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MEASURE CHARACTERIZATION

Lifecycle Refrigerant Management, Residential

https://www.caetrm.com/measure/SWSV014/01/

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Technology Summary

The lifecycle refrigerant management (LRM) measure saves energy and reduces peak electricity demand by providing the following measures: (1) electronic refrigerant leak detection, (2) proper training on how to detect, repair, and prevent refrigerant venting, (3) locking Schrader caps (LSC) to prevent venting and refrigerant huffing, (4) non-invasive temperature diagnostic (NTD) software, and (5) adding at least 7.5% refrigerant charge to undercharged units and preventing 5.3% undercharge for all units which improves cooling capacity and reduces air conditioning (AC) or heat pump (HP) operating times. Energy and peak demand savings for preventing 5.3% undercharge on all participating units and correcting at least 7.5% undercharge on 33% of units are based on Intertek test data and Purdue HP test data (see Electric Savings section). R3149 R3147 If no leaks are detected or leaks are repaired, and under charge faults greater than 7.5% of factory charge are detected, then proper refrigerant hose connection and weigh-in methods are used to add refrigerant. R3163 The NTD software determines how much refrigerant charge to add, and only recommends refrigerant adjustments greater than 7.5% to avoid making small refrigerant charge adjustments. The NTD software provides accurate recommendations regarding under charge (UC) and “other faults” including overcharge, evaporator or condenser heat exchanger faults, refrigerant restrictions, and non-condensables. Laboratory tests indicate refrigerant under charge can reduce AC and HP equipment operating efficiency by 10 to 60%. R3147 R3149 R3150 Refrigerant under charge also causes reduced cooling capacity, longer run time, increased energy use, high energy bills, noisy operation, frozen evaporator coils, compressor failure (overheat and burn out), and increased indoor humidity. LRM corrects under charge, reduces refrigerant leakage, and enables AC or HP equipment to operate at or near its optimal efficiency to save energy and improve thermal comfort.

The LRM measure meets best practices identified in the California Public Utilities Commission (CPUC) *Resolution E-5152* for handling refrigerants including: a) electronic leak detectors to rule out leaks, b) proper contractor training, c) LSC, and d) non-invasive techniques for assessing refrigerant charge. R1503 R3165 R3171 LRM is supported by manufacturers and environmental organizations to reduce venting of hydrofluorocarbon (HFC) and hydrochlorofluorocarbons (HCFC) refrigerants and reduce global warming from 0.5 °C to 0.04 °C by year 2100. R3153 According to the U.S. Environmental Protection Agency (EPA) and the California Air Resources Board (CARB), average residential AC and HP equipment operational refrigerant leakage rates are approximately 5.3% per year. R3146 LRM focuses on residential AC and HP equipment which are 32% of the problem (see CARB Table 2 (pp. 9-10) Input factors and emission calculations for refrigeration and AC shows residential AC with 7,059,890 lbs which is 32% of the 22,228,926 lbs total loss in lbs (annual + EOL). R3156 Refrigerant venting reduction goals are required by the United Nations 2016 Kigali Amendment to the Montreal Protocol on substances that deplete the ozone layer. R3154 R3155 As of October 31, 2022, 138 states including the United States and European Union have ratified the Kigali Amendment.

Measure Case Description

The LRM measure detects, repairs, and prevents refrigerant leaks, installs locking Schrader caps (LSCs) to prevent leaks, and provides non-invasive temperature diagnostic (NTD) software to determine how much refrigerant charge to add, if any. The NTD software method uses return, supply, and outdoor air temperatures and liquid and suction line temperatures to evaluate air conditioning (AC) system performance without connecting refrigerant pressure gauges. R3163 The NTD software only recommends refrigerant adjustments greater than 7.5% to avoid making small charge adjustments. The NTD software also provides accurate recommendations regarding other faults including overcharge, evaporator or condenser heat exchanger faults, refrigerant restrictions, and non-condensables. If no leaks are detected or leaks are repaired and at least 7.5% undercharge is detected, then proper refrigerant hose connection and weigh-in methods are used to add refrigerant to improve capacity and efficiency. Intertek NTD verification data indicates 99.1% accuracy with correct fault detection including amount of undercharge for 107 out of 108 tests. R3165

A Purdue University study by Yuill D. P. and J. E. Braun, titled *Evaluating Fault Detection and Diagnostics Protocols Applied to Air-Cooled Vapor Compression Air-Conditioners* (Purdue study), reported the known California Energy Commission (CEC) temperature split (TS) method was less than 60% accurate when diagnosing airflow from -10 to -30%. R3169 R1244 The Purdue study reported refrigerant charge (RC) methods were only 58% accurate diagnosing -10 to -40% undercharge with no recommendations regarding the amount of undercharge. Based on Intertek tests, the known TS method provides 16.7% accuracy based on 15 correct tests out of 90. The known RC method provides 63.3% accuracy based on 57 correct tests out of 90. Known methods do not provide the amount of undercharge and refrigerant restrictions, non-condensables, evaporator heat exchanger (HX), and condenser HX faults are misdetected or misdiagnosed. Furthermore, the RC method requires connecting refrigerant pressure gauges to diagnose AC system faults which causes venting of refrigerant to the atmosphere.

Leak detection and repairs are performed after the AC or HP system is turned on and pressurized and before the NTD evaluation. Leak detection is performed with an electronic leak detector at Schrader valves on low-side and high-side service access ports, flare fittings on mini-split heat pumps, all brazed joints, filter driers, reversing valves, expansion valves, and coils. The LRM training manual has a section on flare fittings and other joints for mini-split heat pumps. See 1.7 Leak Detection and 4.9 Mini-Split AC and Heat Pump Installation Procedure. R3163 Electronic leak detection equipment can detect leak rates of ½ ounce per year. Leak detector sensing device is placed next to Schrader valves and system components and slowly moved (one inch per second) above and below Schrader valves or areas suspected of leaking. Leak detector emits an audible alarm and a bright flashing light or both if refrigerant leak is detected. Leaks are pinpointed with soap bubbles. Major leaks require refrigerant recovery and low/high pressure leak testing with nitrogen. Repair refrigerant tube or HX leaks with brazing torch, flux, and brazing alloys (SIL FOS). After major leak repairs, perform triple evacuation to eliminate non-condensables. Tighten or replace Schrader valves if leaking. After leak repair, install LSC with “O” ring seals with thread-lock blue on high- and low-pressure ports to prevent refrigerant leaks. Thread lock blue does not prevent removing locking Schrader caps for future serviceability. LRM training and NTD software provide proper installation procedures to prevent refrigerant leaks and ensure proper evacuation for flare fittings on mini-split AC and heat pumps. R3163

Refrigerant venting damages the ozone layer and produces 1,810 to 2,088 lbs (i.e., about 1-ton) of equivalent carbon dioxide (CO2) per pound of R-22 or R-410a. R3146 Locking Schrader caps (LSCs) prevent refrigerant venting at Schrader valves and also provide a barrier to prevent subsequent technicians from removing LSCs and randomly connecting refrigerant gauges which would cause venting of refrigerant. Non-locking Schrader caps provide no deterrence to prevent subsequent technicians from removing non-locking caps and connecting refrigerant gauges which causes refrigerant venting. The International Residential Code (section M1411.8) requires LSC. R1287 While LSCs are included in codes, they are generally not installed on new and existing AC and HP. Based on 30,831 AC tune-up records in the Pacific Gas & Electric (PG&E) Energy Savings Partners (ESA) low-income program, no AC units had pre-existing LSCs installed. R3148

The SWSV014-01 Lifecycle Refrigerant Management (LRM) measure package (MP) replaces the SWSV006-01 Refrigerant Charge Adjustment (RCA), Residential MP, which was sunsetted on December 31, 2022, per Resolution E-5152 (page 17). R1503 The LRM MP may be implemented statewide for AC tune-up measures to detect and repair refrigerant leaks, prevent refrigerant venting, and improve cooling efficiency, reduce utility bills, and maintain comfortable indoor conditions during summer heat waves for health and safety. AC units with pre-existing LSC installed will not receive credit for 5.3% undercharge correction unless refrigerant leaks are detected and repaired. Therefore, the baseline comprises AC or HP units leaking 5.3% per year without LSC. R3156 LRM will reduce refrigerant venting and equivalent CO2 emissions and help transition to low global warming potential (GWP) refrigerants. The refrigerant avoided cost calculator (RACC) is used to calculate refrigerant benefits. R3172 The 5.3% undercharge correction for all LRM measures is based on detecting, repairing, and preventing refrigerant leaks by installing a set of LSCs on the Schrader valves of each unit. The 5.3% annual leakage reduction is for the whole system. However, leakage from Schrader valves is the most common source of leakage and the LSC prevents leakage from Schrader valves. Significant leaks at coils may warrant recommendations to replace the existing unit with a new more efficient unit which is why LRM includes NR to recover refrigerant and perform proper installation with low- and high-pressure testing, triple evacuation, proper charge, and LSC to prevent 5.3% leakage for life of new unit.

