**Measure Review of the CMUA TRM and CPUC’s**

**Database for Energy Efficiency Resources (DEER)**

**Overview and Background**

This document details the findings and recommendations from the Cal TF subcommittee tasked with reviewing a subset of measures from the California Municipal Utility Association (CMUA) Technical Reference Manual (TRM)[[1]](#footnote-1) and the California Public Utility Commission’s (CPUC) Database for Energy Efficient Resources (DEER).[[2]](#footnote-2)

This document includes the following information:

* General observations made during the subcommittee review process
* Recommendations on next steps for California’s ex ante development process for use by both publicly and investor-owned utilities based on the subcommittee findings and observations
* Detailed findings and recommendations for the subset of TRM and DEER measures reviewed by the subcommittee
* Summary of source data found when researching EULs in DEER/Remote Ex-Ante Database Interface (READI) for measures under review (see appendix)

The list of measures from the TRM and DEER shown in Table 1 were selected based on an assessment of the most impactful Investor-Owned Utility (IOU) measures for 2014, assessment of the overlap between the TRM and DEER measures, and input from the subcommittee members. The TRM leverages DEER as a source for measure information in many cases, and several of the TRM measures selected are based on historic DEER measures or IOU workpapers that incorporate elements of DEER.

|  |  |
| --- | --- |
| **Measure** | **Reviewed[[3]](#footnote-3)** |
| Clothes washer | TRM |
| Appliance recycling | TRM, DEER |
| Low flow showerheads | TRM, DEER disposition |
| Faucet aerators | TRM, DEER disposition |
| Residential LEDs | TRM, DEER  |
| Commercial LEDs | TRM, DEER  |
| Commercial air conditioners | TRM, DEER  |
| Whole House Fans | TRM, DEER |
| VFDs for pumps and motors | TRM, DEER  |
| EC motors for refrigeration | TRM, DEER  |

1. **General Observations**

**Format and Documentation**

The TRM consists of a PDF summarizing measure details in addition to supporting Excel workbooks with a list of measure combinations[[4]](#footnote-4) and, in some cases, measure calculations. This format is accessible, easy to follow, and available online. The sources for the majority of assumptions used to establish measure parameters (energy savings, measure life, measure cost) are included in footnotes and/or the supporting workbooks. In many cases, IOU workpapers are referenced that are not publicly available and have since been updated by the IOUs. Additionally, there is little to no discussion of assumptions that appear to be based on professional judgment.

Current DEER measures are found in the READI tool which is downloadable from the DEER website. The READI tool is a database that displays very brief measure definitions and unit energy savings values for different measure combinations and is difficult for an unfamiliar user to navigate. The space available to provide measure descriptions in READI is limited which in certain cases makes it difficult to completely describe the measure. Sources and assumptions used to establish the energy savings values are not included in the READI tool, and EUL information is listed in a separate table that can be traced to individual measures through an EUL ID. It is also important to note that the EUL ID and the Measure ID for the same measure do not match and are not linked. Some documentation for measure savings and EULs can be found in supporting excel workbooks and reports on the DEER website, but generally it is not a straightforward process to identify source documentation, and know whether it is either current or relevant. Also, many documents are included on the DEER website that are not clearly linked to a measure in READI, and appear to be either out-of-date and/or the relevance of the documentation to measures in READI is not clear.

**Reproducibility and Transparency**

The reproducibility of the TRM values depends on the sources used to support the energy savings assumptions. Values based on DEER are not reproducible in most cases, and if sufficient documentation exists, are only reproducible if one is familiar with the DEER format and documentation is available and can be located.

DEER values are generally not reproducible and assumptions lack transparency.

Many EULs seem to be very dated, sources are difficult to find, and some are based on “best professional judgment” rather than data or studies, while some date back to the mid to late 1980’s (See appendix for detailed EUL/RUL research on each measure).

**Other Jurisdictions / Best Practices**

*Form*

The subcommittee considered information from the TRMs of 22 other jurisdictions. While these TRMs varied considerably in their format, documentation, reproducibility, and transparency, the following observations were made regarding best practices:

* Well-documented with clear citations of primary sources linked directly to TRM content via footnotes or endnotes (instead of listed with no cross-references at the end).
* Effective formatting that enables information to be located and digested easily.
* Clear and detailed explanations of all assumptions, including professional judgment.

*Content*

* Interactive effects were typically applied to residential lighting measure to account for additional savings due to reduced cooling loads, however increased heating energy was not accounted for in most cases.
* A combination of building simulations, algorithms, and engineering calculations are used to estimate HVAC and refrigeration measure savings in the various TRMs
1. **Recommendations**

As part of the planned 2016 POU TRM update, review the measure specific data compiled and consider the observations and recommendations provided for each measure during that process. Longer term, consider the potential to participate in the development of a statewide repository that could be used by both POUs and IOUs to provide consistent savings values statewide, regardless of program administrator.

Based on its findings, the subcommittee recommends that the following be considered in the development of statewide ex ante values that can be used by both municipal and investor-owned utilities.

