

# **Suggestions for HVAC Efficiency Improvements for the 2008 California Building Energy Efficiency Standards**

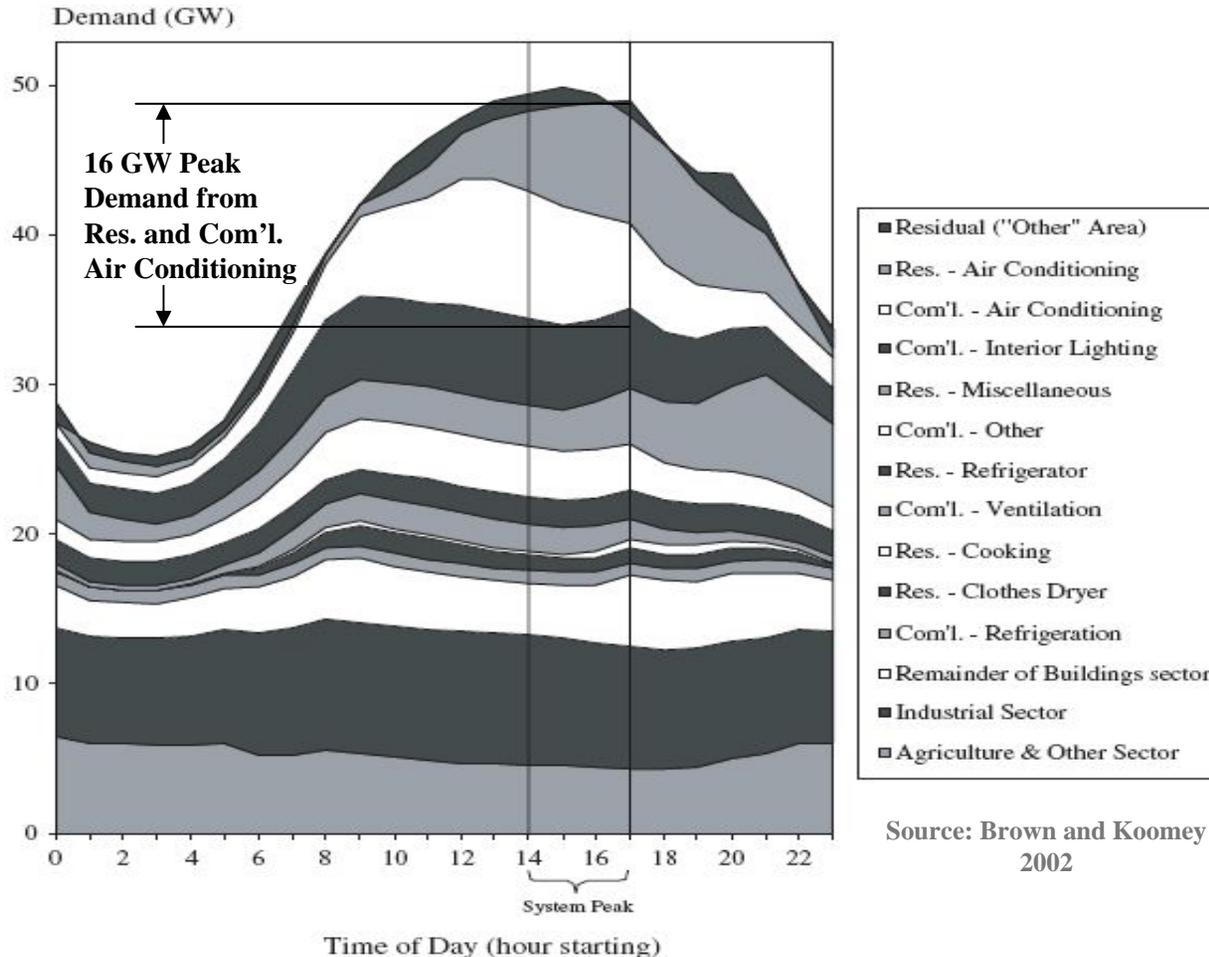
*July 12, 2006*

*901 P Street, Sacramento, Hearing Room 102-A*

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# Why is HVAC Important?

- Residential and commercial air conditioning uses the largest share of peak demand in California with 33% or 16 GW in 1999.



# Overview of HVAC Market in California

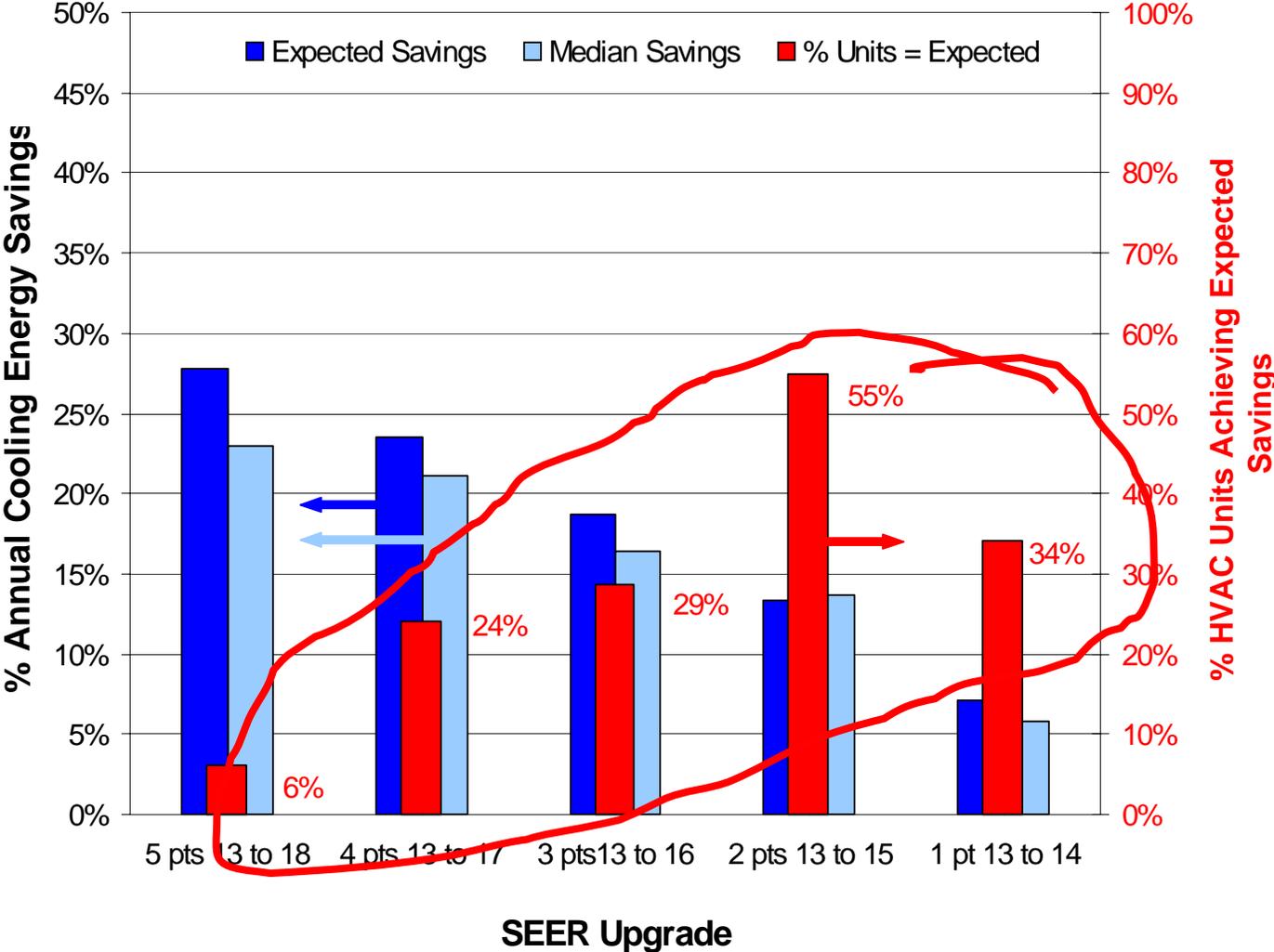
- California has 4.1 million residential and 3.5 million commercial air conditioners, and 0.5 million new units are installed annually.
- 50 to 70% of HVAC systems are 10-40% less efficient than the labeled efficiency due to improper installation and service.
- Potential savings in California from proper RCA, TXVs, tight ducts, proper sizing, matching coils, cool attics, and economizer operation are approximately  $3 \pm 0.5$  TWh and  $2.5 \pm 0.5$  GW.
- Most technicians don't have proper training, equipment, or verification methods to ensure proper installation. Instead they rely on rules of thumb such as "bigger is better" or "add or remove refrigerant until the suction line is 6-pack cold or suction pressure is 70 psig."

