Crosscutting Technical Position Paper No. 1
Savings To Code Subcommittee

Overview

The California Technical Forum (Cal TF) launched its Savings To Code subcommittee in early 2015 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 subcommittee's work is summarized in this Technical Position Paper, which contains key findings from the existing literature and program data. It also includes actionable implementation recommendations that could be used to support the Commission's process to meet the tight implementation deadlines of Assembly Bill 802.

Key Findings

1. One of the greatest opportunities for capturing "to code" savings is in Repair Indefinitely (RI) measures. The concept of RI measures is defined in the Key Findings section of this paper.

- As has been shown by extensive evaluations of IOU Codes & Standards (C&S) programs, there is little "to code" savings potential remaining in new construction.[1]
- While there does appear to be some "to code" savings opportunities in permitted and non-permitted alterations of existing buildings, it is much more difficult to estimate the savings potential from such alterations.[2]
- Per the work of this subcommittee, as described in the following sections, it is feasible to characterize and target RI opportunities that could be captured from voluntary retrofits not mandated by code.

2. Key High Opportunity measures were, and should continue to be, identified by collecting and analyzing existing program data, and data *readily available* from other sources.

Key Recommendations

1. The California Public Utilities Commission (CPUC) should adopt Repair Indefinitely (RI) as a deemed measure type such that savings and other measure parameters can be established through the existing workpaper review process.

- The rule set proposed in the following sections can be used to make up-front determinations about the initial list of RI measures.

[1] DNV GL and Cadmus, *Statewide C&S Program Impact Evaluation Report for Program Years 2010-2012*.
[2] See Benningfield Group, BKi, ABAG*, PROP Final Report and Energy Code Resource Guide*, 2015, p3.

- Further data requirements during measure implementation to establish whether a particular project will qualify for existing conditions baseline should be minimized so as to reduce barriers to customer adoption in this class of already costly retrofit opportunities.
- Implementation of measures estimated with readily available data, even if that information is initially limited, can enable collection of increasingly robust data sets.

2. Initial RI measure determinations and savings estimates should be based on existing and readily available data. Additional data can be collected through implementation of RI measures to validate savings and establish "reasonable expected values" for a more permanent workpaper. However, initial measure characterization should not be dependent on overly burdensome data requirements.

Background and Process

Regulatory Background

Early in the CPUC's current Energy Efficiency rule making (R13-11-005), several interveners requested that the Commission revisit its practices on energy efficiency baselines. At that time Commission decisions and implementation practices had created a default baseline assumption of the highest applicable code, standard, or Industry Standard Practice determination.[3] Program Administrators (PAs) and other interveners argued that the de facto requirement that customers independently bring existing buildings up to Title 24 standards threatened the PA's ability to capitalize on time-limited Proposition 39 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 Rolling Portfolio in 2017, at which time they expected both Commission Staff and interveners to have compiled sufficient empirical data for the requisite evidentiary record.[4]

In the meantime, the state 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 code baseline. 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 contracts the timeline that the Commission was expecting to have for discussing, establishing, and implementing existing conditions baselines.

[3] 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.
[4] Assigned Commissioner and Administrative Law Judge's Ruling and Scoping Memorandum Regarding Implementation of Energy Efficiency "Rolling Portfolios" (Phase II of Rulemaking 13-11-005), February 24th, 2015, at 10.

Subcommittee Process

The Cal TF's Savings To Code subcommittee was launched 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[5] 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. Their recently completed work is now being made available to assist the CPUC in their hastened implementation of AB 802's legislative mandates.

The subcommittee's work was rooted in a comprehensive literature review performed by Cal TF staff.[6] This work revealed that while the various formal evaluations of the IOU's Codes & Standards programs have been a useful tool in measuring Title 24 and 20 compliance in new and significantly altered buildings, those studies can not be used to inform policies for the existing building stock. This is because all of those test samples are heavily skewed towards new construction and definitely limited to buildings that have received significant alteration permits.[7] 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 the of permitted alterations, where work is commonly not done consistent with permitting requirements.[8] 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. In fact, Cal TF staff's exhaustive research of the existing literature, including non-Commission funded work inside and outside of California, revealed that there is not enough readily available statistically significant studies on the subject of savings to code in existing buildings to reliably inform the implementation of AB 802.

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[5] Subcommittee Co-Champions: Armen Saiyan and Doug 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).