* **Ex ante measures should be documented in a “Technical Reference Manual” format.** Information is easier to access in the TRM format than the DEER format, however best practices for TRM development should be identified to ensure the most effective format and tool. DEER’s primary location for measure information is the READI tool, which has a steep learning curve and does not list references, assumptions, or other relevant supplemental information from the DEER website. This subcommittee relied on Cal TF staff’s experience with DEER to describe relevant DEER information for measure discussions given the time-consuming and challenging task of interpreting DEER.
* **Measure documentation should contain the level of detail and transparency contained in IOU workpapers**. Workpapers clearly explain the methods and assumptions used to establish cost-effectiveness parameter values as well as appropriate references at a level that enables reproducibility of workpaper values. While the CMUA TRM contains extensive references, many of the references are historical IOU workpapers that are not publicly accessible or DEER measures that are insufficiently documented. Consequently, many of the CMUA TRM values are difficult to reproduce. Additionally, DEER documentation of the references, assumptions, and methods one would need to clearly reproduce and vet DEER values is either not published or incomplete.
	1. In order for DEER information to be leveraged for measures moving forward at the level of documentation and transparency on par with IOU workpapers, additional information on DEER references, assumptions, and methods would need to be provided by the DEER ex ante development team.
	2. References should be primary sources. A common practice in TRM development (and workpaper development, in some cases) is to reference secondary sources. Referencing a secondary source requires one to locate the secondary source to determine the primary source of information. When TRMs reference other TRMs as sources, in some cases the original source cannot be identified. It is important to reference primary sources so the reader can immediately determine the applicability and credibility of the source, and whether better or newer information exists for a specific measure application.
* **Create guidelines for measure development.** The Cal TF currently has three Technical Position Papers in draft form which will be finalized in early 2016. They address three foundational issues associated with measure development going forward:
	1. Modeling Tool Assessment
	2. Measure Complexity
	3. Defining “Best Available Data”

The modeling tool assessment paper addresses specific criteria that need to be considered when selected a default modeling tool:

* Policy/Regulatory – Policy and regulatory directives and goals.
* Operational – Ease of accessing, using, modifying and extending modeling tools; ratepayer benefits; cost and cost-sharing opportunities; ability to collaborate in development/updating activities.
* Technical – Technical capabilities for performing energy modeling for newer measures that are needed to meet California’s energy savings goals.

The measure complexity paper addresses the measure complexity issue and proposes guidelines to maintain the integrity of savings estimates, while ensuring there is not inordinate amounts of analysis performed for marginal changes in projected savings. Finally, the “Best Available Data” paper puts forward a proposal for establishing data requirements after careful consideration of several sources of information. Sources reviewed included over twenty state l TRMs, the Uniform Methods Project (UMP), and the U.S. EPA Draft EM&V Guidance for Demand-Side Energy Efficiency associated with the Clean Power Plan (CPP).

* **Develop a statewide electronic Technical Reference Manual (TRM).** The Cal TF currently has a draft Technical Position Paper developed by the DEER Improvements Subcommittee that outlines in detail the potential benefits of an electronic TRM versus the status quo. It draws from best practices around the country to lay out a state-of-the-art plan to optimize process, structure and content of the proposed electronic TRM. Some of the key benefits include ensuring all measures are fully documented with a workpaper that is publicly available, uses an open source tool for modeled measures, automates measure updates when inputs change with clear update and revision history and provides clear and documented workflow management. Establishment of the electronic TRM can create a credible resource that could be adopted statewide to ensure all energy savings are captured consistently and accurately.
* **Create a clear process and timeline**. The Cal TF draft Technical Position Paper developed by the DEER Improvements Subcommittee also outlines a process and timeline for the conversion. The design transitions all California measures to the electronic TRM within two years. The plan allows sufficient time and Cal TF review resources to ensure that all measures can be documented and reviewed as needed and migrated to the consolidated electronic repository. This is accomplished via a four track approach that divides the type of existing measures according to existing documentation and review history in order to apply the right treatment to each set. Three key groups would be chiefly responsible for implementing this plan: Cal TF staff, the Technical Forum with participation from the CPUC Staff, and external contractors and PA staff.
1. **Next Steps**

Because significant resources and expertise have gone into the development of DEER, this document explores several options for the role of DEER in a statewide TRM moving forward, consistent with the subcommittee recommendations described in Section III of this document. These options are discussed below.

1. **Document all DEER measures**

Under this scenario, all DEER measures would be documented in workpaper format to be transitioned into a statewide TRM. This is the least viable option of the three discussed due to the resources required to document all DEER measures due to the organization of DEER information through the READI tool and on the website. Additionally, the level of documentation of DEER measures is likely below what would be required to support a workpaper to ensure workpaper content is detailed, transparent, and reproducible.

1. **Identify what is valuable, readily accessible, and current in DEER**

Under this scenario, the information in DEER that is most thoroughly documented, and which has been or can be vetted by third parties, will be evaluated for use to support a statewide TRM. For example, lighting operating hours based on impact evaluations, lighting coincident factors, and the CPUC’s recent cost study may meet the standards of accuracy, transparency, and validity for a statewide TRM

1. **Develop a New California Statewide Electronic TRM**

Under this scenario, each measure would have a workpaper, all measures (including measures developed by third parties (non-utility workpaper developers) and POUs would be housed in a single repository for statewide-consistent values, and all measures would be reviewed through a statewide, collaborative process as is done in other jurisdictions, and consistent with how DEER was originally developed and managed to ensure measure accuracy, validity, transparency, and applicability.

The details (substance, process and timing) of the proposed statewide Electronic TRM are further described in a separate Cal TF Technical Position Paper. However, key elements of the proposed Statewide Electronic TRM are:

* Identify and Follow TRM Best Practices (Structure, Process, Content) – The California Electronic TRM would be developed consistent with TRM best practice research.
* EnergyPlus Default Model– For modeled measures, EnergyPlus rather than DOE 2.2/EQuest/MAS as DOE2.2/EQuest/MAS is not open source, not widely supported beyond a small group of individuals, lacks the capability to model emerging energy efficiency technologies, is infrequently updated, and contains default assumptions and algorithms that are neither well-documented, public nor transparent.
* DEER Assumptions, Methods, Approaches Only if Meet Standards of Accuracy, Transparency, Documentation, Reproducibility and not Out-of-Date.