# Overview of Suggestions

The following suggestions are provided to improve HVAC efficiency for the 2008 Building Energy Efficiency Standards.

1. Verification of proper RCA and eliminate TXV as substitute for proper RCA (since most new units are shipped with TXV).
2. Maintain proper refrigerant charge with Novent caps and labels.
3. Verification of proper TXV installation.
4. Verification of cool attic to install AC equipment in attics.
5. Verification of proper airflow for multi-zone damper systems.
6. Proper sized/matched evaporator and condenser coils to provide rated capacity and efficiency for split-system air conditioners.
7. Verification of proper economizer operation and controls.

# New HVAC Equipment Under Performs

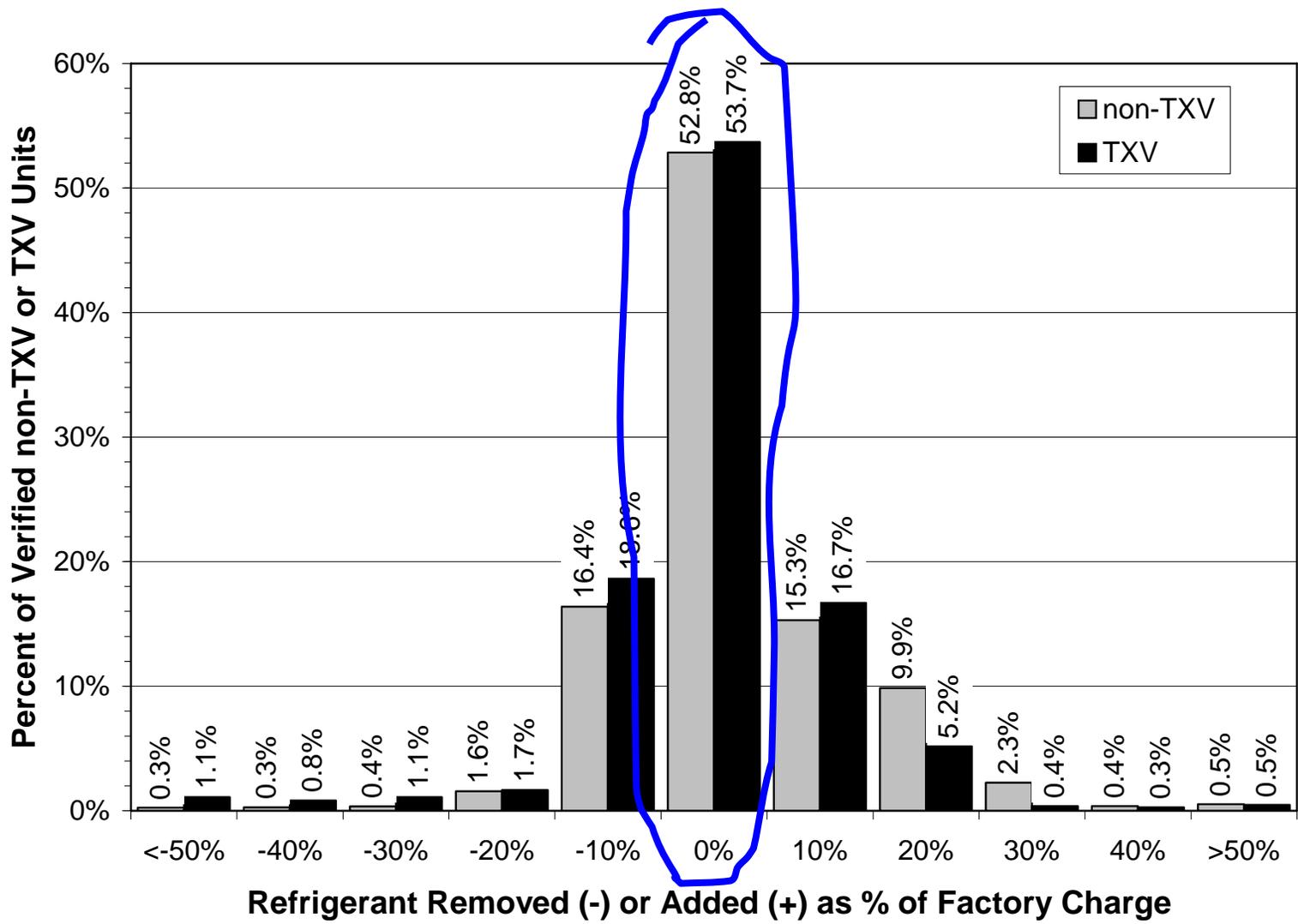


Source: J.J. Hirsch & Assoc., "EER and SEER as Predictors of Seasonal Cooling Performance," Prepared for SCE, 2004.

