Work Paper WPSCREHC0001
Revision 1

Southern California Edison Company
Design & Engineering Services

Energy Star Room Air Conditioners

October 16, 2007

At a Glance Summary

Measure Name:	**Energy Star Room Air Conditioners**
Savings Impacts Common Units:	12,906 Btu Weighted Mean Room Air Conditioner Unit
Customer Base Case Description:	9.4 Weighted Mean EER (Current Code basis)
Code Base Case Description:	Same as Customer Base Case
Costs Common Units:	Same as Savings Impacts.
Measure Equipment Cost ($/unit):	$376.00 per room air conditioner
Measure Incremental Cost ($/unit):	$81.00 per room air conditioner
Measure Installed Cost ($/unit):	$0.00
Measure Load Shape:	AC_Cooling-RC
Effective Useful Life (years):	15 years
Program Type:	Replace On Burnout (ROB) and New
TOU AC Adjustment:	100%
Net-to-Gross Ratios:	For Residential Contractor Program: 0.89 For all other residential programs: 0.80
Building Type:	All Residential
Building Vintage:	All
Important Comments:	This work paper presumes the customer is either replacing a failed room air conditioner (RAC) or purchasing a RAC to be installed where there was no prior RAC. (This work paper also includes calculations and results for the Residential RAC Recycling to delineate efficiencies for the Residential RAC Recycling work paper and this work paper.)

Work Paper RunID WPSCREHC0001.1-	Climate Zone	Customer Annual Electric Savings (kWh/unit)	Customer Peak Electric Demand Reduction (kW/unit)	Above Code Annual Electric Savings (kWh/unit)	Above Code Peak Electric Demand Reduction (kW/unit)
001	6	197.7	0.132	197.7	0.132
002	8	247.0	0.132	247.0	0.132
003	9	232.3	0.132	232.3	0.132
004	10	219.8	0.132	219.8	0.132
005	13	217.9	0.132	217.9	0.132
006	14	201.3	0.132	201.3	0.132
007	15	293.5	0.132	293.5	0.132
008	16	158.2	0.132	158.2	0.132

Document Revision History

Revision 0	February 22, 2007	Original short form work paper.
Revision 1	October 16, 2007	Revision 0 (Rev 0) of this work paper was based on SCE engineering estimates of energy savings and demand reduction using Database for Energy Efficiency Resources (DEER) Annual Energy Consumption (kWh) per Multi-Family Apartment (RASS Weight Averaged) for a 14,000 Btu room air conditioner (RAC). Revision 1 (Rev 1) replaces the Rev 0 energy savings methodology with DEER database measure for Packaged Terminal Air Conditioners (PTAC) units for motel rooms as a basis. The PTAC measure is the only DEER measure using Energy Efficiency Ratios (EER) to measure performance for cooling of any kind: all other measures use the significantly different Seasonal EER. PTAC units are nearly identical to RACs in cooling performance but also provide heat. Establishing an equation for energy savings performance for PTAC EERs, Rev 1 uses a 12,906 Btu RAC and previous & current code and Energy Star room air conditioner EERs to establish energy savings. For demand reduction, Rev 1 retains the Rev 0 methodology. The DEER motel room PTAC measure's 24 hour profile for power demand varies significantly from residential room air conditioner power demand profile. The table below lists values for Rev 0, Rev 1 and the change between the revisions.

E3 Input	Rev 0	Rev 1	Change
Measure Cost	$106.00 per RAC	$81.00 per RAC	-$25.00 per RAC
Effective Useful Life	15	15	Unchanged

The table below lists the energy savings and demand reductions for Rev 0, Rev 1 and the change between the revisions. Rev 0 14,000 Btu RAC numbers were modified to 12,906 Btu RAC to match the RAC size of Rev 1.

Energy Star RAC Summary: Rev 0 to Rev 1 Comparison							
For One 12,906 Btu Room Air Conditioner							
Climate Zone	Rev 0	Rev 1	Change	Climate Zone	Rev 0	Rev 1	Change
Energy Savings (kWh/square foot)				**Demand Reduction (kW/square foot)**			
6	52	198	146	6	0.258	0.132	-0.126
8	101	247	146	8	0.258	0.132	-0.126
9	148	232	84	9	0.258	0.132	-0.126
10	182	220	38	10	0.258	0.132	-0.126
13	361	218	-143	13	0.258	0.132	-0.126
14	220	201	-19	14	0.258	0.132	-0.126
15	594	293	-301	15	0.258	0.132	-0.126
16	56	158	102	16	0.258	0.132	-0.126

Note: The information provided in this Work Paper was developed using the best available technical resources at the time this document was prepared.

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Section 1. General Measure & Baseline Data

1.1 Measure Description & Background

This work paper details the E3 Calculator inputs for purchase of residential room air conditioners (RAC) that meet Energy Star requirements or Energy Star RACs (ES-RAC) instead of minimum efficiency Code RACs (C-RAC). Thus, purchase of a C-RAC is the base case for this work paper and purchase of an ES-RAC is the measure case. Installation costs are presumed to be identical.

In 1992 the U.S. Environmental Protection Agency (EPA) introduced Energy Star as a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. Through 1995, EPA expanded the label to additional office equipment products and residential heating and cooling equipment. In 1996, EPA partnered with the U.S. Department of Energy (DoE) for particular product categories[1]. Energy Star announced labels for RACs in October 1996[2]. Energy Star RACs (ES-RAC) are defined as having a minimum of 10% energy efficiency improvement over minimum DoE requirements[3].