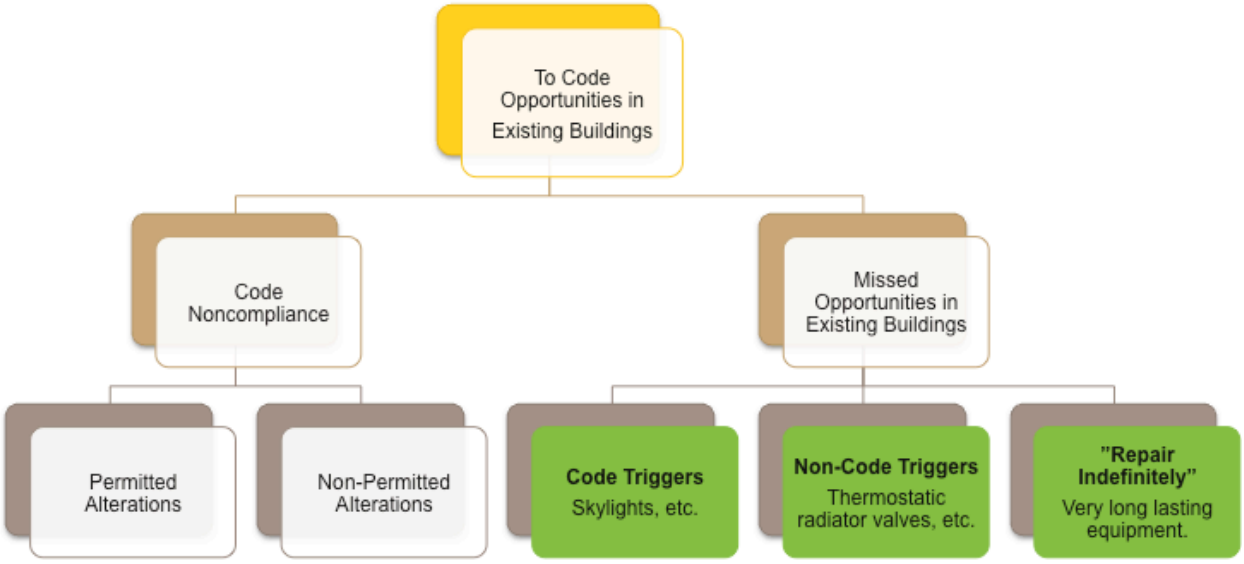
[6] See Appendix D for an annotated bibliography of existing and ongoing work on performance of existing buildings as measured against current codes.

[7] DNV GL and Cadmus, *Statewide Codes and Standards Program Impact Evaluation Report for Program Years 2010-2012*: http://www.calmac.org/publications/CS_Evaluation_Report_FINAL_10052014.pdf

[8] See Benningfield Group, BKi, ABAG*, PROP Final Report and Energy Code Resource Guide*, 2015, p3 for a helpful discussion about the different types of non-compliance discussed in this paragraph. • HVAC *Permitting: A Study to Inform IOU HVAC Programs*, 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,* Navigant for the Vermont Public Service Department, 2012, p.123-124, lists the most frequent cases of under-performance in permitted equipment.

Key Findings

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. This categorization is illustrated in the following chart and explained below:



There are two main types of savings potential below Title 24 standards: A range of code non-compliance 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. Given the lack of readily available data and open policy questions surrounding using ratepayer dollars to fund actions required by code, the subcommittee focused the bulk on their work on the "missed opportunities" type.

The are three sub-categories of "missed opportunities:" Code Triggers are voluntary building upgrades that, when initiated, trigger energy code compliance and thereby increase the cost of installing the upgrade; Non-Code Triggering Additions are additions or changes in existing buildings where owners are not required to upgrade, program incentives or other program activity can cause them to upgrade, and no code is triggered; "Repair Indefinitely" (RI) describes equipment that customers already own and typically repair rather than replace past its deemed expected useful life.[9] The subcommittee concluded that RI measures hold some of the greatest, most easily achieved below code potential—those with the largest savings stranded by code,

[9] McHugh, J., D. Mahone, M. Bruceri, and P. Eilert. 2010. A New Class of Retrofits: "Repair Indefinitely" Proceedings of the 2010 ACEEE Summer Study of Energy Efficiency in Buildings. Washington, D.C.: American Council for an Energy-Efficient Economy http://www.aceee.org/files/proceedings/2010/data/papers/2079.pdf. See answer to question four for a deeper discussion.

about which data is most likely to be readily available, and for which programs could be created while avoiding the potential pitfalls already highlighted by the Commission.[10]