The following table provides twelve measure offerings (A-L) defined by at least 7.5% refrigerant charge adjustment (RCA) or no charge adjustment, detecting and repairing refrigerant leaks, and installing LSCs to prevent 5.3% refrigerant leakage. Measure offerings are also defined by building HVAC system (rDXGF or rDXHP), refrigerant (R22 or R410a), and installation (existing, new construction (NC) or normal replacement (NR).

Offering ID

BUILDING HVAC	INSTALLATION	REFRIGERANT	STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
rDXGF	+7.5% RCA + LSC	R22	**A**	**Lifecycle refrigerant management (LRM) +7.5% refrigerant charge adjustment (RCA) + locking schrader caps (LSC) prevent 5.3% leaks R22 rDXGF**
rDXGF	+7.5% RCA + LSC	R410a	**B**	**Lifecycle refrigerant management (LRM) +7.5% refrigerant charge adjustment (RCA) + locking schrader caps (LSC) prevent 5.3% leaks R410a rDXGF**
rDXGF	Install LSC	R22	**C**	**Lifecycle refrigerant management (LRM) install locking schrader caps (LSC) prevent 5.3% leaks R22 rDXGF**
rDXGF	Install LSC	R410a	**D**	**Lifecycle refrigerant management (LRM) install locking schrader caps (LSC) prevent 5.3% leaks R410a rDXGF**
rDXGF	NC LSC	R410a	**E**	**Lifecycle refrigerant management (LRM) new construction (NC) locking schrader caps (LSC) prevent 5.3% leaks R410a rDXGF**
rDXGF	NR EOL LSC	R410a	**F**	**Lifecycle refrigerant management (LRM) normal replacement (NR) end of life (EOL) locking schrader caps (LSC) prevent 5.3% leaks R410a rDXGF**
rDXHP	+7.5% RCA + LSC	R22	**G**	**Lifecycle refrigerant management (LRM) +7.5% refrigerant charge adjustment (RCA) + locking schrader caps (LSC) prevent 5.3% leaks R22 rDXHP**
rDXHP	+7.5% RCA + LSC	R410a	**H**	**Lifecycle refrigerant management (LRM) +7.5% refrigerant charge adjustment (RCA) + locking schrader caps (LSC) prevent 5.3% leaks R410a rDXHP**

BUILDING HVAC	INSTALLATION	REFRIGERANT	STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
rDXHP	Install LSC	R22	**I**	**Lifecycle refrigerant management (LRM) install locking schrader caps (LSC) prevent 5.3% leaks R22 rDXHP**
rDXHP	Install LSC	R410a	**J**	**Lifecycle refrigerant management (LRM) install locking schrader caps (LSC) prevent 5.3% leaks R410a rDXHP**
rDXHP	NC LSC	R410a	**K**	**Lifecycle refrigerant management (LRM) new construction (NC) locking schrader caps (LSC) prevent 5.3% leaks R410a rDXHP**
rDXHP	NR EOL LSC	R410a	**L**	**Lifecycle refrigerant management (LRM) normal replacement (NR) end of life (EOL) locking schrader caps (LSC) prevent 5.3% leaks R410a rDXHP**

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Base Case Description

The base case for this measure is defined as a non-treated AC or HP system. Base case unit energy consumption (UEC) data are from DEER2024 (D24) EnergyPlus[TM] simulations for the statewide Fan Controller for Air Conditioner, Residential (SWHC029-03) measure package and MASContol3 DOE-2.3 simulations. R3046 R3129 R3137 The UEC data are provided in a reference spreadsheet. R3170

Base Case Descriptions

BUILDING HVAC	REFRIGERANT	STATEWIDE MEASURE OFFERING ID (TEXT)	EXISTING DESCRIPTION (TEXT)	STANDARD DESCRIPTION (TEXT)
rDXGF	R22	**A**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXGF	R410a	**B**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXGF	R22	**C**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXGF	R410a	**D**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**

BUILDING HVAC	REFRIGERANT	STATEWIDE MEASURE OFFERING ID (TEXT)	EXISTING DESCRIPTION (TEXT)	STANDARD DESCRIPTION (TEXT)
rDXGF	R410a	**E**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXGF	R410a	**F**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R22	**G**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R410a	**H**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R22	**I**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R410a	**J**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R410a	**K**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**
rDXHP	R410a	**L**	**No lifecycle refrigerant management (LRM)**	**No lifecycle refrigerant management (LRM)**

Code Requirements

This measure is relevant to but not currently governed by federal or state appliance or building standards. The California Building Energy Efficiency Standards (Title 24) does not deal with lifecycle refrigerant management (LRM). Notably, the California mechanical code states that changes, alterations, or repairs of a minor nature that do *not* affect structural features, egress, sanitation, safety, or accessibility as determined by the enforcing agency are exempt from the requirement to obtain a mechanical permit. While the International Mechanical Code (IMC) (section 1101.10) mentions locking Schrader caps (LSC), they are not required by federal or state appliance or building standards. [R1287] While LSC is mentioned in the IMC code, it is not required or installed on new or existing AC and HP units Therefore, the baseline comprises AC or HP units without leak detection, repairs or LSC to prevent refrigerant leaks of 5.3% per year as indicated by California Air Resources Board (CARB). [R3156] [R3146] LRM will detect, repair, and prevent refrigerant venting and equivalent CO_2 emissions and help transition to low GWP refrigerants.

The LRM measure requires the HVAC contractor to be licensed by the California State Licensing Board (CSLB) and that HVAC technicians are certified by the U.S. Environmental Protection Agency (EPA) per EPA regulations under Section 608 of the U.S. EPA Clean Air Act. [R2179]

Applicable State and Federal Codes and Standards

CODE	APPLICABLE CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24	None	n/a
Federal Standards	None	n/a

Program Requirements

MEASURE IMPLEMENTATION ELIGIBILITY

All measure application type, delivery type, and sector combinations that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

MEASURE APPLICATION TYPE	SECTOR	DELIVERY TYPE
AOE	Res	DnDeemDI
NC	Res	DnDeemDI
NR	Res	DnDeemDI

ELIGIBLE PRODUCTS AND REQUIREMENTS

All residential packaged and split-system AC and HP units are eligible. The following eligibility requirements must be met before the LRM measure is implemented.

- Refrigerant leak detection and repair must be performed using an electronic leak detector at the high-and low-pressure Schrader valve access ports. Detection, repair, and prevention of leaks is required to prevent refrigerant loss to the atmosphere and maintain cooling capacity, efficiency, and reliability.

- Refrigerant leaks must be repaired by tightening or replacing Schrader valves if leaking and installing LSC with “O” ring seals and thread-lock blue on high- and low-pressure ports to prevent refrigerant leaks.

- Clean air filters must be installed and condensing coils must be chemically cleaned, rinsed, and dry per manufacturer specifications. Dirty, blocked, or wet condenser coils and air filters may affect heat transfer and air flow which may also affect diagnostic measurements. Cleaning evaporator coils is performed on packaged units and split-system evaporator coils with removable access panels. If access panels are unavailable on split-system evaporator coils, then it is very difficult to clean the coil since the furnace heat exchanger or piping may block access.

- Non-invasive temperature diagnostics (NTD) software must be used to evaluate airflow and refrigerant charge using supply air, return air, and outdoor air temperature sensors and refrigerant liquid and suction line temperature sensors.

- NTD software must be capable of evaluating low airflow and accurately determining the amount of refrigerant undercharge as a percent of factory charge, and other faults without connecting refrigerant pressure gauges. Other faults may include refrigerant overcharge, evaporator or condenser heat exchanger faults, refrigerant restrictions, and non-condensables.

ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable for all new and existing residential building types including single-family (SFm), multifamily (MFm), and mobile homes (DMo).

ELIGIBLE CLIMATE ZONES

This measure is applicable in all California climate zones.

Program Exclusions

Program exclusions include AC or heat pump system not operating due to compressor, fan motor, reversing valve, expansion valve, or electrical system failure, non-condensables, restrictions, significant unrepairable refrigerant leaks, or no refrigerant in system due to unrepairable refrigerant leaks.

Data Collection Requirements

The LRM measure is a downstream measure implemented by HVAC contractors licensed by the California State Licensing Board (CSLB) and HVAC technicians must be certified by the U.S. Environmental Protection Agency (EPA) per EPA regulations under Section 608 of the U.S. EPA Clean Air Act. R2179

Data collection requirements will include the following information for all claims. Final test-out data will only be provided for measures with a refrigerant charge addition.