**Conclusion**

Establishing a single statewide web-based (electronic) TRM is an important next step in ensuring California's leadership position in energy efficiency.  Furthermore, developing a well-documented, transparent, accurate and consistent repository that is used statewide is consistent with state and federal policy objectives and directives.  Developing this process through a collaborative, public process with staff input will ensure that the information represents best available data and reflects input from a broad range of experts in California and nationally.

1. **Individual Measure Recommendations**
2. **LED MR16**

**Findings and Recommendations**

Table 1. Residential LED MR16

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Residential in-dwelling 7 Watt LED MR16 replacing a 35 Watt or 50 Watt halogen | Residential indoor multifamily common area 7 Watt LED MR16 replacing a 29.69 Watt halogen | Only one jurisdiction included MR16s; the rest included various res and/or commercial LED measures, mostly for omnidirectional lamps. | N/A |
| **Baseline Derivation** | ENERGY STAR calculator which indicates a 7-10 Watt LED as a replacement for a 35 Watt halogen, appears combined with professional judgment | Baseline wattage = wattage ratio x measure wattage. Wattage ratio of 4.24 reported in a 2012 IOU workpaper disposition. Wattage ratio likely derived from PG&E workpaper, however workpaper assumptions do not lead to a ratio of 4.24 exactly. | * Almost no MR16 measures, none with measure/base wattage values reported
* For LED lamps/reflectors, typically professional judgment to establish baseline or lumen equivalents
* In one TRM, MR16 baseline wattage was established using ENERGY STAR Center Beam Candle Power (CBCP) tool
 | * For MR16, Center Beam Candle Power method best for directional lighting
* For general lamp types, use lumen-based approach with justification for selection of representative wattages from a range using sales weighted data
* Do not use wattage ratios since they are not representative of real life performance
 |
| **Unit energy savings (UES)** | kWh = kW x HOU x IESource: calculation parameters from [DEER 2013](http://deeresources.com/files/DEER2013codeUpdate/download/DEER2014-Lighting-IE_and_Adjustment-Factor-Tables-17Feb2014.xlsx)HOU: 541 hrs/yr (Res in unit) | kWh = kW x HOU x IESource: Values taken from READI v2.2.0, calculation parameters from [2016 DEER](http://deeresources.com/files/DEER2016/download/DEER2016_Lighting-HOU-CDF-IE-Update_25May2015.xlsx) HOU: 6142 (MFM common area)*Note: 541 hrs/yr all Res in-unit* | kWh = kW x HOU x IETypical LED lamp sources:* HOU, CF from logged data /EM&V
* SFM HOU from 800 – 1200 hrs/yr
* MFM HOU common area around 6000 hrs/yr (one TRM)
* IE typically calculated using algorithm with assumptions about system cooling efficiency, % of homes with central cooling, and modeling from an ASHRAE article
 | * Hours of Use: 2016 DEER, check the evaluation studies used to support the DEER assumptions to determine if a more appropriate value would be suitable for MR16 applications, and to determine if DEER HOU values are reproducible and why the value is lower than other jurisdictions.
* IE: Recommend not including IE for residential applications unless empirical evidence supports a significant impact of interactive effects on system savings
 |
| **Demand Savings** | KWpeak = kW x CF x IE | KWpeak = kW x CF x IE |  | * The coincident factor should use 2016 DEER assumptions which were derived from metering data
* IE: Recommend not including IE for residential applications unless empirical evidence supports a significant impact of interactive effects on system savings
 |
| **EUL** | Rated life of 25,000 hoursEUL = 15 yrs Source: Consistent with [ENERGY STAR qualified product list reported lamp life](http://www.energystar.gov/productfinder/product/certified-light-bulbs/results) (manufacturer reported)States max EUL of 15 years with no discussion | Rated life of 20,000 hoursEUL Limit of 16 year EUL = rated life / annual hrsSource: Lighting workpaper disposition – cap at 16 years, downlight fixture would only last every 16 years20,000 hrs for MR16 specifically, lowest rated hours in ENERGYSTAR 2012 | Typically 25,000 hour lifeMax LED lamp EULs generally 15 years (persistence cited in some cases) | * Rated Life: Use 25,000 unless other studies exist to support a lifetime assumption that goes beyond manufacturer ratings
* Investigate whether studies exist to support an EUL cap based on LED fixture life and not CFL fixture life
* See if Title 24 rulemaking includes any information on lamp life
 |
| **IMC** | Measure cost $33Source: “Retail data obtained from online research” – appears combined with professional judgment | No cost values | One MR16 IMC of $25 ($3 base, $28 measure)Other LED lamp IMCs in $15 - $60, but not differentiated well by lamp type, wattage, lumen output | * Cost values from TRM, workpapers, other jurisdictions seem high and out-of-date
* CPUC IMC study’s hedonic price model for LED lamps is based on old data that likely does not reflect the current market. Additionally, cost values cannot be calculated to the level of granularity (pack size, lamp type) needed.
* Energy Solutions webcrawling results for LED codes & standards work ideally could be used to support LED workpaper cost values
* Otherwise, more recent retailer data would be appropriate
 |

HOU = annual hours of use (hrs/yr)

IE = energy interactive effects (whole building consumption / direct end use consumption)

CF = coincident factor (kW peak / kW total)

