, information and established beforehand, or ex ante. Once a measure is determined to have met the three key RI criteria, it can be deemed for widespread use with an existing conditions baseline. When program or other similar data is not readily available for setting assumed baseline efficiencies for existing equipment, it may be feasible to use conservative proxy values. For instance, if the median age of a sample of pumps in the field is 50 years, the approximate efficiency of pumps as manufactured in 1960 could be used for initial implementation. In most cases, that would be a conservative estimate since equipment efficiency degrades over time.

At that point, exclusions and documentation requirements for individual projects could be implemented, but should be applied in moderation. Project-specific data should be collected only to refine future iterations of the measure, not as a condition to disburse retrofit funds. RI measures are costly, burdensome retrofits, and so are unlikely to be easily sold to the market. Measures and program requirements should be designed to maximize the opportunity, not become additional barriers to efficiency. It will be important for program efficacy that deemed RI measures not have additional site-specific data collection requirements during program implementation to establish whether any one site should be allowed the “existing conditions” baseline. This will allow programs to reach more customers and collect data through program implementation to refine rule sets and program requirements.

The same concepts can be applied for custom projects; however, in custom projects, equipment would have to be qualified as RI on a case-by-case basis. Therefore, RI determination in custom projects would require less upfront market research and more project specific data gathering in comparison to the deemed approach described above. Custom implementation could also allow PAs to keep track of market data to eventually establish enough documentation for a deemed RI program.

It is important to note that RI measure status should not mean that the new efficient equipment being installed will last indefinitely, or that the savings from that

[10] Deemed savings are pre-determined estimates of savings attributable to energy efficiency measures. Once established, these savings values are applied uniformly across all installed iterations of a measure.

intervention should be credited to the Program Administrator indefinitely. However, it does mean that the inefficient equipment being replaced would have been kept in service indefinitely. In other words, the counterfactual—what would have happened in absence of program intervention—and therefore the appropriate baseline for the entire measure life, would have been the existing conditions and power draw before program intervention. This is because inherent in the Repair Indefinitely definition is the requirement that the type of system to be retrofitted has a strong data-supported history of being kept in service long past its boilerplate life. The following RI measure case studies illustrate the level of data support that should be required and sufficient for awarding deemed RI status to measure opportunities.

Case Study Measures for Deemed Applications

In the absence of readily available studies on savings from RI measures—as was shown by Cal TF staff's extensive review of literature inside and outside of California—the Cal TF subcommittee instead collected and reviewed data from industry about deferred retrofits in the market. Mining existing data and deducing answers, aided by proxy variables and implementer experience, allowed the subcommittee to show significant savings potential in several High Opportunity RI measures. As is explained in the following sections, the methods that were used to make these showings involved some informed judgment (such as deducing the age of a boiler by the type of models that were being manufactured during a certain time period). However, the peer review-style process of the subcommittee was used to ensure the final methods were credible and defensible.

Multifamily boilers. Steam and hot water boilers involve complex systems that are often literally "built into" buildings. They consist of one or more large machines housed in the bowels of a structure, often closed in by walls that would need to be altered to remove the equipment from the building and replace it with new equipment. They may also have heating systems that run through the interior walls of the entire building. Due to both the cost of replacing the boiler and the operational cost and length of disruption associated with such a project, building owners typically choose to repair individual system components as they fail, rather than retrofitting the entire system. This results in boilers regularly exceeding their estimated lives by decades.

In 2010, a San Francisco Environment (SFE) program funded by the American Reinvestment and Recovery Act (ARRA) replaced inefficient boilers in 177 multifamily sites within the City of San Francisco. The boilers replaced ranged from some of the city's first low-pressure steam residential applications to much more modern hot water boilers. Cal TF Staff reviewed all available documentation for each of the projects and was able to estimate that roughly 77% of the equipment replaced by the program had been maintained in operation significantly past its current estimated useful life of 20 years.