PROGRAM DATA FOR DOWNSTREAM FOCUSED PROGRAMS
Site ID – A unique identifier for the installed location of the incentivized equipment
Site address (street, unit, city, ZIP)
Building type (SFm, MFm, DMo)
HVAC equipment manufacturer
HVAC equipment model number
HVAC equipment serial number
Refrigerant type R22 or 410A
Factory charge pounds or ounces
Expansion device non-TXV or TXV
Cooling capacity tons or kBtu/hr
Split or packaged unit
Existing HVAC system type rDXGF (DX cooling gas furnace) or rDXHP (heat pump)
Refrigerant leak detection findings
Refrigerant leak repair description (if needed)
Installation of locking Schrader caps (check)
Coil cleaning confirmed
Air filter installation (new or clean) confirmed

PROGRAM DATA FOR DOWNSTREAM FOCUSED PROGRAMS
Initial return-air and supply-air dry bulb and wet bulb temperatures
Initial condenser entering air temperature
Initial suction line temperature
Initial liquid line temperature
Initial non-invasive temperature diagnostic (NTD) evaluation results
If NTD evaluation indicates undercharge greater than or equal to 7.5% or factory charge, then amount of refrigerant charge added to system (ounces)
Final return-air and supply-air dry bulb and wet bulb temperatures
EER^*_{TS} Impact of recharging units with ≥7.5% UC
Final condenser entering air temperature
Final suction line temperature
Final liquid line temperature
Final NTD evaluation results

Data collection may include other information including but not limited to the following site information data:

ADDITIONAL PROGRAM DATA FOR DOWNSTREAM FOCUSED PROGRAMS
Initial and final refrigerant system suction and liquid line pressures and saturation temperatures, if the NTD evaluation indicates an undercharge or other faults.
Normal replacement (NR): - The refrigerant charge (lbs or ounces) recovered from the pre-existing HVAC system equipment **New construction (NC):** - Low and high-pressure leak detection test information (psig and time) - Evacuation information including initial and final pressure (microns), time, and outdoor air temperature (°F) - NTD evaluation information to ensure proper installation.

VERIFICATION AND QUALITY CONTROL DATA

The NTD method provides verification and quality control (QC) data for units with ≥7.5% under charge based on test-in and test-out measurements of temperature split (TS) across the evaporator coil which is proportional to the sensible cooling capacity used to calculate the application sensible energy efficiency (EER*) impact. The TS is equal to the return air temperature minus the supply air temperature across the evaporator coil. The following tables provide Intertek laboratory test data indicating that the EER* impact is equivalent to the EER^*_{TS} impact based on TS measurements. For LRM, the EER^*_{TS} impact of recharging units with ≥7.5% UC provides confidence that energy efficiency is improved and ensures work is performed successfully.

The EER* impact is calculated using the following equation based on Intertek measurements of sensible cooling capacity (Btu) and total system power (Watts or W).

$$EER^*\ Impact = EER^*_{\geq 7.5\%}/EER^*_{100\%}-1$$

$EER^*_{\geq 7.5\%}$ = EER at ≥7.5% UC (Btu/W)*
$EER^*_{100\%}$ = EER at 100% of factory charge (FC) (Btu/W)*

The EER^*_{TS} impact is calculated using the following equation based on Intertek measurements of TS test-in (TS_{in}) and TS test-out (TS_{out}).

$$EER^*_{TS}\ Impact = (TS_{in}/TS_{out}-1)*0.84$$

TS_{in} = Temperature split of return minus supply air in °F at test-in
TS_{out} = Temperature split of return minus supply air in °F at test-out
0.84 = Coefficient to convert TS impact to EER^*_{TS} impact (dimensionless)

The following table provides EER* and EER^*_{TS} impacts from refrigerant under charge (UC) based on Intertek laboratory tests for a 3-ton air conditioner (AC) at 95°F outdoor air temperature (OAT). For 7.5 to 40% UC, the non-TXV EER* impacts range from -20.8 to -74% and the non-TXV EER^*_{TS} impacts range from -20.7% to -64%.

Non-TXV EER* and EER^*_{TS} Impacts of UC based on Intertek Tests at 95°F OAT

MEASURE % UNDER CHARGE (UC)	NON-TXV EER* INTERTEK	NON-TXV EER* IMPACT	NON-TXV TEMP SPLIT (TS)	NON-TXV EER^*_{TS} IMPACT
0%	7.02	0	17.7	0
7.5% UC	5.56	-20.8%	13.3	-20.7%
10% UC	4.81	-31.4%	11.3	-30.2%
20% UC	4.23	-39.7%	9.4	-39.6%
30% UC	2.43	-65.4%	5.6	-57.5%

MEASURE % UNDER CHARGE (UC)	NON-TXV EER* INTERTEK	NON-TXV EER* IMPACT	NON-TXV TEMP SPLIT (TS)	NON-TXV EER*$_{TS}$ IMPACT
40% UC	1.82	-74.0%	4.2	-64.0%

The following table provides non-TXV EER* and EER*$_{TS}$ impacts of UC based on Intertek tests at 82°F OAT. For 7.5 to 40% UC, the non-TXV EER* impacts range from -12.59 to -70.95% and the non-TXV EER*$_{TS}$ impacts range from -11.3% to -62.45%.

Non-TXV EER* and EER*$_{TS}$ Impacts of UC based on Intertek Tests at 82°F OAT

MEASURE % UNDER CHARGE (UC)	TXV EER* INTERTEK	TXV EER* IMPACT	TXV TEMP SPLIT (TS)	TXV EER*$_{TS}$ IMPACT
0%	7.48	0	16.45	0
7.5% UC	6.54	-12.59%	14.24	-11.3%
10% UC	6.29	-16.0%	13.36	-15.8%
20% UC	4.43	-40.79%	8,42	-41.01%
30% UC	3.16	-57.75%	6.36	-51.51%
40% UC	2.17	-70.95%	4.22	-62.45%

The following table provides TXV EER* and EER*$_{TS}$ impacts of UC for a 3-ton air conditioner (AC) based on Intertek tests at 95°F OAT. For 7.5 to 40% UC, the TXV EER* impacts range from -7.7 to -66.5% and the TXV EER*$_{TS}$ impacts range from -7% to -58.9%.

TXV EER* and EER*$_{TS}$ Impacts of UC based on Intertek Tests at 95°F OAT

MEASURE % UNDER CHARGE (UC)	TXV EER* INTERTEK	TXV EER* IMPACT	TXV TEMP SPLIT (TS)	TXV EER*$_{TS}$ IMPACT
0%	7.18	0	18.1	0
7.5% UC	6.63	-7.7%	16.6	-7.0%
10% UC	6.47	-9.9%	15.9	-9.9%
20% UC	5.37	-25.2%	12.6	-25.3%
30% UC	4.29	-40.2%	9.7	-38.8%
40% UC	2.40	-66.5%	5.4	-58.9%

The Pearson product-moment correlation coefficient (or Pearson coefficient) for the EER* (x-variable) and EER^*_{TS} (y-variable) is 0.996 for the non-TXV EER* at 95°F, 0.997 for the non-TXV at 82°F, and 0.998 for the TXV EER* at 95°F indicating high correlation. R2209 The Pearson coefficient is calculated using the following equation.

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r = Sum((xi–xmean)(yi–ymean))/(Sqrt(Sum(xi–xmean)^2(yi–ymean)^2))
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r = Person product-moment correlation coefficient (close to +1 is high correlation)
x_i = Values of the x-variable in the sample (EER)*
x_{mean} = Mean of the values of the x-variable
y_i = Values of the y-variable in the sample (EER^*_{TS})
y_{mean} = Mean of the values of the y-variable

Electric Savings (kWh)

The LRM measure provides electric savings for direct expansion (DX) cooling (rDXGF) and heat pump cooling and heating (rDXHP). Electric savings are based on UEC data and calculated savings per measure offering and building HVAC type. R3170 The methodology used to derive the calculations are provided in the sections below.

Annual Unit Energy Savings - Electric

EQUATION (KWH / YR)
$UECBase\_YrkWh - UECMeas\_YrkWh$

UECBase_YrkWh = Annual unit energy consumption - electric, baseline (kWh/yr)
UECMeas_YrkWh = Annual unit energy consumption - electric, measure case (kWh/yr).