Defining Repair Indefinitely (RI) Measures

RI measures involve equipment that is less prone to catastrophic failure than a typical measure,[11] can be repaired long after its boilerplate life, and is operationally and logistically costly to replace in its entirety. Large multifamily and commercial boiler systems are a model example of an RI measure as the savings resulting from upgrading existing boilers will not be realized absent program intervention. 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, and well past the Commission's 20-year limit on EULs. According to current Commission equipment lifetime assumptions, the 1930's 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.[12] The unnecessary carbon emissions from this RI equipment could have been curtailed decades ago by energy efficiency program incentives that sufficiently reflected the real savings from the retrofit, which should be calculated as existing conditions to the efficiency of the new boiler, rather than an artificial Title 24 baseline compared to the new boiler efficiency

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-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 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).

Key High Opportunity measures were, and should continue to be, identified by collecting and analyzing existing program data.

In the absence of readily available studies on savings from RI measures—as was shown by Cal TF staff's extensive literature 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. Appendices A and B use data sets from current and past programs to demonstrate how two particular measure opportunities—multifamily boilers and windows—fall

[10] D14-10-046, October 16, 2014, p. 55

[11] 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.

[12] 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.

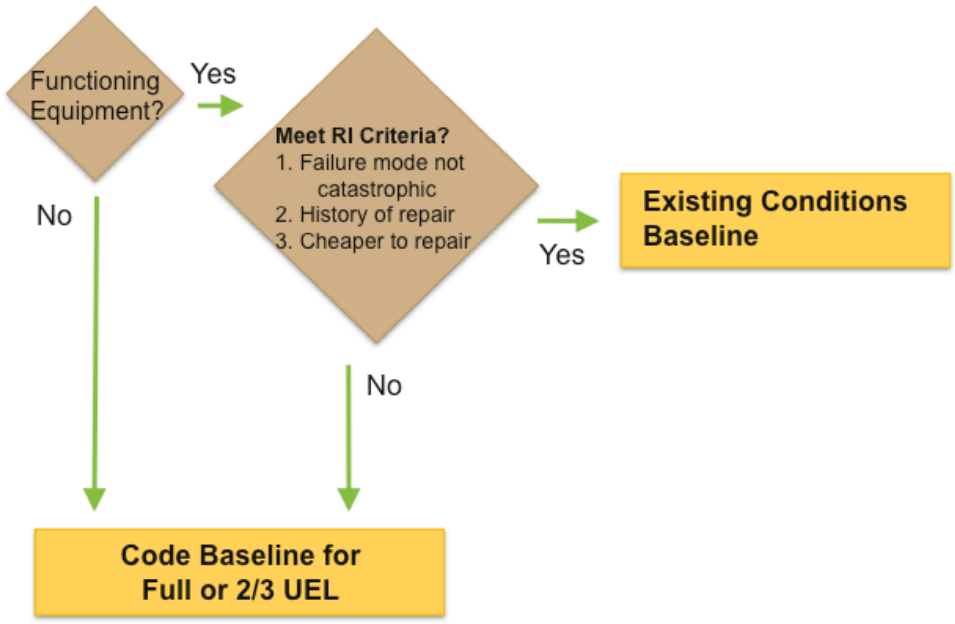
within the RI category. The appendices also identify savings and market potential from these measures.

Key Recommendations

The California Public Utilities Commission (CPUC) should adopt Repair Indefinitely (RI) measure as deemed measures to be reviewed and approved through the existing workpaper process.

The subcommittee recommends that the measure characterizations in Appendices A and B be used to test a new RI measure type that uses existing conditions baseline throughout the measure life of the replacement equipment. It will be important for program efficacy that deemed RI measures not have additional data collection requirements during program implementation to establish whether the measure in a particular instance should be allowed the "existing conditions" baseline. This will allow PAs and the CPUC to reach more customers and collect data through program implementation to refine rule sets and program requirements.

The following rule set was used by the subcommittee to determine whether a measure qualifies as RI and thus should be eligible for existing conditions baseline for the life of the measure without further on-site data collection for the sample RI measures in Appendices A and B. It can also be used by the CPUC as they identify future RI measures and how savings from these measures should be calculated.



There are three criteria that a potential measure must meet before it can be qualified as RI: The type of equipment or system to be retrofitted must not have a catastrophic failure mode; it must have a history of repair; and it must be more economical to repair than to replace. The satisfaction of these three ex ante requirements can be documented in a format similar to the one used by the subcommittee in their two appended sample characterizations. 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, it may be feasible to use conservative proxy values to estimate existing conditions baselines. For instance, if the median age of a sample of equipment in the field is 50 years, the approximate equipment efficiency of that piece of equipment 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. RI measures are costly, burdensome retrofits already 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.