Table 2. Commercial LED MR16

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Commercial interior 5 Watt pin-based LED MR16 replacing a 35 Watt or 50 Watt halogen | Commercial exterior 7 Watt LED MR16 | Only one jurisdiction included MR16s; the rest included various res and/or commercial LED measures, mostly for omnidirectional lamps. | N/A |
| **Baseline Derivation** | Commercial interior 20 Watt pin-based halogen MR16Source: unknown, likely professional judgment | Baseline wattage = wattage ratio x measure wattage. Wattage ratio of 4.24 reported in a 2012 IOU workpaper disposition. Wattage ratio likely derived from PG&E workpaper, however workpaper assumptions do not lead to a ratio of 4.24 exactly. | * Almost no MR16 measures, none with measure/base wattage values reported
* For LED lamps/reflectors, typically professional judgment to establish baseline or lumen equivalents
* In one TRM, MR16 baseline wattage was established using ENERGY STAR Center Beam Candle Power (CBCP) tool
 | * For MR16, Center Beam Candle Power method best for directional lighting
* For general lamp types, use lumen-based approach with justification for selection of representative wattages from a range using sales weighted data
* Do not use wattage ratios since they are not representative of real life performance
 |
| **Unit energy savings (UES)** | kWh = kW x HOU x IESource: calculation parameters from [DEER 2013](http://deeresources.com/files/DEER2013codeUpdate/download/DEER2014-Lighting-IE_and_Adjustment-Factor-Tables-17Feb2014.xlsx)HOU: 541 hrs/yr (Res in unit) | kWh = kW x HOU x IESource: Values taken from READI v2.2.0, calculation parameters from [2016 DEER](http://deeresources.com/files/DEER2016/download/DEER2016_Lighting-HOU-CDF-IE-Update_25May2015.xlsx) HOU: 6142 (MFM common area)*Note: 541 hrs/yr all Res in-unit* | kWh = kW x HOU x IETypical LED lamp sources:* HOU, CF from logged data /EM&V
* SFM HOU from 800 – 1200 hrs/yr
* MFM HOU common area around 6000 hrs/yr (one TRM)
* IE typically calculated using algorithm with assumptions about system cooling efficiency, % of homes with central cooling, and modeling from an ASHRAE article
 | * Hours of Use: 2016 DEER, check the evaluation studies used to support the DEER assumptions to determine if a more appropriate value would be suitable for MR16 applications, and to determine if DEER HOU values are reproducible and why the value is lower than other jurisdictions.
* IE: Use DEER 2016 in lieu of other sources since the factors generally seem in-line with other jurisdictions.
 |
| **Demand Savings** | KWpeak = kW x CF x IE | KWpeak = kW x CF x IE | KWpeak = kW x CF x IE | * The coincident factor should use 2016 DEER assumptions which were derived from metering data
 |
| **EUL** | Rated life of 25,000 hoursEUL = 5 - 15 yrs (varies by building type)Source: unknown, likely ENERGY STAR and professional judgment | Rated life of 20,000 hoursEUL Limit of 12 years EUL = rated life / annual hrsSource: Lighting workpaper disposition – cap at 12 years, downlight fixture would only last 12 years. | In 15 year range for LED lamps, less information for commercial applications. | * Rated Life: Use 25,000 unless other studies exist to support a lifetime assumption that goes beyond manufacturer ratings
* Investigate whether studies exist to support an EUL cap based on building retrofit schedules or other limiting factors
* See if Title 24 rulemaking includes any information on lamp life
 |
| **IMC** | Measure cost $33Source: “Retail data obtained from online research” – appears combined with professional judgment | No cost values | One MR16 IMC of $25 ($3 base, $28 measure)Other LED lamp IMCs in $15 - $60, but not differentiated well by lamp type, wattage, lumen output | * Cost values from TRM, workpapers, other jurisdictions seem high and out-of-date
* CPUC IMC study’s hedonic price model for LED lamps is based on old data that likely does not reflect the current market. Additionally, cost values cannot be calculated to the level of granularity (pack size, lamp type) needed.
* Energy Solutions webcrawling results for LED codes & standards work ideally could be used to support LED workpaper cost values
* Otherwise, more recent retailer data would be appropriate
 |

HOU = annual hours of use (hrs/yr)

IE = energy interactive effects (whole building consumption / direct end use consumption)

CF = coincident factor (kW peak / kW total)