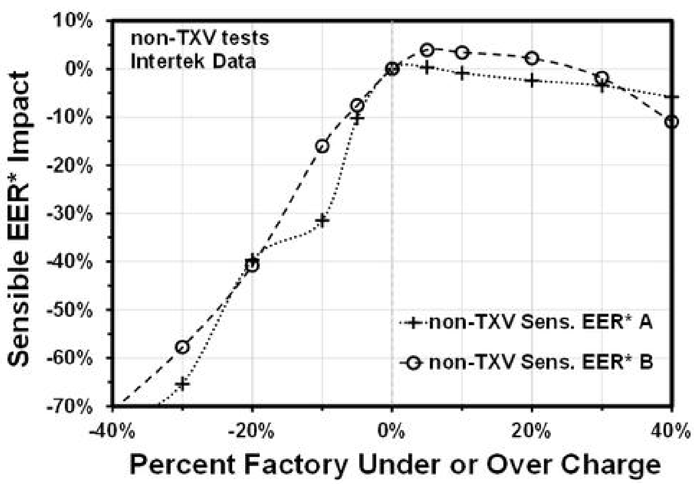
Annual Unit Energy Consumption - Electric, Measure Case

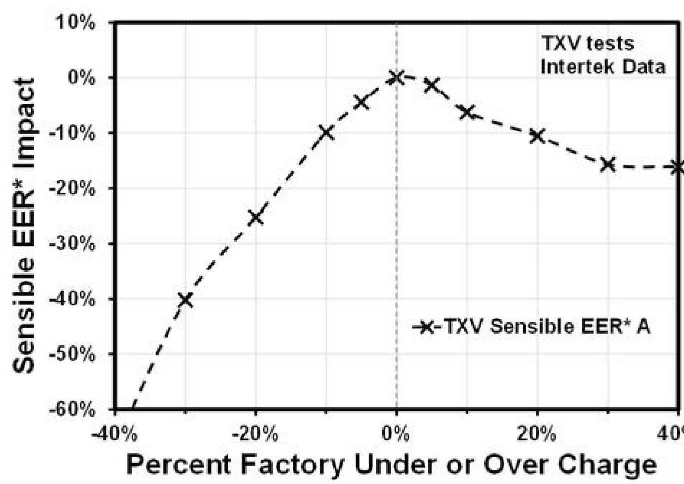
BUILDING HVAC	EQUATION (KWH / YR)
rDXGF	$UECBase\_cool\_\_YrkWh \bullet (1 - constReg\_\_mEER \bullet pctUnderCharge\_\_value)$
rDXHP	$UECBase\_cool\_\_YrkWh \bullet (1 - constReg\_\_mEER \bullet pctUnderCharge\_\_value) +$ $UECBase\_heat\_\_YrkWh \bullet (1 - constReg\_\_mCOP \bullet pctUnderCharge\_\_value)$

UECBase_cool__YrkWh = Annual unit energy consumption - electric, baseline, cooling (kWh/yr)
constReg__mEER = Regression result - DX cooling sensible energy efficiency ratio (EER) improvement savings coefficient versus factory under charge based on Intertek test data (dimensionless)
pctUnderCharge__value = Percentage of factory undercharge (>= 7.5%) less than the factory charge determined based on NTD plus first-year undercharge (5.3%) prevented by refrigerant leak detection, repair, and LSC (%)
UECBase_heat__YrkWh = Annual unit energy consumption - electric, baseline, heating (kWh/yr)
constReg__mCOP = Regression result - heat pump heating coefficient of performance (COP) improvement savings coefficient versus factory under charge based on Purdue study (dimensionless)

ELECTRIC UNIT ENERGY SAVINGS - DIRECT EXPANSION (DX) COOLING

DX cooling electric savings are based on NTD software determining at least 7.5% undercharge and after detecting and repairing leaks adding at least 7.5% refrigerant charge for approximately 33.5% of units. R3148 Leak detection, repair, and installation of LSC are performed on all participating units to prevent 5.3% undercharge. R3146 R3161 The 5.3% first-year leak prevention is based on HVAC refrigerant venting emission rates from the U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB). R3156 The NTD software detects faults and determines percentage undercharge without connecting refrigerant pressure gauges which reduces venting. NTD software only recommends adding charge to system with greater than or equal to 7.5% undercharge. R3157 All participating AC units receive electronic leak detection, repairs, NTD evaluation, and LSC to prevent refrigerant leakage with claimed energy savings and refrigerant benefits associated with preventing 5.3% undercharge per the CARB and RACC annual leakage rate. R3156 R3172 R3157 R3158 R3159 R3160 R3161 Cooling energy savings are based on the sensible Energy Efficiency Ratio (EER*) impact versus refrigerant undercharge, and preventing leaks that cause undercharge is based on Intertek test data shown in the following figure. R3150 (The * on EER indicates applicable EER)

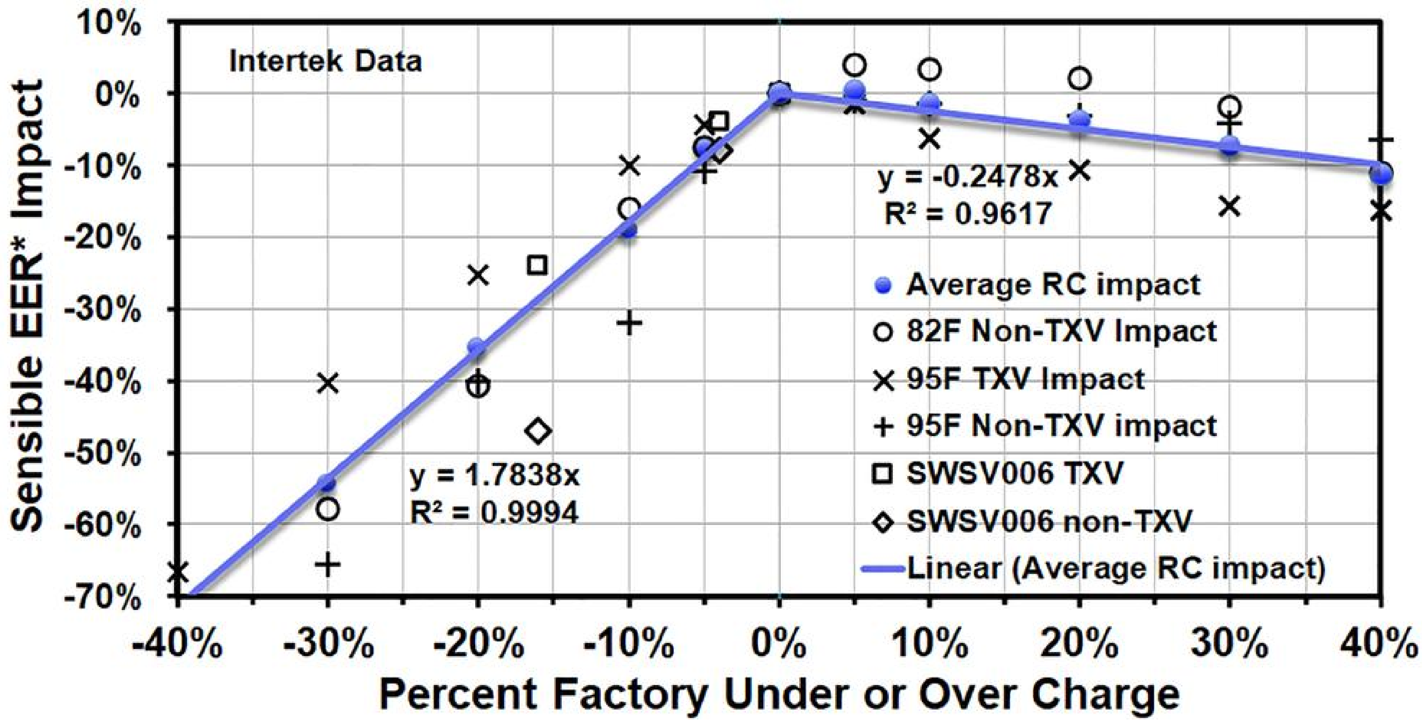




Sensible EER Impact vs. Under or Overcharge for non-TXV and TXV Systems (Intertek)*

The regression equation shown in the following figure is based on Intertek laboratory test data for sensible EER* averaged over 82 °F and 95 °F outdoor air temperatures and provides the same results as modeling impacts using cooling efficiency adjustments based on test data. Reducing sensible EER* impacts AC operation based on sensible thermostat temperatures which are satisfied based on sensible capacity delivered to the conditioned space and not total capacity. The following figure provides TXV and non-TXV percent savings from the statewide Refrigerant Charge Adjustment, Residential (SWSV006-01) measure package for 4% undercharge and 16%

undercharge. A database of 30,881 AC tune-up records for a program in northern California indicates that 33.5% of units are undercharged by 7.5 % with average cooling savings of 13.4% (13.4% = 1.7838 * 0.075). R3148



Sensible EER Impact vs. Factory Under and Overcharge*

The regression equation curve fit for refrigerant undercharge is as follows (e.g., under charge ≥ 7.5% – add refrigerant charge to correct).

y_{dx} (constReg__mEER) = 1.7838 * x (pctUnderCharge__Value)

y_{dx} = DX cooling undercharge impact (constReg__mEER) (%)
x = % of factory charge (pctUnderCharge__Value) (%)

For x = 0.075, y_{dx} = 13.4%
For x = 5.3%, y_{dx} = 9.5%
For x = (5.3% + 7.5%) = 12.8%, y_{dx} = 22.8%