The Initial Determination of Whether a Savings Opportunity can be considered an RI Measure Should Be Based on Already Available Data.

Cal TF staff's thorough literature review and the subcommittee's early work demonstrated that there exists no "systematically catalogued" data (surveys, potential studies, etc.) to support "to code" RI measures at this time. The only currently available sources of information are case studies and program data. This type of evidence should not be categorically dismissed as anecdotal, since it is currently best available information. Instead, future RI characterizations should be required to demonstrate that measures meets the three key criteria using existing data.

Conclusion

California's Zero-Net-Energy goals and the strict energy codes that will make them possible will ensure that the next generation of buildings will be the most efficient ever. Yet, focusing only on those next-generation goals would ignore the inefficiencies left behind by all of the generations before now. The state legislature has already recognized the savings potential being "stranded" by code baselines in existing buildings. The findings and recommendations in this document can be the first step towards implementing the legislative mandates of AB 802 and ensuring that all of the state's saving potential is captured.

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Approved by:	Savings To Code Subcommittee
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Appendix A:
Repair Indefinitely Multifamily Boilers Characterization

I. Measure Description

Steam and hot water boilers involve complex systems often virtually "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 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 disruptions associated with such a project, building owners overwhelmingly choose to repair individual system components as they fail over retrofitting the entire machine. This results in boilers regularly exceeding their boilerplate lives by decades.

II. Estimated Savings Potential per Project

The savings estimates in this section are based on a 2010 San Francisco Environment (SFE) program funded by the American Reinvestment and Recovery Act (ARRA) that replaced inefficient boilers in 177 multifamily sites within the City of San Francisco.[13] The boilers replaced ranged from some of the city's first low-pressure steam residential applications to much more modern hot water boilers. Over the course of two years, **SFE reported 164,465 annual Therms in savings from their boiler replacement activities. The average savings claimed per project was 1,015 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.

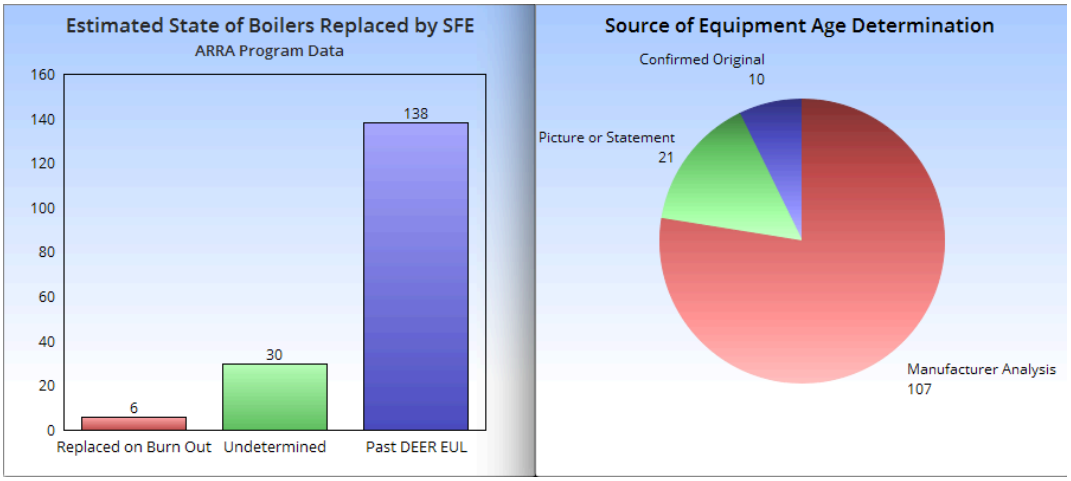
Savings were calculated ex ante and reported to the Department of Energy (DOE) and City of San Francisco based on existing IOU methodologies modified by internal SFE engineering calculations as needed to adapt to the federally-funded program guidelines. While the exact calculations were not available for review as part of this characterization, it is worth noting that the saving estimate outputs were accepted by DOE as valid evidence of results from federal tax dollar investments.

III. Estimated Market Potential

This section leverages the same SFE ARRA program data to estimate the percentage of residential boilers that are kept in service long past their boilerplate life/DEER EUL.[14] **Cal TF**

[13] This measure characterization only takes into account savings attributed to boiler replacement and disregards all other savings claimed by the program.
[14] Market potential is not limited to Northern California. Upon request from the subcommittee, The Energy Coalition identified 16 potential local government boiler replacement projects in Southern California.