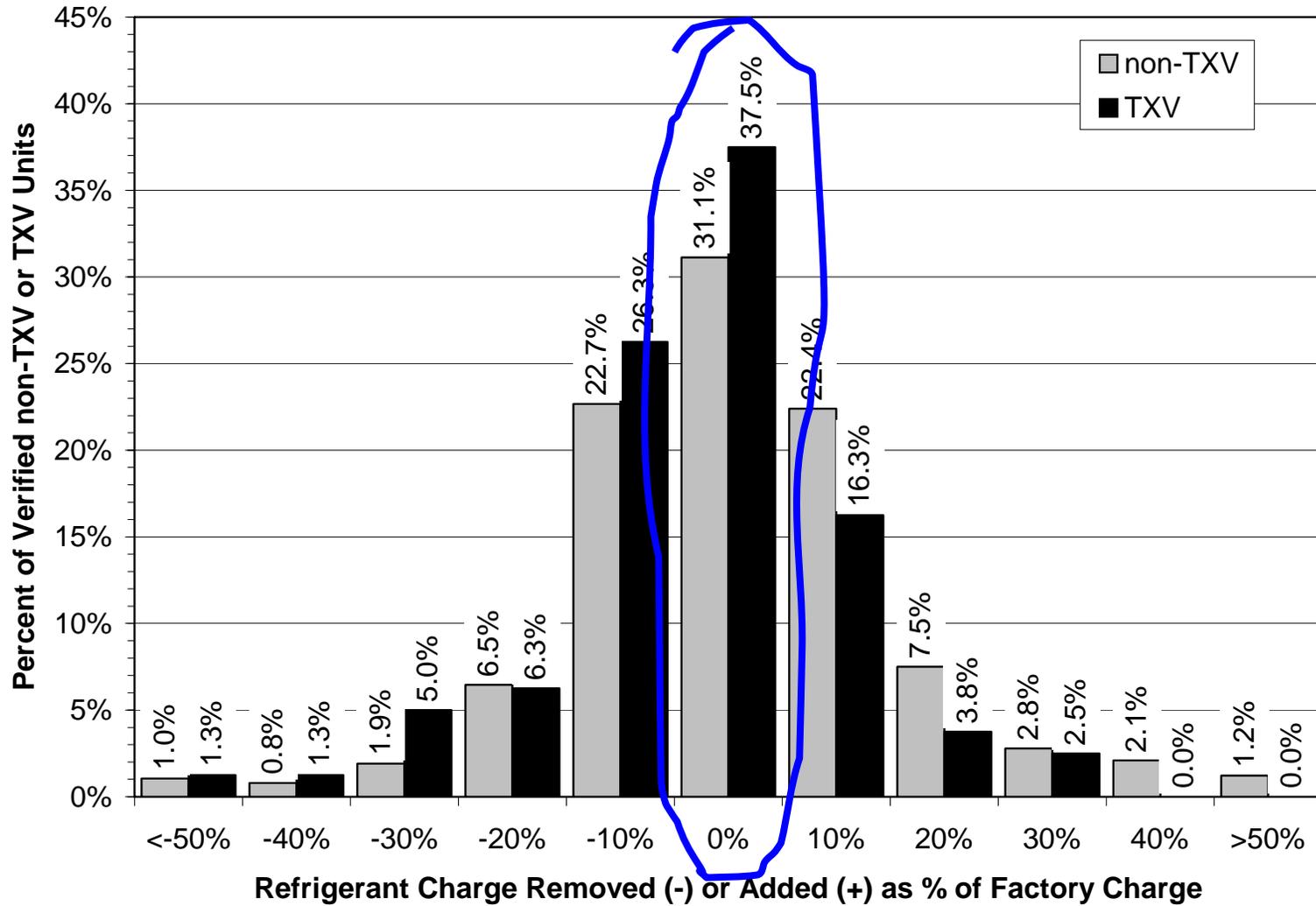
# Refrigerant Charge and Airflow

- The CEC should consider verification of proper RCA for all air conditioners under the 2008 Building Energy Efficiency Standards.
- Current Title 24 building efficiency standards allow a TXV to substitute for proper RCA to receive the same compliance credit.
- Manufacturers provide the same warranty irrespective of whether an air conditioner has proper RCA.
- Research studies show HVAC dealers lack motivation, training, equipment, and methods to verify proper RCA.
- Field data from 16,500 units show improper RCA on 48% of new residential split-systems, 62-69% of existing residential units, 30-67% of new commercial packaged units, and 64-70% of existing commercial units.

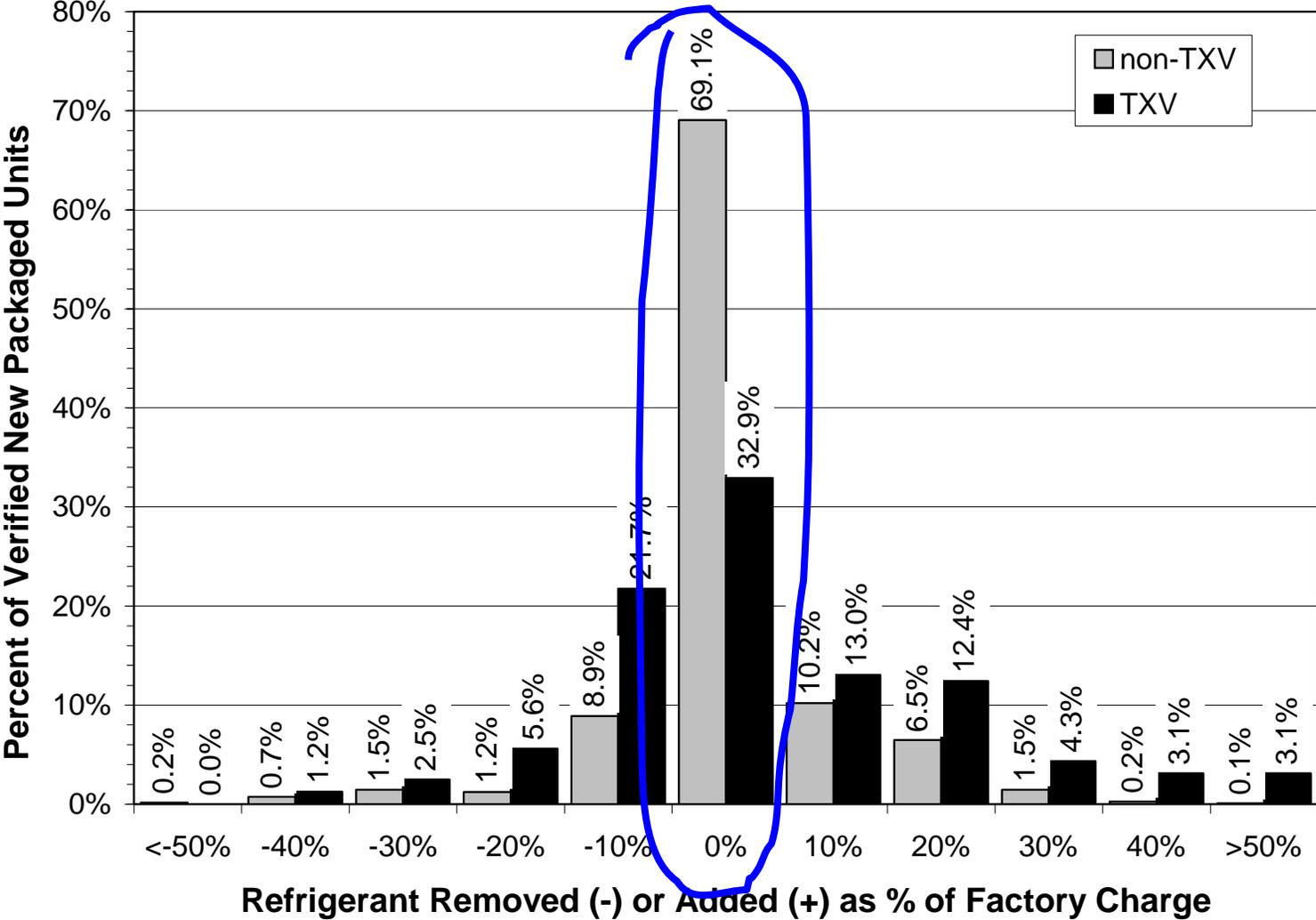
# RC Data for New Residential Split-Systems