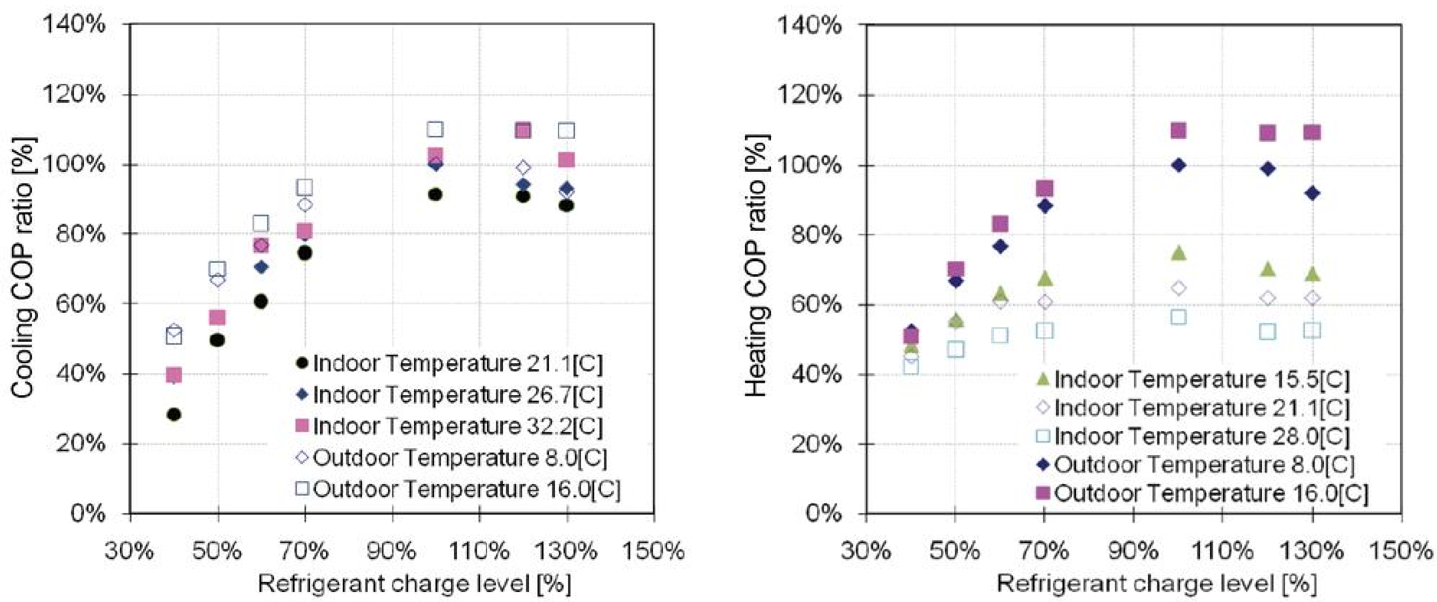
Weighted average cooling savings (%):
y_{dx} = 14% = 1.7838 * [0.053 * 0.665 + 0.128 * 0.335]

Most units will be undercharged due to average 5.3% refrigerant leakage per year. The database of 30,881 units indicates 33.5% of units are undercharged by 7.5%. R3148 Another database of 11,244 units indicates 43% of units are undercharged by 6% or more and

27% are undercharged by 16% or more. R1094

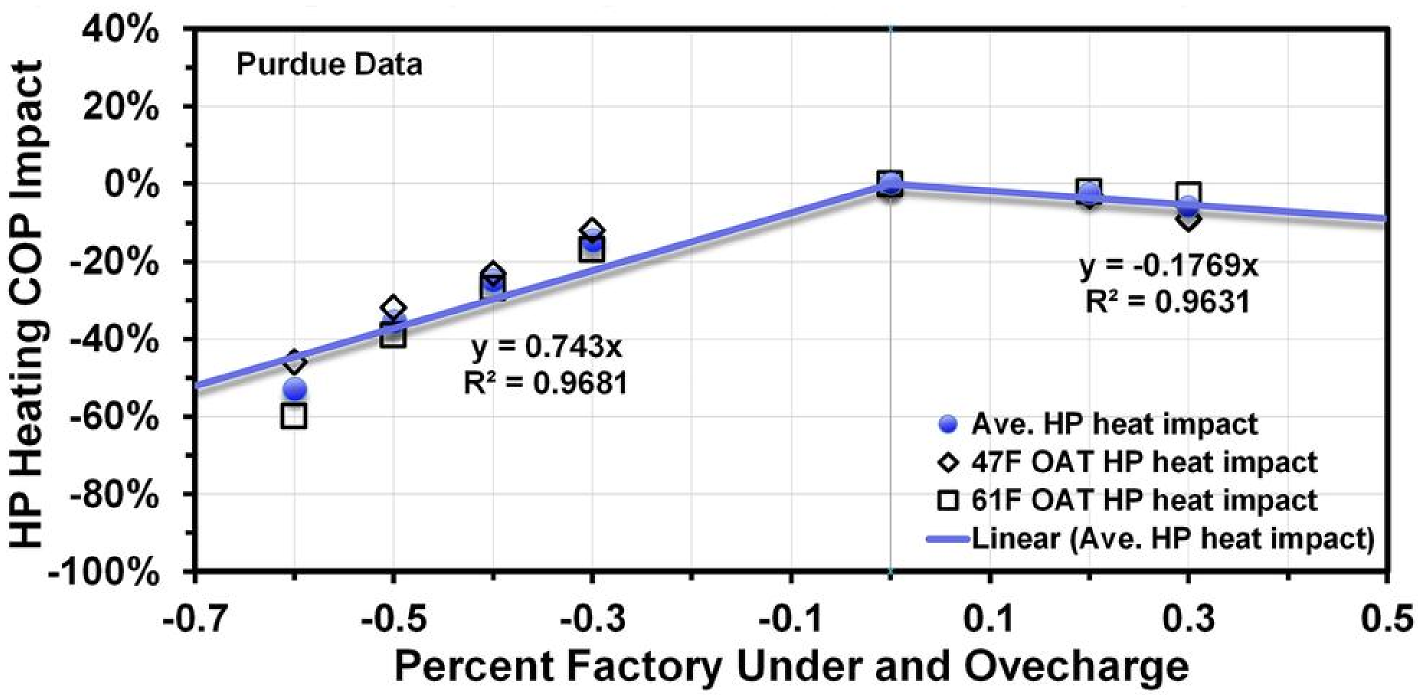
ELECTRIC UNIT ENERGY SAVINGS - HEAT PUMP HEATING

Heat pump heating electric savings are based on adding at least 7.5% refrigerant charge to correct to undercharged units for 33.5% of units and preventing 5.3% undercharge on all units based on preventing 5.3% per year of refrigerant venting due to leaks. The following figures provide RCA impacts based on the coefficient of performance (COP) versus under or overcharge for TXV systems based on laboratory tests performed by the Purdue study for HP cooling (left figure) and HP heating (right figure). R3147 Impacts are similar to the Intertek test data for AC cooling shown above.



Heat Pump Cooling and Heating COP Impact versus Under or Overcharge for TXV Systems at different OAT (Purdue data)

The following figure provides HP heating COP impacts versus factory under and overcharge. The 47 °F and 61 °F outdoor air temperature (OAT) Purdue study data are normalized to 0% impact at 100% factory charge.



Heat Pump Heating COP Impact vs Factory Under and Overcharge (Purdue Data)

HP heating energy savings for refrigerant charge adjustments are 5.8% based on the Purdue study data and following regression equation from the above figure regarding the HP heating COP impact.

y_{hp} (constReg__mCOP) = 0.743 * x (pctUnderCharge__Value)

y_{hp} = Undercharge impact (constReg__mCOP) (%)
x = % of factory charge (pctUnderCharge__Value) (%)

For x = 0.075, y_{hp} = 5.5%
For x = 0.053, y_{hp} = 3.9%
For x = 0.128, y_{hp} = 9.5%

Weighted average heat pump heating savings (%):
y_{hp} = 5.8% = 0.743 * [0.053 * 0.665 + 0.128 * 0.335]

The electric unit energy consumption (UEC) data are based on the statewide Fan Controller for Air Conditioner, Residential (SWHC029-03) and DEER2024 MASControl3 DOE-2.3 simulations, and the unit energy savings (UES) data for direct expansion (DX) AC (rDXGF) and HP heating (rDXHP) are based on Intertek test data and the Purdue study. R3170 The permutations tab provides UEC and UES data for add-on equipment (AOE), normal replacement (NR), and new construction (NC). Peak demand reduction (kW) and energy savings (kWh/yr) are based on multiplying the above equations times the UEC data. Electric savings are normalized per square foot of building floor area shown in the following table. R3130 The baseline electric UEC data are from EnergyPlus. R3130 The baseline UEC

AC peak demand data are based on DEER2024 MASControl3 DOE-2.3 simulations. R3137 The EnergyPlus and MASControl3 prototypes are calibrated to *California Residential Appliance Saturation Study* (RASS) data. R1588 R3130 R3142 R3170 R3137