Staff reviewed all available documentation for each of the project and was able to estimate that roughly 77% of the equipment replaced by the program had been maintained in operation significantly past its DEER EUL of 20 years.



Cal TF staff's analysis consisted of a combination of project documentation review and industry trends and manufacturer analysis. Not surprisingly, given the extended age and corrosion of many of the boilers and lack of record keeping at time of installation, only ten of the 177 projects had explicitly documented the age of the replaced equipment; 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 approximate 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.[15]

Importantly, only six of the projects out of the 177, under 4%, were determined to have been replaced upon equipment burn out (ROB).[16] That number ROB projects can be compared against the 138 boilers estimated to have been replaced significantly after their DEER EULs to **approximate a free ridership estimate of less than 4% would-have-been ROB projects that were given incentives at an existing conditions baseline**.

Given the strong evidence of market potential presented in this characterization, the limited availability of further market data, and the cost of deducing an individual piece of equipment's exact age, the subcommittee recommends that multifamily boilers be deemed as a Repair Indefinitely measure. Furthermore, the subcommittee also recommends that once the measure is deemed Repair Indefinitely, data collection requirements for individual projects be restricted as much as possible so as to not create any more barriers to customer adoption

[15] The remaining 20 projects were conservatively labeled "Undeterminable."

[16] Only 3 boilers were explicitly labeled emergency replacements upon failure; the other 3 were still in service but had serious leaks, so the conservative assumption of ROB was made.

Appendix B:
Repair Indefinitely Multifamily Windows Characterization

I. Opportunity Description.

In the realm of energy efficiency, windows operate as system: While individual panes may get replaced with a similar technology as they are broken or damaged, the real opportunity for retrofitting to a more energy efficient state is to replace the system as a whole. 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 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. Window systems in multifamily buildings are the quintessential Repair Indefinitely measure.

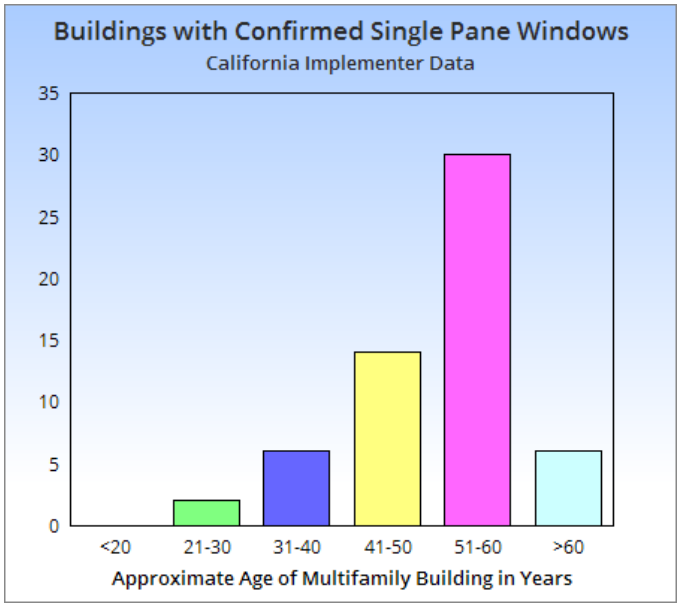
II. Estimated Savings Potential per Project

Using existing conditions as a baseline, DOE2.1e modeling simulations of window glazing in multifamily buildings estimate savings of .19 Therms per square foot of window for gas-heated buildings and 2.54 kWh per square foot of window for building heated and/or cooled with electricity.[17] **Average savings per window are 2.9 Therms per 15 square foot window (typical 3 ft by 5 ft model) for gas-heated buildings and 38.1 kWh by equal dimension window for electric buildings.** These savings can be significant in medium to large multifamily buildings where the average residence has about four windows.

III. Estimated Market Potential

The following graph depicts the age of 58 multifamily buildings retrofitted in the 9-county BayREN territory. All of the buildings in this sample had single-pane, aluminum frame windows, which, given the advanced ages of the buildings in the sample, can be inferred to have been in operation for longer than the 20 year DEER EUL cap.

[17] Modeling performed by the Association for Energy Affordability.



The data in the above graph shows that that single pane windows are maintained in multifamily buildings decades past the current 20-year EUL cap on all early retirement measures. Based on the real savings and market potential demonstrated by this data and DOE2.2 modeling, the subcommittee recommends that multifamily windows are also deemed as Repair Indefinitely measures.