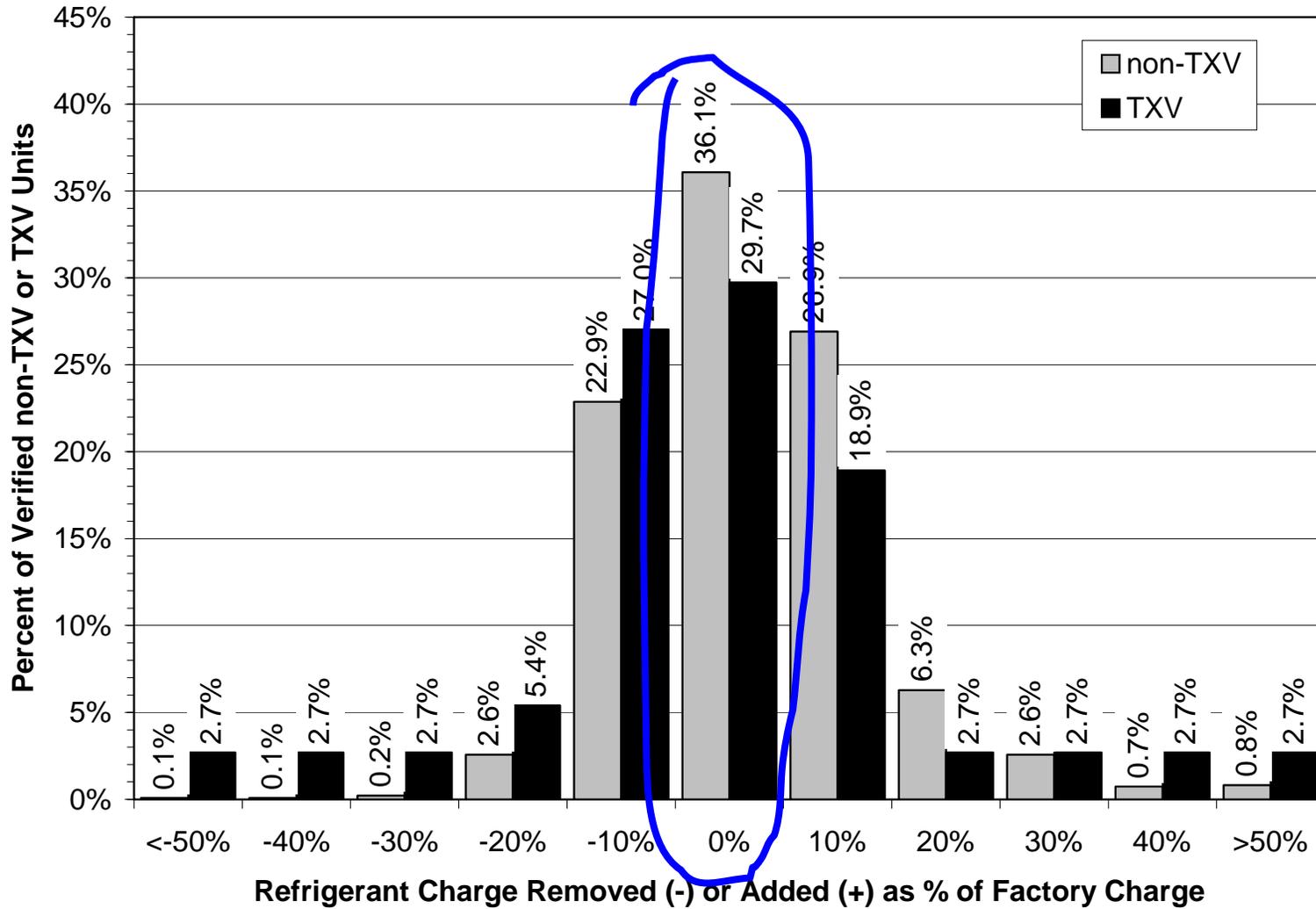
# RC Data for Existing Residential Systems