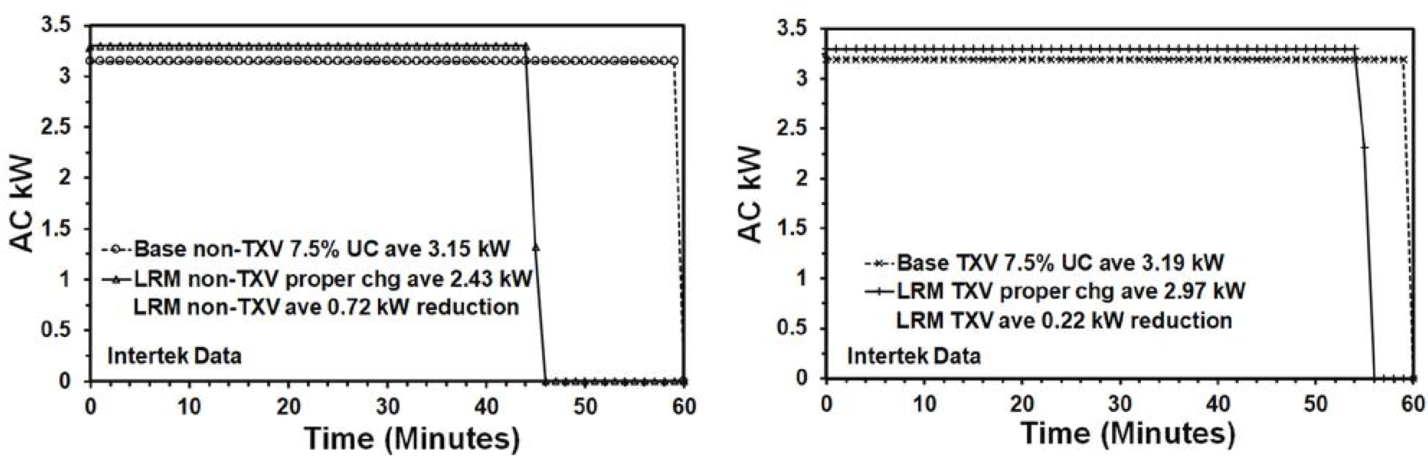
Building Floor Area (ft^2) per Prototype (DMo, MFm, SFm)

CLIMATE ZONE	DMO FLOOR AREA (FT^2)	MFM FLOOR AREA (FT^2)	SFM FLOOR AREA (FT^2)
CZ01	1240	1020	2160
CZ02	1240	1020	2160
CZ03	1240	1020	2160
CZ04	1240	1020	2160
CZ05	1240	1020	2160
CZ06	1240	1020	2250
CZ07	1240	1020	2250
CZ08	1240	1020	2250
CZ09	1240	1020	1930
CZ10	1240	1020	2070
CZ11	1240	1020	1790
CZ12	1240	1020	1790
CZ13	1240	1020	1790
CZ14	1240	1020	1630
CZ15	1240	1020	1630
CZ16	1240	1020	1900

Peak Electric Demand Reduction (kW)

The peak demand reduction values for correcting refrigerant undercharge on residential AC units are derived from Intertek laboratory tests. [R3126] [R3127] [R3149] [R3150] The DEER2022 peak demand periods are used to calculate the peak demand reduction for the California Title 24 climate zones (CZ) based on the DEER peak demand definition, adopted by *Resolution E-5152*. [R1503] These periods occur from June 1st through September 30th and provide the highest peak and average temperatures from 4:00 p.m. to 9:00 p.m. over three-day "heat wave" periods. Peak electric demand reduction savings are normalized per square foot of building floor area.

The following figures are based on Intertek test data. [R3149] [R3150] The left figure for a 3-ton non-TXV equipped AC unit shows a peak day AC cycle from 4:00 p.m. to 9:00 p.m. where LRM reduces average peak demand by 0.72 kW compared to 7.5% undercharge. The right figure for 3-ton TXV unit shows a peak AC cycle from 4:00 p.m. to 9:00 p.m. where LRM reduces average peak demand by 0.22 kW compared to 7.5% undercharge. The LRM average peak demand reduction is based on proper charge requiring less AC operating time to provide the same sensible cooling capacity for the peak hour. Data from 30,881 AC tune-up records indicate 79.1% are non-TXV and 20.9% are TXV. [R3148] Therefore, the weighted average peak demand reduction is 0.62 kW based on Intertek test data (0.62 = 0.791 * 0.72 kW + 0.209 * 0.22). The CPUC EnergyPlus residential building hourly simulation models may use an adjusted EIR for cooling or HP heating excluding the indoor fan power to calculate peak electric demand based on the Intertek test data shown converted to COP savings per the equation below. [R1568] The tables below show LRM provides an average 0.72 kW reduction for the non-TXV unit and an average 0.22 kW reduction for the TXV unit based on Intertek tests and total average power over a peak hour normalized for sensible capacity. [R3149]



Peak Electric Demand (kW) reduction for proper charge vs 7.5% undercharge for non-TXV and TXV systems

Peak Electric Demand (kW) reduction for proper charge vs. 7.5% undercharge for non-TXV and TXV systems

DESCRIPTION	EER* (BTU/W)	EER* EXCLUDING FAN	COP	TOTAL KW	AVE. KW	KW REDUCTION
Non-TXV 7.5% undercharge	5.56	6.78	2.30	3.15	3.15	
Non-TXV LRM proper charge	7.02	8.43	2.87	3.30	2.43	0.72
TXV 7.5% undercharge	6.75	8.16	2.78	3.19	3.19	
TXV LRM proper charge	7.08	8.54	2.91	3.28	2.97	0.22

Average Demand - Measure Case

EQUATION (KW)
$UECBase\_cool\_\_YrkW \bullet (1 - (constReg\_\_mEER \bullet pctUnderCharge\_\_value \bullet constReg\_\_kW\_kWh))$

UECBase_cool__YrkW = Annual unit energy consumption - average demand, baseline, cooling (kWh/yr)
constReg__mEER = Regression result - DX cooling sensible energy efficiency ratio (EER) improvement savings coefficient versus factory under charge based on Intertek test data (dimensionless)
pctUnderCharge__value = Percentage of factory undercharge (>=7.5%) less than the factory charge determined based on NTD plus first-year undercharge (5.3%) prevented by refrigerant leak detection, repair, and LSC (%)
constReg__kW_kWh = Regression result - kW/kWh multiplier (dimensionless)

The following equation from ASHRAE 90.1 is used to calculate the COP. R1036 (Section G3.1.2.1 Equipment Efficiencies, page 267)

```
COP = 7.48E-8 * EER * Q + EER
```

EER = Sensible energy efficiency ratio (EER) excluding fan power where the asterisk indicates application EER**
Q = Air Conditioning, Heating, and Refrigeration Institute (AHRI) rated cooling capacity at 95 °F OAT, 80 °F return dry bulb temperature (RDB), and 67 °F return wet bulb temperature (RWB) (Intertek test data)(kBtu/hr)

The LRM estimated peak demand reduction is calculated using an average kW/kWh savings coefficient based on savings values from the statewide Refrigerant Charge Adjustment, Residential (SWSV006-01) measure package and 192 UES undercharge records per the following equation. R3173

```
kW/kWh coefficient = UES %kW/UES %kWh = 0.03539/0.05655 = 0.626
```

kW/kWh coefficient = The average peak demand reduction per kWh savings (kW/kWh) (dimensionless)
UES %kW = The average % kW savings (%)
UES % kWh savings = The average kWh savings (%)

The kW/kWh coefficient is used in the following equation to calculate the percentage kW savings for correcting an undercharge ($\%kW_u$).

$$y_{kW} = 1.7838 * \text{kW/kWh coefficient} * \text{pctUnderCharge\_value}$$

y_{kW} = Peak demand impact (kW)
kW/kWh coefficient = Regression result - kW/kWh multiplier (dimensionless)
pctUnderCharge__value = Percentage of factory undercharge (>=7.5%) less than the factory charge determined based on NTD plus first-year undercharge (5.3%) prevented by refrigerant leak detection, repair, and LSCs (%)

pctUnderCharge__value = 0.075, y_{kw} = 8.4%
pctUnderCharge__value = 5.3%, y_{kw} = 5.9%
pctUnderCharge__value = (5.3% + 7.5%) = 12.8%, y_{kw} = 14.3%

Weighted average peak demand reduction (kW):
8.7% = [1.7838 * 0.626] * [0.053 * 0.665 + 0.128 * 0.335]

For the 8.7% weighted average peak demand reduction and base 3.15 kW, the weighted average LRM demand reduction is 0.274 kW (0.274kW = 3.15kW * 8.7%). This is 44.2% of the weighted average kW savings of 0.62 kW based on the Intertek test data shown in the figure titled "Peak Electric Demand (kW) savings for proper charge vs 7.5% undercharge for non-TXV and TXV systems" figure (44.2%=1-0.274/0.62). This indicates that the weighted average %kW savings calculation method is conservative by more than a factor of 2.