1. **Residential Clothes Washers**

**Findings and Recommendations**

Table 3. Residential Clothes Washers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Clothes Washer with Modified Energy Factor (MEF) of 2.0 – 2.4 | No current measure as of April 2015 |  | Update measure level to reflect changes in Title 20 efficiency metric and efficiency level |
| **Baseline** | Clothes washer with MEF of 1.26Source: Federal standard through 3/2015 or CA Title 20 through March 2015 | No current measure as of April 2015 |  | Update baseline to the he new Title 20 standard which requires clothes washer integrated modified energy factor (IMEF) of 1.29 (standard) or 1.84 (front-loading), respectively |
| **Unit energy savings (UES)** | kWh/yr = capacity(ft3) x (cycles/yr) / MEFSource: ENERGY STAR calculator TRM assumes 312 cycles/yr based on arbitrary selection of 6 cycles/weekENERGY STAR Assumptions: * 295 cycles/yr from [2012 DOE Technical Support Document](http://www.regulations.gov/) for federal standard, in turn derived from [2005 RECS study](http://www.eia.gov/consumption/residential/index.cfm)
* kWh/cycle for units derived using 392 cycles/yr per [DOE Federal Test Procedures](http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=b48736ddbf29fcfe9285bb7ea3e524e1&r=SUBPART&n=10y3.0.1.4.18.2)
* MEF 2.0 unit assumed to consume 186 kWh/yr based on EPA “research for available models”
* Per cycle energy distribution: 20% machine energy, 80% water heating energy (no source)
* Unit capacity of 3.1 ft3, “EPA research on available models”
* Gas water heater efficiency of 75% per [DOE Federal Test Procedure](http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=b48736ddbf29fcfe9285bb7ea3e524e1&r=SUBPART&n=10y3.0.1.4.18.2)
 | No current measure as of April 2015 | * RECS data for cycles/yr (CA-specific data available for 2009)
* IL and RTF TRMs use CEC appliance database to determine average efficiency and capacity for given measure levels (may require shipment weighting if possible)
 | * Consider using IOU workpaper as basis for IMEF methodology moving forward
* Use 2009 RECS survey data available with CA-specific values (weighted average of CA “homes that use a clothes washer” appears to be 261 cycles/yr
* Use water heater recovery efficiency
* Use [DOE TSD (Ch 7, p 7-7)](http://www.regulations.gov/) for split between machine, dryer, water heating energy
 |
| **Demand Savings** | No demand savings | No current measure as of April 2015 |  |  |
| **EUL** | 11 yearsSource: DEER 2011, cites Appliance magazine; other potential sources are 2012 CLASS CW age saturation, 2009 RECS CA data with CW age saturation | No current measure as of April 2015 | Some jurisdictions cite 14 years, [2012 DOE CW TSD](http://www.regulations.gov/) indicates CW life of 14.2 years, per RECS data and Appliance magazine / manufacturer data | Use [DOE TSD (Ch8](http://www.regulations.gov/)) for clothes washer EUL |
| **IMC** | $165 - $277Source: PG&E workpaper, likely 2008 DEER cost values which are no longer current | No current measure as of April 2015 |  | Consider IOU workpaper as potential source |

1. **Appliance Recycling**

**Findings and Recommendations**

Table 4. Appliance Recycling

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Unit recycled, removed from service  | Unit recycled, removed from service | Unit recycled, removed from service |  |
| **Baseline** | Continued appliance use / grid impact  | Continued appliance use / grid impact  | Continued appliance use |  |
| **Unit energy savings (UES)** | 616 kWh per refrigerator recycled643 kWh per freezer recycled(Per DEER 2011 unit energy savings for refrigerators and freezers) | Updated in DEER 2016 Refrigerator range 226-438 kWhFreezer range 235-484 | Vast majority UES values based on in situ impact evaluation | TRM should update values to 2016 DEER values when availableConsider using multiple climate zones, or weight climate zones together vs. selecting a single representative value for each. |
| **Demand Savings** | Refrigerator- 0.124 kW; freezer – 0.129 kW | DEER2016Refrigerator range .0295-.0774 kWFreezer range .0341-0843kW | ∆kW=kWh/8766\*CFCF= coincidence factor defined as summer kW/average kW | TRM should update values to 2016 DEER values when availableConsider using multiple climate zones, or weight climate zones together |
| **EUL** | Refrigerators – 5 yrs Freezers – 4 yrs (2011 DEER) | Refrigerators – 5 yrs Freezers – 4 years  | RULs vary from 5-8 yearsRequires assumptions about average age of existing refrigerators, which may differ by regionA few TRMs include a 1.25% annual degradation factor leading to annual savings increases as units age (Cited NV 2010 Refrig. Recycling report) |  |
| **IMC** | $100Recycling cost  | (2008 DEER, costs no longer valid)  | Measure costs in $100-$120 range (program cost) | Re-visit how the measure cost feeds into cost-effectiveness calculations to ensure represented correctly |

1. **Whole House Fans**

**Findings and Recommendations**

Table 5. Whole House Fans

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Installation of a whole-house ventilation fan  | Install whole house fan | Install whole house fan (solar in HI) | Measure has evaluation risk based on how user operates system, ensure customer educated on proper use. |
| **Baseline** | Home with air-conditioning and sufficient attic ventilation to exhaust fan’s rated flow  | No night ventilation/economizer | Home with central air-conditioning and no whole-house fan (PA, TN)Home with Energy Star room air-conditioner and no whole-house fan (HI) |  |
| **Unit energy savings (UES)** | Varies based on climate zone, values from CEC Case Study, savings and cost table provided in TRM spreadsheet | Modeled DOE2.2 natural ventilation feature | Modeled (REM/Rate, eQUEST) | Assess if DEER may be a better source for savings estimates since it models multiple building types while CEC Case Study only models SF 2700ft2 residence. Note in WP SCE13HC005 R1 suggests DEER significantly overestimates energy consumption of fan motor, further investigate. |
| **Demand Savings** | NA | NA | NA |  |
| **EUL** | 20 year (DEER) | 20 years  | PA 15 years, DEERTN 20 years, DEERHI 5 years |  |
| **IMC** | Varies based on CFM required and climate zone  | Did not find in READI  | Not provided |  |