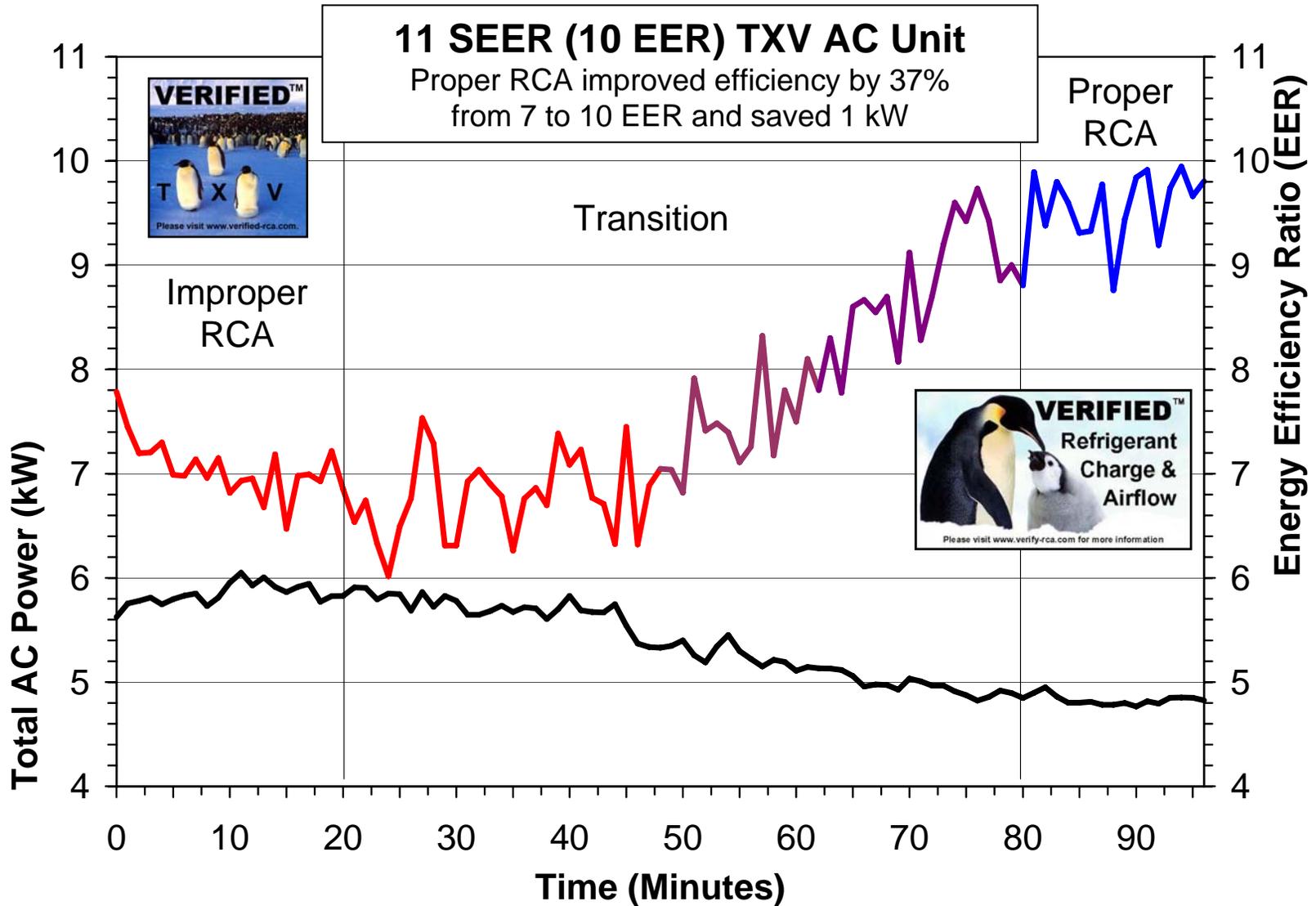
# RC Data for New Commercial Pkg. Units



# RC Data for Existing Commercial Pkg. Units



# Proper RCA on TXV Units

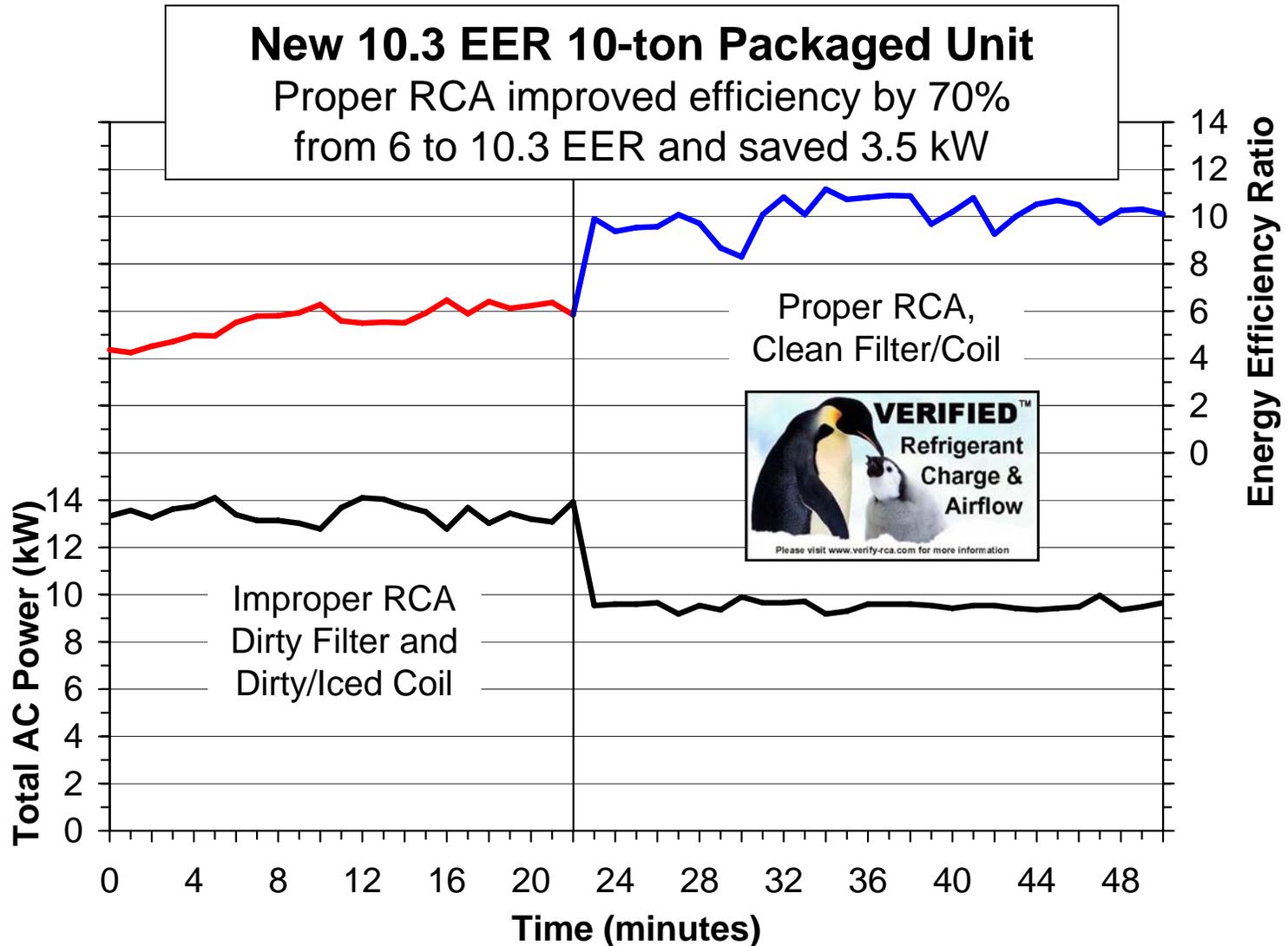


# Proper RCA on Packaged Units

- Improper RCA can cause ice to form on packaged units. This lowers efficiency and can damage compressors.



# Proper RCA on Packaged Units



# Maintaining Proper RCA

- To maintain proper RCA, the CEC should consider requiring:
  - Third-party VSP quality-control registration,
  - Permanent labels, and
  - Locking Schrader caps.
- This will help maintain efficiency and prevent refrigerant leakage, tampering, injury, future mal-adjustments, and proper refrigerant management to prevent stratospheric ozone depletion consistent with section 608 of the Federal Clean Air Act regulated by US EPA
- Without these measures the EUL for proper RCA will be reduced and the savings assumed by the standards will be reduced.
- Field studies show that mal-adjustments of proper refrigerant charge by untrained and ill-equipped AC technicians can occur within 1 to 3 years without Novent Schrader caps and permanent labels.