For comparison, the New York State Joint Utilities (NYSJU) use a 0.8 kW/kWh coefficient or coincidence factor for AC and HP - refrigerant charge correction. R3164 (page 104) The 0.8 kWh/kWh coefficient from New York is provided for reference to indicate that other states are using higher kW/kWh coefficients indicating the 0.626 kW/kWh coefficient is conservative .

Peak electric demand reduction is normalized per square foot of building floor area.

Gas Savings (Therms)

Not applicable.

Life Cycle

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The 5-year RUL for LRM regarding retention of locking Schrader caps installed on existing AC or HP host equipment is supported by a 2006 third-party verification study prepared by Aloha Systems titled "Evaluation, Measurement, and Verification Final Report: RCA Verification Program for New and Existing Residential and Commercial Air Conditioners" ("Aloha Systems Study"), which found 99.2% of sites had locking caps still installed after 2 years. R3151 (Page 14)

> *"We inspected 124 HVAC units to assure that the refrigerant charges and airflows of the units were correct (i.e., that the verification software did not recommend a change) and that the stickers and locking caps were in place. The sample size of 1% (120 units) was selected based upon the available budget. Temperature, pressure, and airflow measurements were entered into the program PDA. Verification of proper completion of the RCA at any given site would have been indicated by the PDA showing that no changes to the system were required. All of the units inspected showed proper charge and airflow. In one location we observed that locking caps had not been installed. RMA verified that this contractor had used up its supply of caps and the contractor was aware of the problem and had already flagged the units to have the caps installed upon receipt of more."*

The EUL and RUL for the split-system AC and HP are provided below. R240 Note that host HVAC equipment RUL is only applicable for determining the EUL of the add-on equipment (AOE). For normal replacement (NR) and new construction (NC) applications, the EUL is the full 15-year EUL of the host HVAC equipment. For AOE applications, the EUL is the lesser of the host equipment 15-year EUL and the 5-year RUL (see Calculations EUL Years).

Effective Useful Life and Remaining Useful Life

EFFECTIVE USEFUL LIFE ID	EUL DESCRIPTION (TEXT)	SECTOR (TEXT)	EUL YEARS (YR)	RUL YEARS (YR)	START DATE (TEXT)	EXPIRE DATE (TEXT)
HV-ResAC	**High Efficiency Air Conditioner (package and split systems)**	**Res**	**15.00**	**5.00**	**2013-01-01**	
HV-ResHP	**High Efficiency Heat Pump**	**Res**	**15.00**	**5.00**	**2013-01-01**	

Base Case Material Cost ($/Unit)

The base case is defined as the existing equipment so the base case material cost is $0.

Measure Case Material Cost ($/Unit)

The LRM measure material costs vary by offering and are normalized per square feet of building floor area. Material costs include LSCs, Schrader valve core valves, miscellaneous parts, and refrigerant charge. Material costs also include NTD software services, secure cloud storage scheduling, invoicing, and QC. Material costs are gross costs exclusive of taxes or shipping. R3152 The measure case material costs are calculated based on the average of materials costs from several online retailers and software providers and are normalized per square foot of building floor area.

Base Case Labor Cost ($/Unit)

The base case is defined as the existing equipment so the base case labor cost is $0.

Measure Case Labor Cost ($/Unit)

The LRM measure labor costs vary by offering and are normalized per square feet of building floor area. Measure labor costs are normalized per square foot of building floor area. Labor costs are based on 2022 RSMeans labor rates for HVAC technicians. Material plus labor costs are gross measure costs. R3152

Net-to-Gross

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. For low-income customers residential hard to reach (HTR) direct install customers, the NTG ratio is 0.85 with NTG ID "Res-Default-HTR-di" where the LRM measure package is targeted to HVAC contractors who are generally not implementing LRM measures. *Resolution E-5221* summarizes the CPUC decision on the NTG ratio for HTR customers who receive equipment through direct install delivery channels. R2026 The CPUC definition of HTR is as follows. R1270 Hard to Reach, Residential are defined as customers who do not have easy access to program information or generally do not participate in energy efficiency programs due to a language, income, housing type, geographic, or home ownership (split incentives) barrier. These barriers are defined as follows.

- Language – Primary language spoken is other than English.
- Income – Those customers who fall into the moderate income level (income levels less than 400 percent of the federal poverty guidelines.
- Housing Type – Multi-family and Mobile Home Tenants.
- Geographic – Residential or commercial customers in areas other than the San Francisco Bay Area, San Diego area, Greater Los Angeles Area (Los Angeles, Orange, San Bernardino, Riverside and Ventura counties) or Sacramento.
- Home Ownership – Renters.

For non-low-income customers, the NTG ratio is 0.70 with NTG ID "All-Default<=2yrs" for measures not covered by other NTG values and the measure technology type has been available in marketplace for 2 years or less. R2190

Net to Gross Ratio

NET TO GROSS RATIO ID	NTG DESCRIPTION (TEXT)	NTG ELECTRIC (RATIO)	NTG GAS (RATIO)	START DATE (TEXT)	EXPIRE DATE (TEXT)
All-Default<=2yrs	**Measures not covered by other NTG values and measure technology type has been available in marketplace for 2 years or less. This NTG value shall not be used for higher efficiency products of technology types that have been available in market place for more than 2 years.**	**0.7000**	**0.7000**	**2019-01-01**	
Res-Default-HTR-di	**HTR measure for Res sector, any building type**	**0.8500**	**0.8500**	**2022-01-01**	

Gross Savings Installation Adjustment (GSIA)

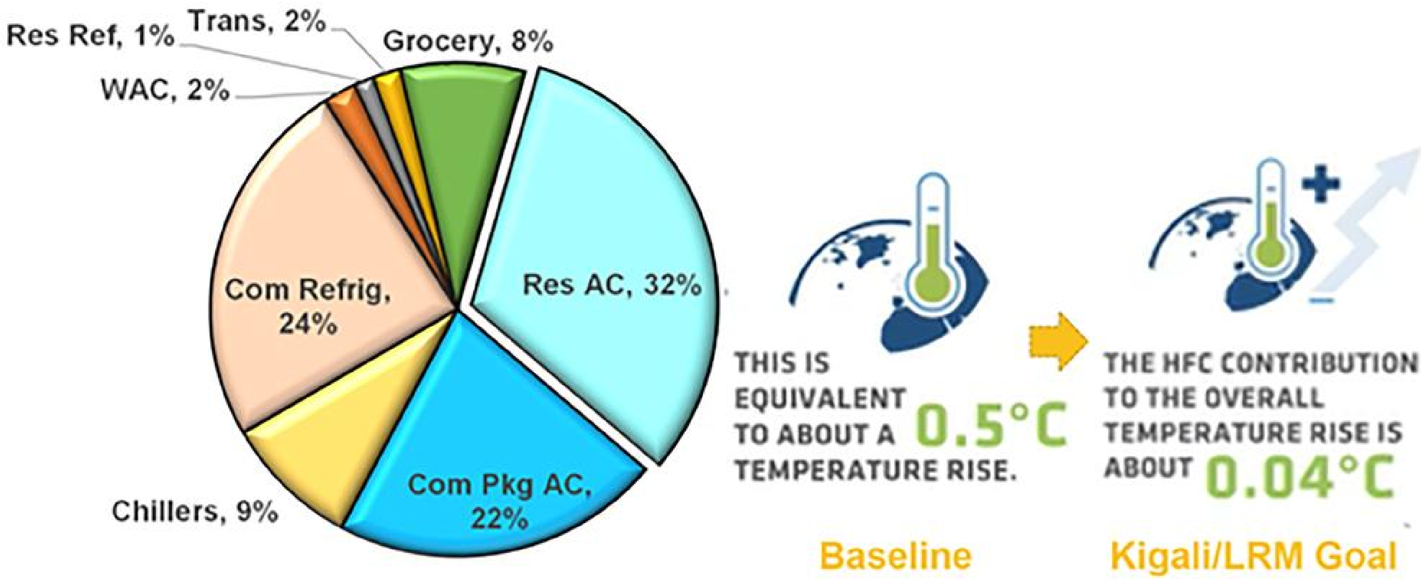
The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved. R1270

Gross Savings Installation Adjustments - Default

GSIA ID	GSIA (RATIO) R1270
Def-GSIA	**1.0000**

Non-Energy Impacts

Non-energy impacts include refrigerant benefits for reducing venting of hydrofluorocarbon (HFC) and hydrochlorofluorocarbons (HCFC) refrigerants to help reduce global warming from 0.5 °C to 0.04 °C by year 2100. Refrigerant venting reduction goals are required by the United Nations 2016 Kigali Amendment to the Montreal Protocol on substances that deplete the ozone layer. R3154 As of October 31, 2022, 138 states including the United States and European Union have ratified the Kigali Amendment. The residential sector accounts for 32% of the GWP impact as shown in the following figure (see CARB Table 2 (pp. 9-10) Input factors and emission calculations for refrigeration and AC shows residential AC with 7,059,80 lbs which is 32% of the 22,228,926 lbs total loss in lbs (annual + EOL). R3156