Appendix C:
Commercial Rooftop HVAC
Opportunity for Further Study

I. Measure Description

Replacing a rooftop HVAC system can cost between $873/ton and $6977/ton;[18] performing aggressive maintenance and minor replacements to make the system last long past its DEER Estimated Useful Life of 15 years can cost as little as $137/ton[19]. Like with multifamily boilers, the lower cost and ease of repairing different system components compared to replacing the entire rooftop unit make repair and maintenance the prevalent choice by many building owners.

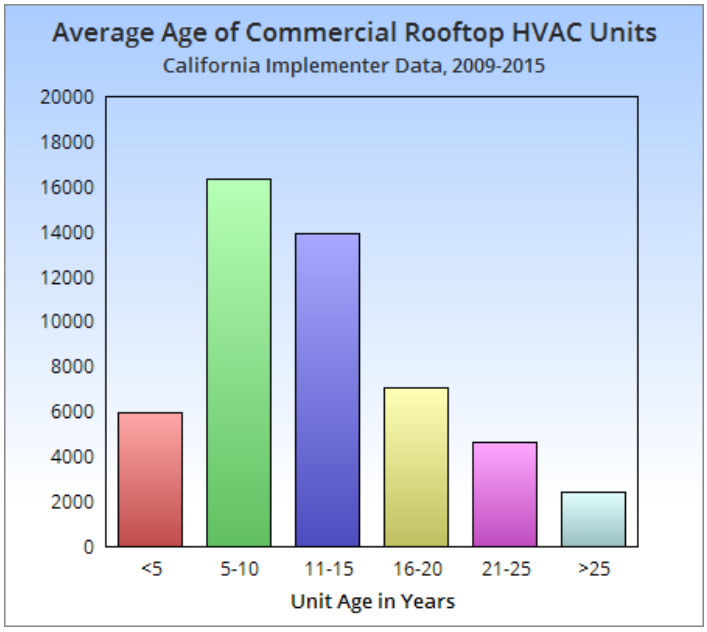
II. Estimated Savings Potential per Project

In California, retrofitting a rooftop HVAC unit in a commercial building creates about 174 kWh of savings per ton of handling capacity.[20]

III. Estimated Market Potential

The following market potential graph uses data from programs from 2009 through 2015 to show that age of many commercial HVAC rooftop units in the market exceed the 15 year DEER EUL for package air conditioning units. As is clearly shown by the graph below, almost 30% of the over 50,000 units in this sample were maintained in operation past their DEER EUL. Furthermore, 2,403 (almost 5%) had been kept in service for more than ten years longer than their DEER EUL. The size of the sample is large enough to suggest that roughly the same percentage of commercial HVAC rooftop units are kept in service for longer than 15 years throughout the California market, and therefore that the current paradigm is leaving the oldest, least efficient HVAC equipment on the state's grid.

[18] DEER2016-Costs_PkgHVAC-Boilers_8-21-2015-DRAFT (sorted for commercial DX AC equipment)
[19] CPUC's 2010-2012 WO-017 Ex Ante Measure Cost Study
[20] This value is the savings estimate from current Commercial Quality Maintenance IOU workpapers averaged across California's climate zones and all applicable building types.



The data available for this measure characterization does not show that commercial rooftop HVAC units are kept in service as long past their DEER EULs as other clearly RI measures. However, the bars in the right hand side of the chart do show that significant numbers of very old HVAC units are repaired and maintained in service long past their 15-year EUL. The subcommittee recommends that this measure be studied further in hopes that program parameters can be adjusted to better capture the oldest, least efficient units remaining on the grid.

Appendix D:
Annotated Below Code Resource Bibliography

Code Noncompliance

Compliance in Permitted Buildings

The descriptions below summarize research to identify code non-compliance in permitted facilities (primarily new construction) and to quantify savings that would result if the facility had complied with code. Program interventions targeting code non-compliance must subtract from their savings claim the percent of buildings that would have achieved compliance absent the program intervention.