# Maintaining Proper RCA

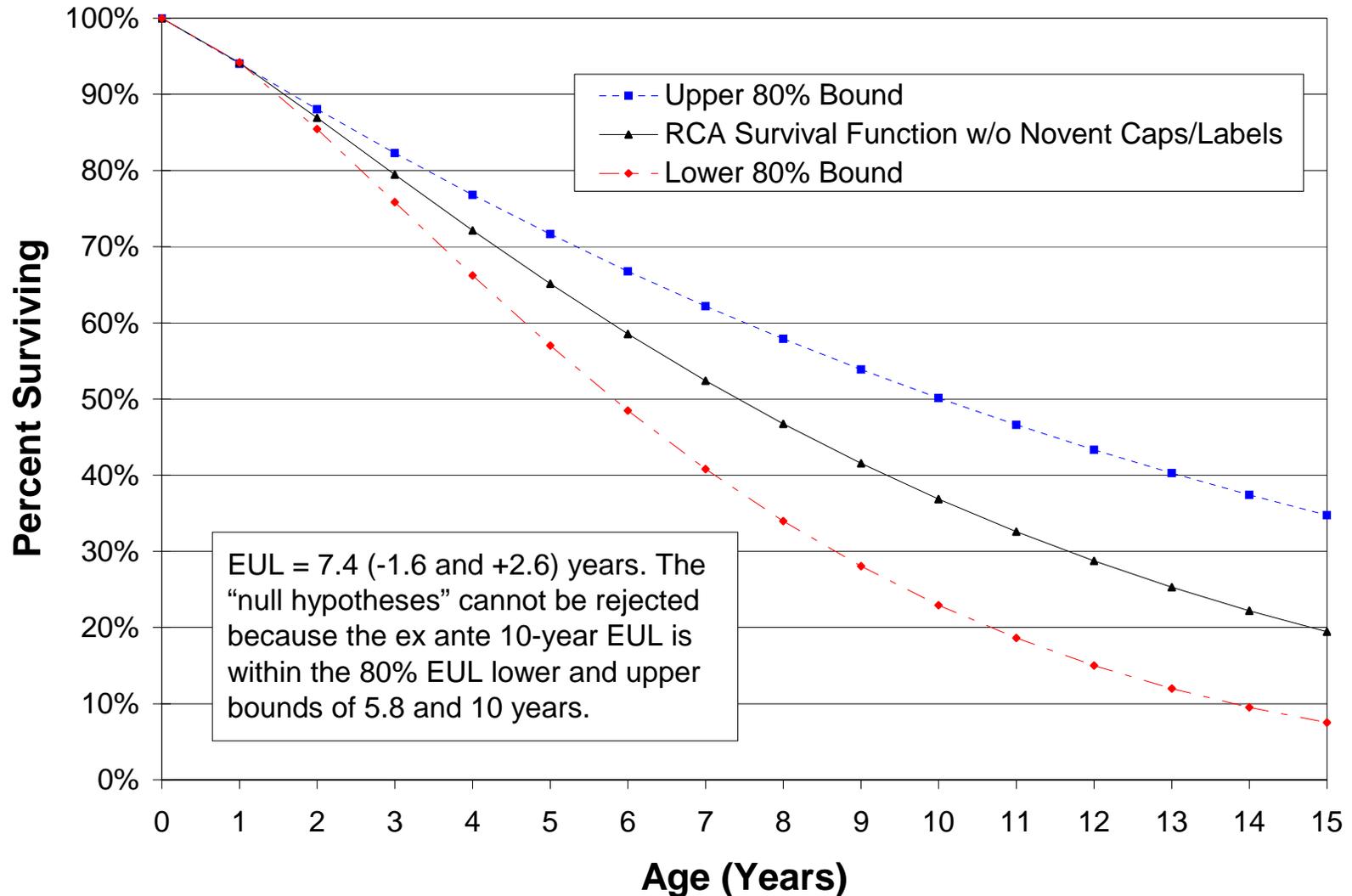
Registration, permanent labels, and locking Novent™ caps maintain proper RCA, promote public health and safety, and prevent stratospheric ozone depletion.



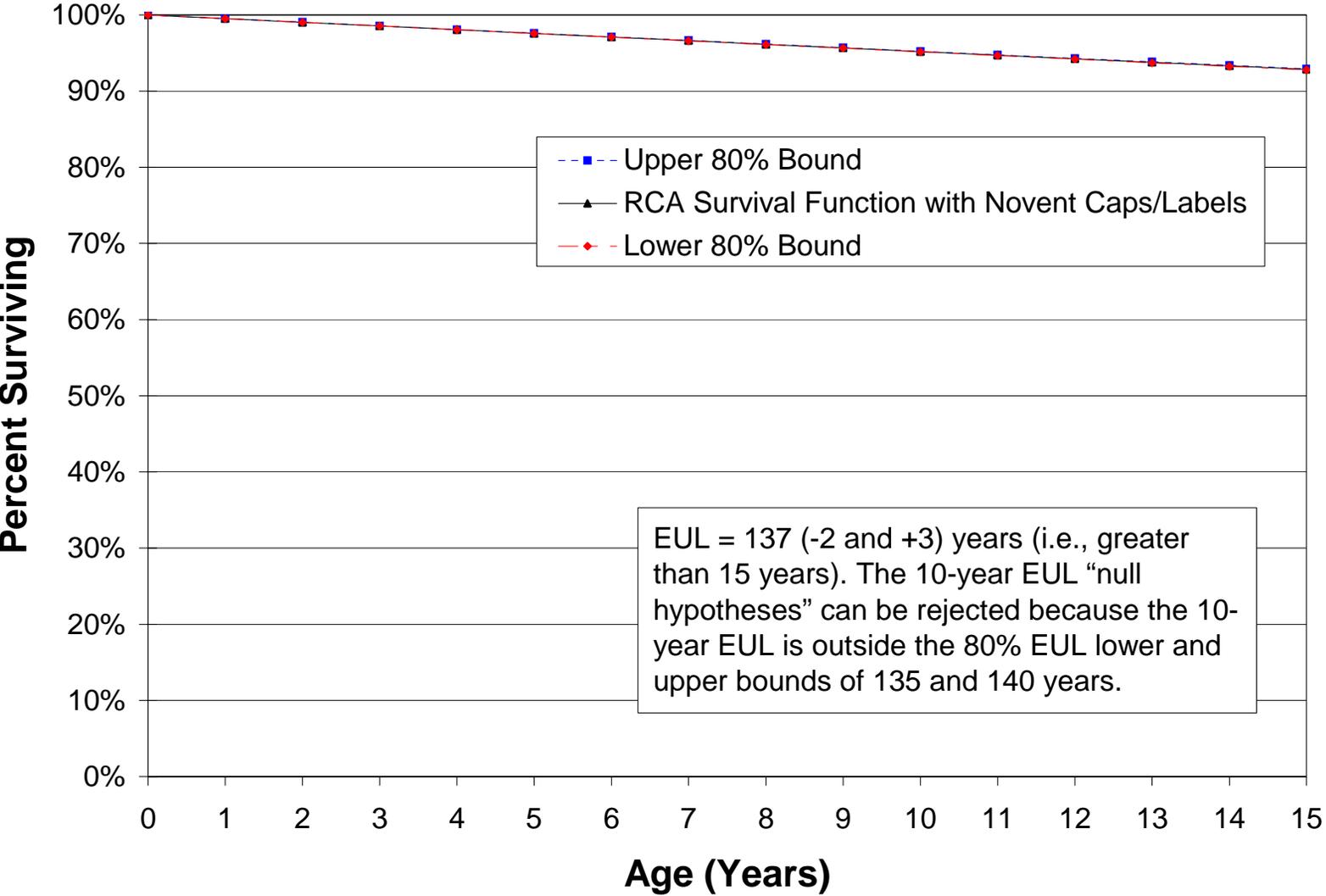
# RCA Effective Useful Life (EUL)