1. **Low Flow Showerheads**

**Findings and Recommendations**

Table 6. Low Flow Showerheads

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Installation of a low-flow showerhead that reduces flow to 2 GPM or lower  | Installation- 1.5, 1.6, 1.7, 2.0 GPM showerhead. In READI, version “ExAnte2015” | All TRMs reviewed have similar measure for installation of low-flow showerheads but most include deemed values for 1.5 GPM installation | Consider adjusting measure case in TRM from 2 GPM to 1.5 GPM to match other TRMs and DEER |
| **Baseline** | Existing showerhead with a flow of 2.5 GPM or higher  | Pre-existing showerhead 2.25 GPM In READI, version “ExAnte2015” | Base case for showerheads 2.2-2.5 GPM |  |
| **Unit energy savings (UES)** | UES based on PGE3PDHW116 and DEER:2011 Update, Itron, Nov 8, 2011Electric water heater savings 2 GPM showerhead:SF 124.5 kWh, MF 64.4 kWhGas water heater savings 2 GPM showerhead:SF 7.6 therms, MF 7.1 therms | Uniform set of savings values that are applicable to all IOUs (after applying climate adjustment factor) provided in worksheet in workpaper disposition for water fixtures dated February 22, 2013 from CPUC Energy Division (ED) | TRMs have savings algorithms clearly specified along with necessary inputs and in most cases references for those inputs, easy to replicate savingsIn the Il TRM they include an adjustment for “drain factor” which attempts to count only usage of the sort that would go straight down the drain (as opposed to volume based usage like filling a pot of water). By consensus they use 90% for bathrooms and 75% for kitchens | Consider adopting statewide savings values outlined in WP disposition.Review calculation methodology and measure input values from other TRMs to determine if higher savings values may be appropriate in CA. Subcommittee felt like some of the national numbers were quite high, but that the CA savings for low-flow showerheads might be conservative.Incoming groundwater temperature explains some of the variations in savings estimates across the country.Evaluate if it would be beneficial to distinguish between primary and secondary shower savings. |
| **Demand Savings** | UES based on PGE3PDHW116 and DEER:2011 Update, Itron, Nov 8, 2011Electric water heater savings .5GPM aerator:SF 0.027 kW, MF 0.014 kW | Uniform set of savings values that are applicable to all IOUs (after applying climate adjustment factor) provided in worksheet in workpaper disposition for water fixtures dated February 22, 2013 from CPUC Energy Division (ED) | TRMs have savings algorithms clearly specified along with necessary inputs and in most cases references for those inputs, easy to replicate savings | TRM says based on 0.5 GPM aerator but believe is should have been 2.0 GPM showerheadConsider adopting statewide savings values outlined in WP disposition.Review calculation methodology and measure input values from other TRMs to determine if higher savings values may be appropriate in CA.Incoming groundwater temperature explains some of the variations in savings estimates across the country. |
| **EUL** | 10 years (DEER\_EUL\_Summary\_10-1-2008.xls) | 10 years, no new info to change DEER 2005 EUL (From EUL/RUL values (Updated 10 Oct 2008) link on DEER 2011 page)  | Most common value for LF showerhead is 10 years (IL, MN, NW RTF). WI FOE uses 12 years. |  |
| **IMC** | $45.96  | Values found in READI (Technology Cost), reference to IOU WP and match POU TRM value $45.96 | MN $12, IL $12, NW RTF $31WI $5  | Review IMC noting significantly lower costs in many TRMs |

1. **Low Flow Faucet Aerators**

**Findings and Recommendations**

Table 7. Low Flow Faucet Aerators

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Installation of an aerator that reduces flow to 1.5 GPM or lower  | Installation of LF aerator Kitchen 1.5 GPMLavatory 0.5, 1.0, 1.5 GPM In READI, version “ExAnte2015”  | Installation of LF aerator Kitchen 1.5-2.2 GPMBathroom 1.0-1.5 GPM  |  |
| **Baseline** | Existing faucet with a flow of 2.2 GPM or higher  | Pre-existing lavatory 2.2-2.41 GPM, kitchen 2.2-2.5 GPMIn READI, version “ExAnte2015” | Kitchen aerators from 2.5-2.75 GPMFaucet Aerators from 2.25-2.5 GPM  |  |
| **Unit energy savings (UES)** | UES based on PGE3PDHW116 and DEER:2011 Update, Itron, Nov 8, 2011 (had to extrapolate values for 1.0 and 1.5 GPM based on 0.5 GPM values). Deemed values listed on page 15-7 of CMUA TRM | Uniform set of savings values that are applicable to all IOUs (after applying climate adjustment factor) provided in worksheet in workpaper disposition for water fixtures dated February 22, 2013 from CPUC Energy Division (ED) | TRMs have savings algorithms clearly specified along with necessary inputs and in most cases references for those inputs, easy to replicate savingsIn the Il TRM they include an adjustment for “drain factor” which attempts to count only usage of the sort that would go straight down the drain (as opposed to volume based usage like filling a pot of water). By consensus they use 90% for bathrooms and 75% for kitchensNW RTF doesn’t include aerators and questions whether they save energy, especially in kitchen applications | Consider adopting statewide savings values outlined in WP disposition.Review calculation methodology and measure input values from other TRMs to determine if higher savings values may be appropriate in CA. Subcommittee felt like some of the national numbers were quite high, but that the CA savings for low-flow showerheads might be conservative.Incoming groundwater temperature explains some of the variations in savings estimates across the country. |
| **Demand Savings** | UES based on PGE3PDHW116 and DEER:2011 Update, Itron, Nov 8, 2011. Deemed values listed on page 15-8 of CMUA TRM | Uniform set of savings values that are applicable to all IOUs (after applying climate adjustment factor) provided in worksheet in workpaper disposition for water fixtures dated February 22, 2013 from CPUC Energy Division (ED) | TRMs have savings algorithms clearly specified along with necessary inputs and in most cases references for those inputs, easy to replicate savings | Consider adopting statewide savings values outlined in WP disposition.Review calculation methodology and measure input values from other TRMs to determine if higher savings values may be appropriate in CA.Incoming groundwater temperature explains some of the variations in savings estimates across the country. |
| **EUL** | 10 years (DEER\_EUL\_Summary\_10-1-2008.xls) | 10 years (EM&V report for the gas-only multifamily efficiency program #197-02 (was 9 years in DEER 2005)). From EUL/RUL values (Updated 10 Oct 2008) link on DEER 2011 page)  | IL 9 yearsMN 10 yearsWI 12 years |  |
| **IMC** | $13.24  | Values found in READI (Technology Cost), reference to IOU WP and match POU TRM value $13.24 | WI $3-&5IL $8MN $6.70 | Review IMC noting significantly lower costs in many TRMs |