LRM Focuses on Residential AC Causing 32% of Global Warming from HFC and HCFC Refrigerants

Non-energy refrigerant benefits are captured in the refrigerant avoided cost calculator (RACC) and entered into the cost effectiveness test (CET) calculator. R3172 Resolution E-5221 provides guidelines for using the RACC for measures that involve refrigerant. Page 60 provides the following guidelines. “This guidance provides the PAs with the approved RACC cover sheet and calculator to be submitted as an addendum to active measure packages.” R2026 Per D.21-05-031 and *Resolution E-5152*, "starting in PY2022 the reporting of refrigerant leakage avoided costs (RLAC) is required for all energy efficiency measure claims as calculated from the CPUC’s Refrigerant Avoided Cost Calculator (RACC) for measure packages where the retrofit involves adding (not replacing) equipment that uses refrigerant—these include fuel substitution and electric resistance to heat pump measures—or where low-GWP measure benefits will be claimed." Detecting, repairing, and preventing refrigerant leaks is comparable to low GWP refrigerants insofar as refrigerant venting is avoided. Per CPUC *Resolution E-5221*, "Measure developers will need to submit the updated RACC for applicable measure packages thereafter (June 1, 2023). These updates will be outlined in the Measure Lifecycle Management table, see Section F. PAs are to use the most recent version of the calculator for all off-cycle new Measure Package submissions. Guidance on where to submit the addendums can be found on CEDARS at Guidance for Deemed Measures - CEDARS.

CPUC Decision D.21-05-031 section 8.1 allows program administrators to collaborate with CPUC staff for developing normal replacement measures within energy efficiency programs to encourage low-GWP refrigerants. The Decision specifies “...we will set normal replacement baseline to be either the current regulation, or the refrigerant typically used for similar applications in program years 2020-2021, whichever has lower refrigerant emissions. Given the market uncertainty, we will revisit this baseline policy in 2025.” The refrigerant baseline may be updated for program year 2026.

The refrigerant net present value (NPV) is based on the RACC workbook with a 5.3% annual refrigerant leakage rate and normalized factory charge of 8.2 lbs (131.2 ounces) adjusted per unit. R3158 R3159 R3160 R3161 R3162 The LRM factory charge varies based on cooling capacity which varies based on building type and climate zone. The LRM uses the following average factory charge values: DMo 105.5 ounces, MFm 71.6 +/- 5.1 ounces, SFm 133.8 +/- 9 ounces. The refrigerant cost savings are based on avoiding refrigerant leakage over five years for AOE and fifteen years for NC and NR, 7.34% discount rate, and current price of $1,452 for 30 lb cylinder of R-22 and $372 for 25lb cylinder of R-410a. R3152 Refrigerant costs vary based on quantity and availability of cylinders. The R22 leak prevention benefits (LPB) over 5 years ($LPB5_{R22}$) for AOE are calculated using the following present value (PV) equation.

```
$RC_R22 = ((131.2 * 0.053 * $1451.72) / 30) / 16 = $21.03

LPB5_R22 ($) = PV(DR,YRS,-$RC_R22) = PV(0.0734,5,-$21.03) = $85.45
```

> *$LPB5_{R22}$ = Leak prevention benefits ($)*
> *DR = Discount rate = 0.0734*
> *YRS = Years (yrs)*
> *$\$RC_{R22}$ = Refrigerant cost for R22 based normalized to 131.2 ounces (from RACC), 5.3% leak rate per year (RACC), and $1451.72 cost of R22 for 30-lbs cylinder ($)*
> *30 = 30-lbs of R22 refrigerant per cylinder (lbs)*
> *16 = 16 ounces per lbs (ounces/lbs)*

The R410a leak prevention benefits over 5 years ($LPB5_{R410a}$) for AOE are calculated using the following PV equation.

```
$RC_R410a = ((131.2 * 0.053 * $372.33) / 25) / 16 = $6.47

LPB5_R410a ($) = PV(DR,YRS,-$RC_R410a) = PV(0.0734,5,-$6.47) = $26.3
```

> *$LPB5_{R410a}$ = Leak prevention benefits ($)*
> *DR = Discount rate = 0.0734*
> *YRS = Years (yrs)*
> *$\$RC_{R410a}$ = Refrigerant cost for R410a based on 131.2 ounces (from RACC), 5.3% leak rate per year (RACC), and $372.33 cost of R410a for 25-lbs cylinder ($)*
> 25 = *25-lbs of R410a refrigerant per cylinder (lbs)*
> *16 = 16 ounces per lbs (ounces/lbs)*

The R410a leak prevention benefits over 15 years (LPB15) for NC and NR are calculated using the following PV equation.

```
LPB15_R410a ($) = PV(0.0734,15,-$6.47) = $57.71
```

Refrigerant leak prevention avoids the release of R22 which has a global warming potential (GWP) of 1,810 lbs CO2 for 100 years. R3166 R410a has a GWP of 2,088 lbs CO2 for 100 years based on 50% HFC-32 (CH2F2) and 50% HFC-125 (CHF2CF3). *Resolution E-5152* requires IOU program administrators to report refrigerant leakage avoided costs (RLAC) for which GWP refrigerant measure benefits will be claimed, such as a change in the type or amount of refrigerant or preventing refrigerant leaks. R1503 Refrigerant benefit assumptions are shown in the following table based on refrigerant benefits from the refrigerant avoided cost calculator (RACC) and the present value (PV) of leak prevention benefits (noted above). R3172 R3152

Refrigerant Benefits - Calculation Inputs

BUILDING HVAC	INSTALLATION	REFRIGERANT	MEASURE APPLICATION TYPE	RACC REFRIGERANT BENEFITS (USD) R3158 R3159 R3160 R3161 R3162	LEAK PREVENTION BENEFITS (USD)
rDXGF	+7.5% RCA + LSC	R22	AOE	**$111.51**	**$85.45**
rDXGF	+7.5% RCA + LSC	R410a	AOE	**$128.61**	**$26.30**
rDXGF	Install LSC	R22	AOE	**$111.51**	**$85.45**
rDXGF	Install LSC	R410a	AOE	**$128.61**	**$26.30**
rDXGF	NC LSC	R410a	NC	**$546.43**	**$57.71**
rDXGF	NR EOL LSC	R410a	NR	**$910.40**	**$57.71**
rDXHP	+7.5% RCA + LSC	R22	AOE	**$111.51**	**$85.45**
rDXHP	+7.5% RCA + LSC	R410a	AOE	**$128.61**	**$26.30**
rDXHP	Install LSC	R22	AOE	**$111.51**	**$85.45**
rDXHP	Install LSC	R410a	AOE	**$128.61**	**$26.30**
rDXHP	NC LSC	R410a	NC	**$546.43**	**$57.71**
rDXHP	NR EOL LSC	R410a	NR	**$910.40**	**$57.71**

The CET input file column labeled "UnitRefrigBens" is calculated using the following equation.

Unit Refrigerant Benefits

EQUATION (USD / UNIT)
$\frac{(refrigBenefitsCalc\_\_rACCRefrigBenefits + refrigBenefitsCalc\_\_leakPrevBenefits) \bullet constFactCharge\_\_avg}{(constFactCharge\_\_rACC \bullet normUnit\_\_floorArea)}$

refrigBenefitsCalc_rACCRefrigBenefits = Unit refrigerant benefits based on RACC and leak prevention ($)
refrigBenefitsCalc_leakPrevBenefits) = Net present value of leak prevention benefits see above equations ($)
constFactCharge_avg = Factory charge per prototype based on climate zone (lbs)

constFactCharge_rACC = Factory charge assumed in RACC or 8.2 lbs per unit (lbs)
normUnit_floorArea = Conditioned floor area see last table in Electric Savings *(ft^2)*

DEER Differences Analysis

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based. DEER2024 EnergyPlus unit energy consumption (UEC) values are used with percentage annual savings based on Intertek and Purdue University laboratory tests. DEER does not currently provide space cooling energy savings for the LRM measure which is an early adopter of low GWP lifecycle refrigerant management (LRM) methods for ExAnte2023.

DEER Difference Summary

DEER ITEM	COMMENT
Modified DEER methodology	Yes
Scaled DEER measure	Yes
DEER Base Case	Yes
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER2024 EnergyPlus Unit Energy Consumption (UEC) values are used with percentage annual savings based on Intertek and Purdue University laboratory tests
Reason for Deviation from DEER	DEER does not currently provide space cooling energy savings for the LRM. This measure is an early adopter of low GWP LRM methods for Ex Ante 2023.
DEER Measure IDs Used	No

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