- Survival analysis of retention data was used to estimate the EUL and test the 10-year EUL “null hypotheses” for RCA.
- Retention data from RCA programs without Novent™ caps or permanent labels found failures of 7 to 9% per year over 3 years. This is equivalent to a 7.4 +/- 2.6 year EUL.
- Retention data for RCA verification programs with Novent™ caps and permanent labels found failures of 0.5% per year over 2-years. This is equivalent to a 137 +/- 3 year EUL.

# RCA Effective Useful Life without Novent™ Caps and Labels



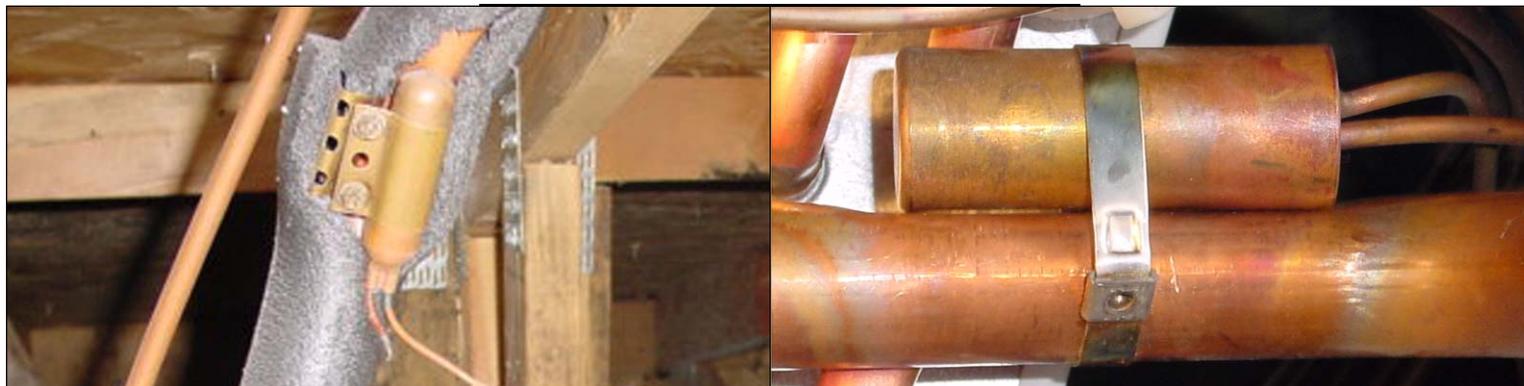
# RCA Effective Useful Life with Novent™ Caps and Labels



# Thermostatic eXpansion Valve (TXV)

- The CEC should eliminate the TXV as a substitute for proper RCA.
- Laboratory and field studies show that TXV-equipped air conditioners have no efficiency advantage compared to non-TXV-equipped air conditioners when units are overcharged.
- TXV sensing bulbs are improperly installed and current Standards don't address installation quality (insulation, contact, orientation).
- Laboratory studies indicate improved performance for TXVs, but only when undercharged. Studies lack similitude to field conditions, and didn't consider TXV "hunting" with improper RCA.

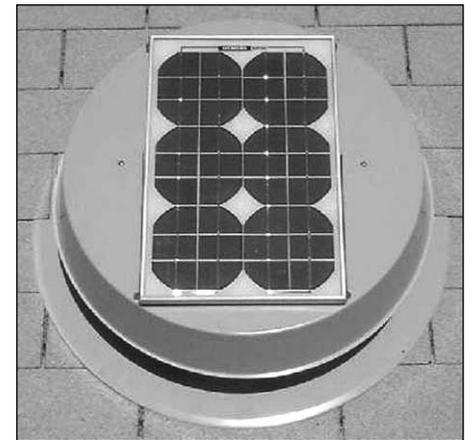
# Proper TXV Installation



- TXVs are supposed to optimize refrigerant flow and efficiency as cooling loads vary.
- Most TXV sensing bulbs are installed with no insulation and improper contact/orientation. Improper installation, low RCA, or dirty/iced coils cause “hunting” and compressor damage.
- Field data shows TXV and non-TXV units have comparable efficiency gains from proper RCA.