1. **EC Motors for Refrigeration**

**Findings and Recommendations**

*Table 8.* EC Motors for Refrigeration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | High efficiency EC motor (ECM) with a minimum efficiency of 66%  | Not Found in DEER | High Efficiency EC motor  | Review data on Q-Sync motor technology (permanent magnet synchronous AC motor, no need to rectify to DC). Preliminary results suggest significant savings potential compared to EC Motor. |
| **Baseline** | Shaded-pole (SP) display case evaporator fan motor with no controls  | Not Found in DEER | Most TRMs also assume ECM is replacing shaded pole motor although some assume a percentage of the replacements will be permanent split capacitor (PSC) motors  | Re-evaluate if the baseline assumption of 100% shaded pole motors is still appropriate or should a baseline mix should be determined to reflect a certain level of PSC motors in the market. Alternatively, have separate deemed calculations based on the baseline condition found (SP or PSC).  |
| **Unit energy savings (UES)** | Savings analysis is from IOU workpaper (PGE3PREF124-R1) which includes DOE-2.2 modeling.UES 705 kWh per motor | NA | Algorithms provided, no modeling noted | Is building modeling necessary or is an engineering algorithm acceptable for calculating deemed savings. |
| **Demand Savings** | Savings analysis is from IOU workpaper (PGE3PREF124-1) which includes DOE-2.2 modeling.Peak demand reduction 0.073 kW | NA | Algorithms provided, no modeling noted |  |
| **EUL** | 15 years (from DEER\_EUL\_Summary\_10-1-2008.xls | 15 years (from DEER\_EUL\_Summary\_10-1-2008.xls) | Most TRMs use 15 year EUL and site DEER as the source | EUL data in DEER appears to be very old. Look for an additional source to verify or update the value.  |
| **IMC** | $169Source PG&E Workpaper | NA  | Il- $50, NW RTF $83, MN $100, CO $88, VT $120  | Re-evaluate IMC based on much lower costs from other TRMs |

1. **Commercial Air Conditioners**

**Findings and Recommendations**

*Table 9.* Commercial Air Conditioners

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Varies based on unit size, efficiency, building types, climate zones<5 tons up to 20 tons14, 15 SEER10.5 – 12 EER | Varies based on unit size, efficiency, building types, climate zones  | Varies based on unit size and efficiency, region in some cases |  |
| **Baseline** | 2013 Title 24Source: DEER 2014  | 2016 Title 24 | Varies depending on standard used |  |
| **Unit energy savings (UES)** | Varies, POU TRM references 2014 DEER, which is based on DOE-2.2 building simulations | DEER2016 (DOE-2.2 building simulations) | Most use an engineering algorithm to calculate savings | UES methodology: building model or engineering algorithm? Building model ouput and engineering equations should be compared with field data |
| **Demand Savings** | POU TRM references 2014 DEER, which is based on DOE-2.2 building simulations | DEER2016 (DOE-2.2 building simulations) | Most use an engineering algorithm to calculate savings |  |
| **EUL** | 15 yearsSource: DEER 2008 | 15 yearsSource: unknown  | 15 years | EUL lacks documentation. Tracking through READI sources leads to “Commercial AC class set to 15”. Investigate other potential sources to update or verify. |
| **IMC** | $20 - $200 / tonSource: PG&E Workpaper, distributor cost quotes  | No official costs, however CPUC measure cost study (WO 17) contains hedonic price model for DX AC <= 5 tons and >5 tons  | Around $100 - $160  |  |

1. **VFDs on Pumps and Fans**

**Findings and Recommendations**

Table 10. VFDs on Pumps and Fans

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **TRM** | **DEER** | **Other Jurisdictions** | **Subcommittee Recommendations** |
| **Measure Description** | Retrofit of a pump or fan system by installing a variable frequency drive (VFD) for variable load or fixed load control  | D03-051VSD Supply Fan MotorsVFD with 30% min-cfm-ratio | A variable frequency drive (VFD) installed on a n HVAC pump or fan motor  |  |
| **Baseline** | Fans (constant volume, inlet guide vane, inlet damper box, eddy current drives, outlet damper)Pumps (mechanical flow control, recirculation, throttle valve)  | damper controlled VAV with 30% min-cfm-ratio | Assumes a constant speed motor where air or water volume/temperature is controlled using valves, dampers, inlet guide vanes  |  |
| **Unit energy savings (UES)** | Project specific savings are calculated using the TRM401 energy savings calculator, semi-custom measure | DEER2005 (modeled for building type, vintage and climate zone) | Algorithm provided∆ kWh= [(HP x 0.746) / ŋBASE] x HOURS x ESF | Can methodologies from other TRMs be adopted to make this a deemed savings measure?If so, should a HP threshold be set, with larger applications still utilizing energy savings calculator?Evaluate the potential to increase savings by including interactive effects for certain fan motors operating in the conditioned envelope (ref: IL TRM) |
| **Demand Savings** | In general, no peak demand reduction. Possible there is a 2%-5% demand penalty due to efficiency losses when VFD controller operating at 100% flow | DEER2005 (modeled for building type, vintage and climate zone) | Algorithm provided∆kW=[(HPx0.746) / ŋBASE] x DSF x CF  | Re-evaluate the potential for peak demand (kW) reductions |
| **EUL** | 15 years | 15 years  | Small range (13-15 years) |  |
| **IMC** | varies  | varies  | Varies, lots of cost data provided |  |