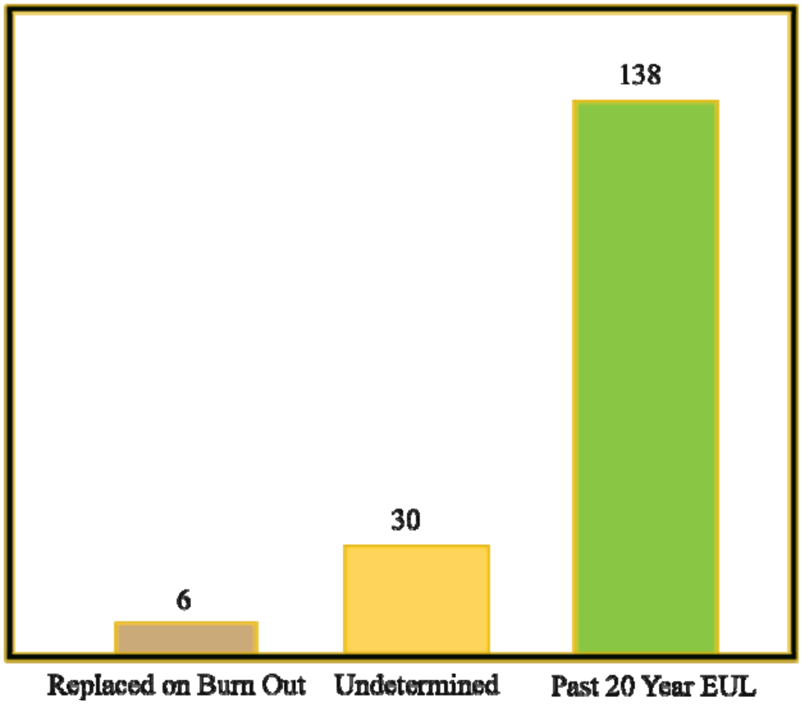


Figure 2: Estimated state of boilers replaced by SFE.
Source: San Francisco Environment.

This analysis consisted of a combination of project documentation review, industry trends and manufacturer analysis. Not surprisingly, given the extended age and corrosion of many of the boilers and the lack of record keeping at the time of installation, only ten of the 177 projects had explicitly documented the age of the replaced equipment;[11] however, it was possible to clearly establish that another 21 boilers had been installed very early in the 20th century by reviewing project pictures. Cal TF staff was also able to derive similar conclusions by reviewing the type of equipment replaced in 107 of the buildings—low-pressure steam boilers installed by long out of business manufacturers like Fitzgibbons and Kewanee.

Using estimated existing conditions, not code minimum, as baselines, SFE reported 164,465 annual therms in savings from their boiler replacement activities over the course of two years. The mean savings claimed per project was 929 therms per year; however, the much lower median savings (633 therms per year) suggests a distribution heavily skewed towards greater savings. That is to say, the bulk of the 177 projects yielded more than one thousand annual therms of energy savings.

Multifamily windows. In the realm of energy efficiency, windows operate as system. While individual panes may get replaced with a similar technology when they are broken or damaged, the real opportunity for retrofitting to a more energy efficient state is to replace the system as a whole (all of the windows in a building). Window retrofits are also one of the least likely energy efficiency measures to be upgraded to the more efficient alternative in the already difficult-to-reach and hard-to-finance multifamily

[11] The mean age of the ten boilers with documented ages was 73 years.

market. Window systems are highly unlikely to fail catastrophically, as individual panes can be repaired at a very low cost for decades, and whole system replacement is very costly. Therefore, window systems in multifamily buildings are a quintessential Repair Indefinitely measure.

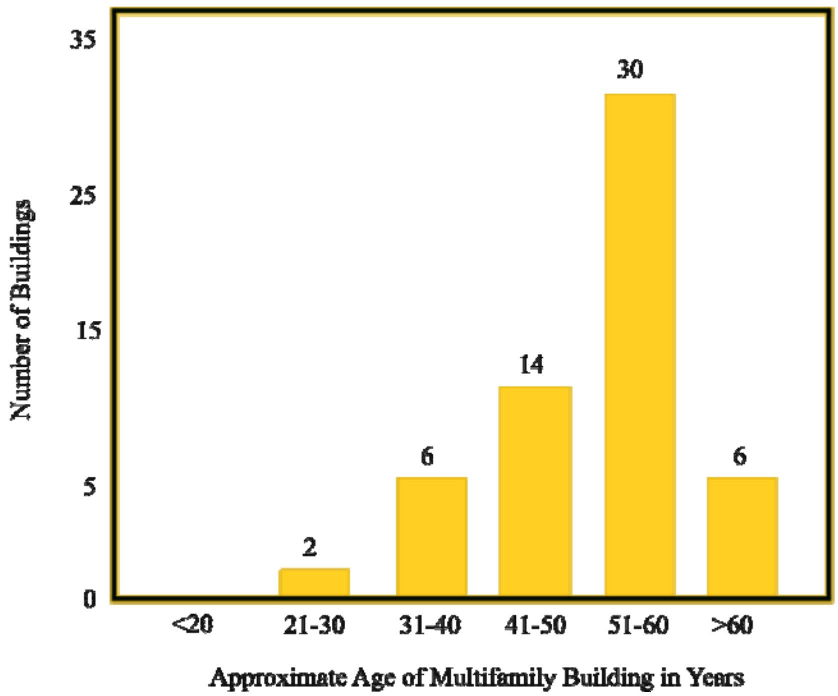


Figure 3: Buildings with confirmed single pane windows from San Francisco Bay area sample.
Source: California implementer data.