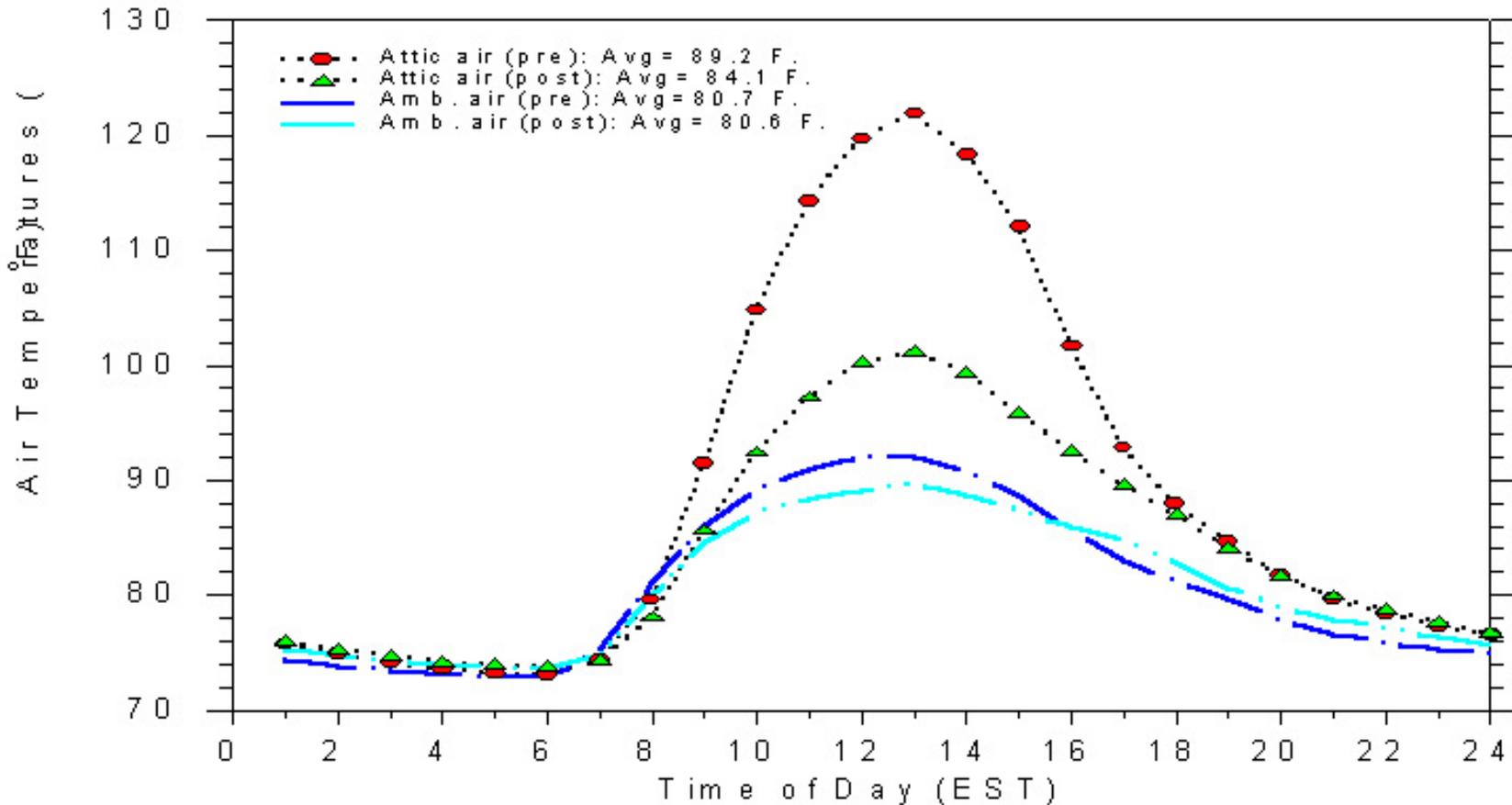
# Cool Roofs and Attics

- Cool roofs and attics reduce cooling loads and AC run time, improve capacity, and allow AC down-sizing by 16 to 35% and save 75 MW.
- Cool roofs use high solar reflectance and/or thermal emittance roofing and cool attics use radiant barriers or attic fans (solar-powered or conventional) to reduce solar heat transfer to conditioned space and attic temperatures where evaporators and ducts are often located.
- Average savings are 10 to 30% based on studies by Lawrence Berkeley National Laboratory, Florida Solar Energy Center (FESC), and DEER.
- FESC Study showed attic temperatures were reduced by 22°F with 6% cooling savings even with a pre-existing radiant barrier that limited pre-retrofit attic temperatures to 136°F.



# Cool Attics Reduce Peak Cooling

- Average attic temperature was reduced by 22°F after solar attic fan.



# Multi-Zone AC Systems

- The CEC should consider Standards requiring two-stage or variable-speed compressors/fans on multi-zone damper systems.
- Conventional constant-speed split-system air conditioners suffer efficiency degradation when installed with multi-zone dampers.
- Many multi-zone systems use dampers and damper assemblies that reduce the cross-sectional area by 50% to 75%.
- Multi-zone systems should have 2-stage or variable-speed compressors/fans to eliminate low airflow which can cause:
  - Icing of the evaporator coil,
  - Slugging (i.e., liquid refrigerant entering the compressor),
  - Reduced efficiency, and
  - Premature compressor failure.

# Multi-Zone AC Systems

- Field measurements of multi-zone damper systems show 10 to 14% lower capacity and 20 to 30% lower Energy Efficiency Ratio (EER).
- HVAC dealers install larger indoor fans (i.e., 1 to 1½ tons larger) to overcome larger static pressure when dampers are engaged.
- This increases kW (i.e., indoor fan, condenser fan, and compressor).
- This lowers the field-measured EER compared to rated EER.
- Based on field measurements, the multi-zone damper systems reduce capacity and EER compared to units without dampers.
- Multi-zone damper systems can cause icing of the evaporator, slugging, reduced efficiency, and premature compressor failure.
- Additional field testing should be performed to better understand performance with and without the multi-zone damper systems.

# Proper Sized HVAC Systems

- The CEC should consider Standards requiring proper sized HVAC systems (per ACCA Manual J) to improve the capacity and efficiency of split-system air conditioners.
- Energy and peak demand savings for proper sized evaporator/condenser coils per ACCA Manual J are 10 to 20%.
- Field studies show most units are oversized by ½ to 1 ton or more.
- This causes inefficient operation, reduced reliability due to frequent cycling of compressors, and poor humidity control.
- Oversized systems waste capital invested in the HVAC system.
- Oversized commercial units affect the ability of the system to provide simultaneous economizer and compressor operation, and exacerbates problems with distribution system fan power, since larger units are supplied with larger fans.

# ARI Matching Coils

- The CEC should consider Standards requiring ARI matching evaporator and condenser coils to provide rated capacity and efficiency for split-system air conditioners.
- Even with correct RCA, many split-system air conditioners do not perform at their rated efficiency due to improperly matching evaporator and condenser coils.
- Field measurements of new split-system units indicate 10 to 35% lower EER values due to improper matching coils.
- Original Equipment Manufacturers (OEM) of condensing coils cannot guarantee the rated efficiency per the Air-Conditioning and Refrigeration Institute (ARI) SEER/EER ratings with evaporator coils manufactured by Independent Coil Manufacturers (ICM) that are not listed in the ARI directory as a proper match for the condensing coil.

# Economizer Operation

- Proper economizer set-up maximizes non-mechanical natural cooling.
- Average energy and peak demand savings for economizer set-up and maintenance are 9 to 21% based on DEER.
- A California study found 64% of economizers not operating properly (i.e., dampers, sensor/controls, or poor operation).
- Problems can be corrected by requiring: 1) factory-installed and run-tested economizers, 2) direct drive actuators to eliminate damper linkage failure, 3) differential (temperature or enthalpy) changeover, and 4) low leakage dampers.

# Conclusions

- Potential savings in California from proper RCA/TXV, cool attics, multi-zone damper systems, proper sized/matched coils, and economizer set-up are  $3 \pm 0.5$  TWh and  $2.5 \pm 0.5$  GW.
- The CEC should consider standards to achieve these savings.
  1. Verification of proper RCA and eliminate TXV as substitute for proper RCA (since most new units are shipped with TXV).
  2. Maintain proper refrigerant charge with Novent caps and labels.
  3. Verification of proper TXV installation.
  4. Verification of cool attic to locate AC equipment in attics.
  5. Verification of proper airflow for multi-zone damper systems.
  6. Proper sized/matched evaporator and condenser coils.
  7. Verification of economizer operation and controls.