- **The Cost of Enforcing Building Energy Codes**
  Alison Williams et. al. (LBNL), 2014
  http://aceee.org/files/proceedings/2014/data/papers/4-76.pdf
  Literature review found that the cost (on local governments) of enforcing building codes ranges from $50 to $200 per residence and from $150 to $1,000 per commercial building.
  [Longer LBNL paper has listing of compliance rates by state. California surveys seem a little dated, but the most recent ones estimate 50% and 25% compliance rates for commercial and residential new construction and retrofits: http://eetd.lbl.gov/sites/all/files/lbnl-6181e.pdf]
- **I Want CANDI: Establishing a Utility Code Compliance Program in Illinois**
  MEEA, Nicor Gas, UIC, 2014
  http://aceee.org/files/proceedings/2014/data/papers/6-963.pdf - page=1
  Roadmap for a statewide energy code compliance program that measures compliance, converts compliance rates into energy usage and savings, attributes savings to programs, allocates costs, and calculates cost effectiveness. The cost effectiveness calculation does not seem to directly address free ridership, but does assume that only 30% of new construction buildings can improve their compliance via the program.
- **Residential New Construction Baseline Study of Building Characteristics Homes Built After 2001 Codes**
  Itron for PG&E, 2014
  http://www.calmac.org/startDownload.asp?Name=RNC_2003_Final_Report1ES.pdf
  Impact evaluation conducted in 2004. Approximately 27% of sites are identified as non-compliant. A significant percentage (4% to 31% depending on climate zone) was also found indeterminate.
- **Statewide Codes and Standards Program Impact Evaluation Report for**

Program Years 2010-2012
DNV GL and Cadmus for CPUC, 2014
http://www.calmac.org/publications/CS_Evaluation_Report_FINAL_10052014.pdf
The study finds over 100% compliance for the new construction and significant alteration segments, but 'a closer examination shows divergent results for individual codes and standards.' The evaluation methodology uses a compliance adjustment factor for alteration with a less than precise 90% confidence interval between 26% and 47% and DEER interactive effects when calculating potential goals (potentially underestimating the modeled performance of code compliant buildings).

- **2011 Vermont Market Characterization and Assessment Study**
  Navigant for the Vermont Public Service Department, 2012
  - New Construction and Major Renovation (C&I)
    http://psb.vermont.gov/sites/psb/files/docket/7676/IOPA/DPS/2011 VT Commercial and Industrial Existing Buildings Market Assessment Draft Final Report.pdf
    Finds 88% compliance with applicable code in a set of permitted buildings. Has a helpful table with breakdown of non-compliant features (p. 123-124).
- **BayREN Code Compliance Study**
  The Benningfield Group, BKi, ABAG, 2015
  https://www.bayren.org/sites/default/files/BayREN_CS_PROP_Final_Report_2015_0401.pdf
  In 2014 the Association of Bay Area Governments, on behalf of the BayREN, visited fifteen building licensing agencies in its territory and evaluated (via site visits) compliance of construction projects permitted by each of the visited agencies. Key findings from the PROP pilot—including a characterization of what typical errors in permit applications and compliance are—were used to design compliance tools for agencies in the BayREN territory.
- **Driving Innovation, Rewarding Performance: Seattle's Next Generation Energy Codes and Utility Incentives**
  Seattle City Light, Preservations Green Lab, City of Seattle DPD, 2014
  http://aceee.org/files/proceedings/2014/data/papers/6-496.pdf
  Describes code compliance incentive calculation method based on building performance demonstrated during a post-occupancy monitoring period. The initial monitoring period was set for 12 months after the building reached 75% occupancy. Could be model for a below code incentive program.
- **Moving beyond 'Better than Code': New Market Transforming Zero Net Energy Aligned Residential New Construction Programs**
  TRC, the four CA IOUs, 2014

http://aceee.org/files/proceedings/2014/data/papers/2-1265.pdf
New construction program that uses metrics to determine how close energy use is to the floor (ZNE), not how far it is from the ceiling (codes). Could be another model for a below code incentive program.

Compliance in Non-Permitted Projects

Like the cases of noncompliance described in the previous section, the savings opportunities in this section are assumed to be 'outside the Title 24 law.' Also like the opportunities in the previous section, these may present very real opportunities for cost-effective energy efficiency to benefit all Californians, However, much less is known about the actual savings potential from completely unpermitted projects. Collecting information about what isn't being reported to authorities is always difficult and costly. The subcommittee attempted to understand this space and best practices for capturing savings within it as much as possible. The studies below suggest that upgrades that are 'behind the wall' have high rates of non-compliance.