The subcommittee tested this hypothesis on a sample of multifamily buildings with confirmed single pane windows. The sample was gathered in the San Francisco Bay Area by an energy efficiency program implementer. Many building owners indicated the windows were original to the building, which aligned with a visual examination of the window conditions. As such, using the age of the multifamily buildings as a proxy variable for the age of the single-pane windows, Figure 3 shows that the average age of the inefficient window systems is much longer than the current 20 year useful life limit imposed in California. .[12] A large majority of the buildings were over 40 years.

Using existing conditions (single pane windows) as the baseline, DOE2.2 modeling simulations of window upgrades in multifamily buildings provided estimated average savings of 0.19 therms per square foot of window in gas-heated buildings (averaged over a variety of gas heating types and efficiencies) and 2.54 kWh per square foot of window for buildings heated and/or cooled with electricity.[13] Average savings per window (assuming a 3'x5' window) are 2.9 therms for gas-heated buildings and 38.1

[12] Mandatory U-factors for windows were first introduced into Title 24 in 2013. Dual glazing was a compliance option under the prescriptive compliance path as early as 1982. (N. Stone, Stone Energy Associates, pres. comm., May 5, 2016).
[13] Modeling performed by the Association for Energy Affordability.

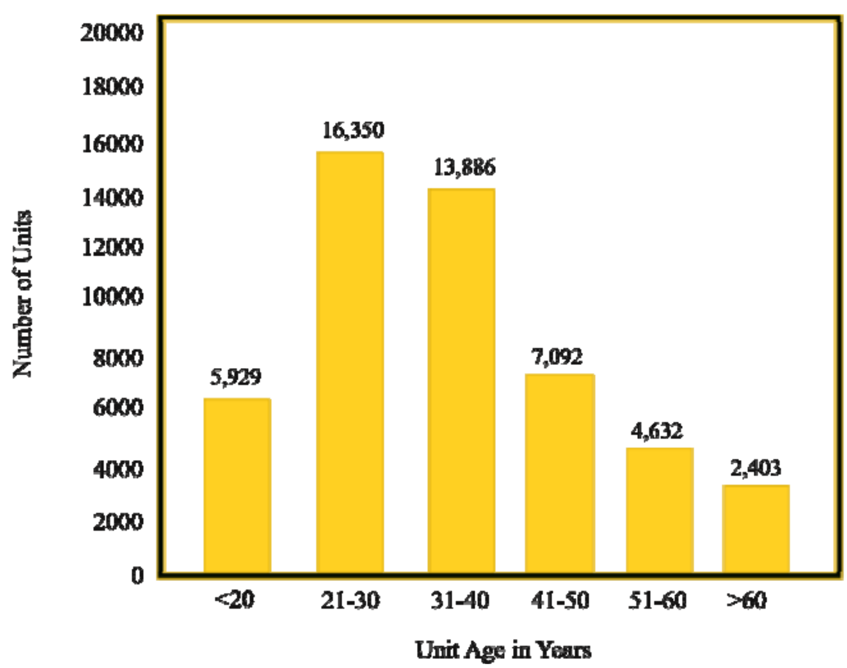
kWh for electric buildings.[14] These savings can be significant in medium to large multifamily buildings where the average residence has four or more windows.

Topics for Further Analysis

Early implementation of AB 802 offered California an opportunity to pilot the concept of Repair Indefinitely measures during the first nine months of 2016. In fact, the CPUC's *Ruling Regarding High Opportunity Energy Efficiency Programs or Projects* only allowed deemed measures that "can be reasonably defined as 'repair indefinitely" to apply for existing conditions baseline treatment during the initial implementation period (Assigned Commissioner, 2015). Such interest from the regulator certainly indicates a strong possibility of further reliance on the RI measure category in the future. In preparation of this broader roll out, and informed by the early implementation experience, it will be important to consider the following topics for further analysis.

Addressing General "Reparability," or "Repair Eligible" Equipment

There are many systems that have a clear and documented history of repair over replacement, but for which the length of that "reparability" period is in question. For instance, the Cal TF subcommittee analyzed data that showed a significantly long tail in the distribution of the lifetimes of existing commercial rooftop HVAC units. The data, as displayed in Figure 4, clearly shows that significant percentages of commercial rooftop HVAC units are repaired and kept in service long past the 15-year useful life estimated for that equipment in California.