**Appendix**

**EUL/RUL Research**

The following appendix compiles data gathered in an attempt to use READI and DEER to determine the source for the EUL on select measures reviewed in this document. The first four columns come directly from READI and the fifth column is a summary of the data gathered from READI or DEER associated references.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure & EUL ID from READI  | EUL/RUL  | Version  | Version Source  | Referencing the Source  |
| FreezerRecycling:Appl-RecFrzr  | RUL4 years  | DEER2014  | D08v2.05 (DEER 2008 Public Version)  | EUL for DEER 2006-2007 changed from DEER2005 value from 10 yrs. to 4 yrs. Comments in “Data Source/Estimation Approaches” states “One-third of the equipment useful life”. No source for 12 year EUL provided and no source or logic provided for the one-third value.  |
| Refrigerator Recycling:Appl-RecRef  | RUL5years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | EUL for DEER 2006-2007 changed from DEER2005 value from 10 yrs. to 5 yrs. Comments in “Data Source/Estimation Approaches” states “One-third of the equipment useful life”. No source for 15 year EUL provided and no source or logic provided for the one-third value. |
| High Efficiency Clothes Washer:Appl-EffCW  | EUL11 yearsRUL 3.7 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | EUL for DEER 2006-2007 changed from DEER2005 from 14 yrs. to 11 yrs. Comments in “Data Source/Estimation Approaches” cites Energy Efficiency Policy Manual v2, Appliance Magazine and ENERGY STAR calculator (uses Appliance Magazine EUL). DEER Team discussion section states that EUL based on Energy Star lifetime assumptions (which seems to contradict previous statement that the EULs were from Appliance Magazine). Also states that 2005 CLASS data shows that less than 20% of units are over 10 years old.  |
| High Efficiency Evaporator Fan Motors:GrocDisp-FEvapFanMtr  | EUL15 yearsRUL 5 years | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it states that no new information was available to change the DEER2005 value. Referring to the DEER 2004-2005 Final Report, it lists High Efficiency Display Fan Motors (D03-203) as having an EUL of 15 years and cites CALMAC protocols published in September 2000. The CALMAC Protocols list PSC Evaporator Fan Motors (not EC Motors, the current high efficiency option) with an EUL of 12 years and cites three potential sources of information, all published between 1985-1990. |
| Measure & EUL ID from READI  | **EUL****/RUL**  | **Version**  | **Version Source**  | **Referencing the Source**  |
| Air Conditioners (packaged terminal AC):HVAC-PTAC  | EUL15 yearsRUL 5 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it indicates no change from DEER2005 value. Under data source/estimation approaches is states “Commercial AC class set to15” and there is no other information provided in the data source or DEER Team discussion section explaining the decision.  |
| VSD Supply Fan Motors:HVCA-VSDSupFan  | EUL15 yearsRUL 5 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it indicates EUL for DEER 06-07 changed from DEER2005 value from 10 yrs. to 15 yrs. Data source/estimation approaches list several retention studies (all appear to be from the mid 90’s). Under DEER Team discussion on EUL decision making process when multiple sources were available it notes “Retention studies supported raising EUL from 10 to 15 years. |
| Whole House Fans:HV-WHFan  | EUL20yearsRUL 6.7 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it indicates EUL for DEER 06-07 changed from DEER2005 value from 15 yrs. to 20 yrs. Data source/estimation approaches cites GDS Measure Life Report , June 2007. In DEER Team discussion section it notes that EUL capped at 20 per CPUC policy. Changed from initial DEER EUL estimate due to utility comments. |
| Low-Flow Faucet Aerators:WtrHt-WH-Aertr  | EUL10 yearsRUL 3.3 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it indicates EUL for DEER 06-07 changed from DEER2005 value from 9 yrs. To 10 yrs. Data source/estimation approaches cites EM&V Report for the Gas-Only Multifamily Efficiency Program #197-02. |
| Low-Flow Showerheads:WtrHt-WH-Shrhd  | EUL10 yearsRUL 3.3 years  | DEER2014  | D08v2.05(DEER 2008 Public Version)  | In EUL/RUL Values (Updated10 October 2008) posted on DEER2008 page of DEER website, it indicates EUL for DEER 06-07 unchanged from DEER2005 value. Data source/estimation approaches indicates no new info found to change DEER 2005 EUL. In DEER 2005 Final report (Page 11-9, measure D03-937) it indicates the EUL source is a CALMAC report from September 2000. |
| D Lamps:Iltg-Com-LED-  | Varies  | DEER2014  | Lighting Disposition  | Appears 2013-2014 Lighting Disposition-13March15.xlsx addresses many LEDs. |

1. Accessible at http://cmua.org/energy-efficiency-technical-reference-manual [↑](#footnote-ref-1)
2. Accessible at http://deeresources.com/ [↑](#footnote-ref-2)
3. Relevant DEER measure information takes the form of a) measures found directly in the READI tool on the DEER website, b) detailed guidance from the CPUC’s DEER / Ex Ante Review team on IOU workpaper measures through workpaper “dispositions” c) DEER building prototypes that utilities are required to use when performing building energy simulations. [↑](#footnote-ref-3)
4. Measure combinations vary by efficiency level (e.g., SEER rating or lamp wattage), building type, climate zone, and/or vintage. [↑](#footnote-ref-4)