- **Contractors Walk on the Wild Side: Why?**
  Kristin Heinemeier, UC Davis, 2013
  http://wcec.ucdavis.edu/wp-content/uploads/2013/07/Kristin-Heinemeier-ACEEE-2012.pdf
  WHPA survey of over 250 HVAC contractors purports to explain why such few contractors pull permits. The survey found that the majority of contractors believe that there is a low probability of getting caught for not pulling permits and that the costs of getting caught for 'behind the wall' or smaller projects is not significant. Furthermore, contractors believe there is a high probability of losing bids if they choose to pull permits. These findings don't necessarily contradict higher compliance levels found by impact evaluations, since those studies model compliance from a set of permitted buildings.
- **Draft Research Plan for HVAC Permit and Code Compliance Market Assessment**
  DNV GL, 2015
  http://www.performancealliance.org/Portals/4/Documents/Committees/Goal1/HVAC%20WO_06%20Draft%20Final%20MAPC%20Research%20Plan_23Jan2015.pdf
  2014-2016 work will attempt to document permitting and compliance practices for residential HVAC replacements. According to the Background section, California's Long-Term Strategic Plan set the goal of 50% permitting rate for all HVAC installations by 2015. This suggests discrepancies in assumptions on baseline permitting.
- **HVAC Permitting: A Study to Inform IOU HVAC Programs**

DNV GL for PGE, 2014
http://www.calmac.org/startDownload.asp?Name=FINAL_REPORT_PGE_HVAC_Permitting_for_IOU_Programs_Study_v20141010ES.pdf&Size=258KB
Preliminary permitting data pulled by PG&E's Code Compliance program found 38% and 13% permitting rates for residential and commercial change-outs that did not participate in IOU programs.

- **SMUD Residential HVAC Program Evaluation**
  RLW Analytics and Benningfield Group for SMUD, 2008
  http://www.performancealliance.org/Portals/4/Documents/Committees/EMV/SMUD - RLW Mar 08.pdf
  Found that 96% of residential HVAC units in territory are below code efficiency. Survey shows that 30% of HVAC replacements (non-participants) are permitted, and 15% of the same set are duct-tested.
- **Navigant Baseline Study**
  As a consequence of D.14-10-046 in the ongoing Rolling Portfolio rulemaking, CPUC Staff engaged Navigant to study the feasibility and consequences of using baselines other than code for utility programs. The scope of work for this project hasn't been finalized yet, but the Commission hopes to have results in time to inform Phase Three of R.13-11-005 in 2016.
- **Center for Sustainable Energy HVAC Permit Compliance Study**
  As part of its HVAC Permit Compliance Pilot, CSE conducted a survey or building department officials, contractors, and other actors to cull out current best practices in permitting. The report is currently in draft form.

Missed Opportunities in Existing Buildings

"Repair Indefinitely"

Cal TF staff found a few studies that document the actual age of equipment, and which demonstrate, in practice, that some equipment is typically in use long after the "expected useful life" contained in DEER.

- **A New Class of Retrofits: "Repair Indefinitely"**
  McHugh, J., D. Mahone, M. Bruceri, and P. Eilert. 2010, Proceedings of the 2010 ACEEE Summer Study of Energy Efficiency in Buildings.
  http://www.aceee.org/files/proceedings/2010/data/papers/2079.pdf
  This paper was the first to propose the Repair Indefinitely measure category. It includes an estimation of the potential that could be captured from small commercial lighting and skylighting through Repair Indefinitely treatment.
- **Amnesty for Ancient Boilers**
  Matthew Greco, City and County of San Francisco, 2012
  http://aceee.org/files/proceedings/2012/data/papers/0193-000135.pdf

Describes City program that supplemented IOU incentives for boiler replacement in multifamily buildings. May have a good set of data, could be used to compare against boiler replacement with only IOU dollars. Audits performed found that many of the heating systems in existing multifamily buildings were installed right after the 1906 San Francisco earthquake.

- **Recycling, Waste Stream Management, and Material Composition of Major Home Appliances**
  AHAM, RW Beck, Weston, 2005
  Contains statistically significant estimates of EULs for appliances. Many of the sources cited are comparable to those found in DEER.
- **2011 Vermont Market Characterization and Assessment Study**
  Navigant for the Vermont Public Service Department, 2012
  - Existing Buildings (C&I)
    http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/EVT_Performance_Eval/VT CI Existing Buildings Market Assessment and Characterization_2012-10-6_FINAL.pdf
    Small sample and doesn't explicitly look at code compliance, si(for a similar tnce codes do not apply to existing buildings. However, finds that average HVAC unit age is 24 years, 61% of small units are below code efficiencies, and an even greater percentage do not have economizer (as directed by code if and when retrofitted). The report doesn't calculate remaining savings potential for this 'below code' equipment, but does detail the distribution of equipment in service by efficiencies and ages.