[14] Heating equipment ranged across various types and efficiencies. Gas heating included in-unit wall furnaces, FAUs, and central heating systems. The savings of 2.9 therms were an average of all of the types encountered. Electric heating was nearly always electric resistance.

Figure 4: Distribution of age of commercial rooftop HVAC units across California.
Source: California implementer data; program participants.

How to deal with this type of "repair eligible" equipment that is not quite RI but nonetheless represents a significant energy efficiency opportunity must be decided in order to fully optimize the energy efficiency industry's ability to address all savings potential in existing buildings. This decision can be informed as initial program data begins to prove or disprove the ex ante free ridership estimates; the existing Cal TF subcommittee is likely the most appropriate forum for this discussion.

Removing Further Barriers to Customer Access

One of the key requirements for granting equipment RI baseline treatment is that it be in functioning order. This requirement is a useful and often used ratepayer protection mechanism. It helps minimize program dollars spent on the replacement of equipment that would have been retired regardless of program influence.

In terms of ease of program administration, this requirement would be an improvement over the current requirement that each rebate application prove that the replaced equipment would have been kept in service for at least another year. However, this requirement does still limit implementers' ability to reach customers at an important decision point: when their equipment has failed, they are in the market for either repairs or a replacement, and have already been forced to invest capital. Requiring that equipment be operational limits access to this very promising set of customers. The costs and benefits of this limitation (foregone savings opportunities vs. ratepayer protection from free ridership expenditures) must be weighed against each other when deciding the optimal program design for RI implementation.

Capturing Savings from Remaining Missed Opportunities

The subcommittee was not able to address the other two types of missed opportunities it identified at the beginning of its work: Code Trigger and Non-Code Trigger additions. However, to the extent that these opportunities are "building envelope and shell measures" (insulation, ventilation, add on controls, water fixture replacements, etc.), CPUC Staff has recently proposed that those savings be counted from an existing conditions baseline. The rationale behind this proposal is that buildings can feasibly operate without these measures and they are rarely voluntarily installed. This is expected to keep free ridership low enough to allow full existing conditions baseline treatment for all "envelope" measures.

Conclusion

California's strict energy codes will ensure that the state's next generation of buildings will be the most efficient ever. Yet, focusing only on those next-generation buildings would ignore the inefficiencies embedded in the earlier generations of buildings. The state legislature has already recognized the savings potential being "stranded" by requiring the use of code baselines for existing building retrofits. The new Repair Indefinitely measure category described in this paper offers an implementation-ready path for beginning to address some of the most significant savings opportunities to and through code. Testing the new approach through implementation of the case study measures already characterized in this paper will allow programs to collect field data to further refine measure estimates, adjust program rules, and optimize the industry's ability to both capture savings in existing buildings and protect ratepayer funds.

References

Benningfield Group and BKi. 2015. *PROP Final Report and Energy Code Resource Guide.* Oakland: ABAG. https://www.bayren.org/sites/default/files/BayREN_CS_PROP_Final_Report_2015_0401.pdf

DNV GL. 2014. *HVAC Permitting: A Study to Inform IOU HVAC Programs.* San Francisco: PG&E. http://www.calmac.org/publications/FINAL_REPORT_PGE_HVAC_Permitting_for_IOU_Programs_Study_v20141010.pdf

DNV GL and Cadmus. 2014. *Statewide Codes and Standards Program Impact Evaluation Report for Program Years 2010-2012*. San Francisco: CPUC. http://www.calmac.org/publications/CS_Evaluation_Report_FINAL_10052014.pdf

Edmister, T., and Peterman, C. 2015. *Assigned Commissioner and Administrative Law Judge's Ruling and Scoping Memorandum Regarding Implementation of Energy Efficiency "Rolling Portfolios."* Rulemaking 13-11-005. San Francisco: CPUC.

Edmister, T., and Peterman, C. 2015. *Assigned Commissioner and Administrative Law Judge's Ruling and Scoping Memorandum Regarding High Opportunity Energy Efficiency Programs or Projects.* Rulemaking 13-11-005. San Francisco: CPUC.

McHugh, J., D. Mahone, M. Bruceri, and P. Eilert. 2010. "A New Class of Retrofits: 'Repair Indefinitely." In *Proceedings of the 2010 ACEEE Summer Study of Energy Efficiency in Buildings*. Washington, DC: ACEEE. http://www.aceee.org/files/proceedings/2010/data/papers/2079.pdf

Navigant. 2012. 2011 Vermont Market Characterization and Assessment Study. Montpelier: Vermont Public Service Department. http://psb.vermont.gov/sites/psb/files/docket/7676/IOPA/DPS/2011 VT Commercial and Industrial Existing Buildings Market Assessment Draft Final Report.pdf