1.2 DEER Differences Analysis

This paper covers residential RAC applications. However, there are no residential RAC application calculations available in the Database for Energy Efficiency Resources (DEER). Residential DEER applications evaluate more efficient split systems and central air conditioning systems with higher Seasonal EER (SEER) requirements.

To determine energy savings, this work paper uses DEER Measure D03-099 which provides an analysis of Packaged Terminal Air Conditioners (PTAC or Packaged Terminal Heat Pumps (PTHP) (collectively: PT units) installed in Motel Lodging Guest Rooms. PT units use similar equipment to RACs for cooling, but also feature heating functions RACs do not have. PT unit EERs are similar to RAC EER requirements. This work paper uses PT unit vintage, code and 20% above code EERs and their related energy savings as points for Least Square Linear Regression (LSLR) Method) to establish a function to calculate equivalent RAC energy savings figures.

This work paper does not use DEER to determine demand reduction. The twenty four hour Time-Of-Use (TOU) profile for DEER measure D03-099 is significantly different from residential RAC TOU. Also, as the PT units include provisions for heating and RACs do not, this paper does not use the DEER cost data that would include capital costs for the PT unit heating elements.

In DEER Section 6 for Motel Lodging Guest Rooms Table 1 and
Table 2 list the following information:

Table 1: DEER Table 6-1 (Partial): Nonresidential Space Characteristics[4]

Activity Area Type	Occupant Density (ft^2/person)	Sensible Occupant Load (Btuh/person)	Latent Occupant Load (Btuh/person)	Ventilation Rate (cfm/person)
Motel Guest Room	300.0	245	155	30.00

Table 2: DEER Table 6-2 (Partial): Nonresidential Prototype Descriptions[5]

Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
10. Lodging - Motel	DEER	Corridor	3,333	11.1	Thermal Zoning: One zone per activity area. Model Configuration: Matches 1994 DEER configuration. Guestrooms are divided among: 12 hour occupied (12,794 ft^2/ 42.6%), 24-hour occupied (6,397 ft^2/ 21.3%) and unoccupied rooms (6,397 ft^2/ 21.3%). HVAC Systems: The oldest vintage uses PTAC systems with electric resistance heating. All other vintages use PTHP systems.
		Motel Guest Room (incl. toilets)	25,587	85.3	
		Laundry	480	1.6	
		Office (General)	600	2.0	
		Total	30,000		

Table 1 lists DEER loads and ventilation rates for Motel Lodging Guest Rooms. The Lodging – Motel section from DEER Table 6-2 identifies PTAC and PTHP (

Table 2 above) as being used in the simulation of Motel Lodging Guest Rooms. The Motel Lodging Guest Room applications appear to be best available DEER simulation for residential RAC applications which are most likely to be for cooling one room with some interior and some exterior walls and ceilings. DEER Measure D03-099 Run IDs differ from the

Table **2** description stating all vintages in the Measure use PTACs.

Motels on average are cooled at 1 ton of cooling (12,000 Btu) per 300 square feet (ft^2)[6]. Based on the DEER occupant density of 300 ft^2 this paper sets PT units at 12,000 Btu cooling 300 ft^2. The DEER Lodging – Motel total floor area is 30,000 ft^2 so dividing total floor area by 300 ft^2 results in 100 total PT units installed in the DEER Lodging – Motel.

DEER uses the PTAC EER values listed in Table 3 below:

Table 3: DEER PTAC EER Values for Lodging - Motel[7]

DEER: PTAC (7-15 kBtu/unit or 0.583 to 1.25 cooling tons/unit)			
Buildings Vintages	Measure Case Description (EER)	Base Case Description (EER)	Code Base Description (T24 minimum EER)
Built before 1978	10.27	6.80	8.56
Built between 1978 and 1992	10.27	7.80	8.56
Built between 1993 and 2001	10.27	8.50	8.56
Built between 2002 and 2005	10.27	8.50	8.56

Built 2006 and later (measures as retrofit for nonresidential)	12.19	10.16	10.16

1.3 Codes & Standards Requirements Analysis

U.S. DoE Office of Energy Efficiency and Renewable Energy Energy's "Conservation Program for Consumer Products: Final Rule Regarding Energy Conservation Standards for Room Air Conditioners: 10 CFR Part 430" is summarized in the State of California Code Of Regulations, Title 20: Division 2, Chapter 4, Article 4, Appliance Efficiency Regulations (Title 20).

Definitions

Title 20 establishes the following selected definitions in Section 1602(c) Air Conditioners[8]:

> "Air conditioner" means an appliance that supplies cooled air to a space for the purpose of cooling objects within the space.
> "Air-source heat pump" means an appliance that consists of one or more factory-made assemblies, that includes an indoor conditioning coil, a compressor, and a refrigerant-to-air heat exchanger, and that provides heating and cooling functions.
> "Btu" means British thermal unit. .
> "Casement-only room air conditioner" means a room air conditioner with an encased assembly designed for mounting in a casement window with a width of 14.8 inches or less and a height of 11.2 inches or less.
> "Casement-slider room air conditioner" means a room air conditioner with an encased assembly designed for mounting in a sliding or casement window with a width of 15.5 inches or less.
> "Casement window" means a window that opens on hinges at the side.
> "Coefficient of Performance (COP)" of a heat pump means the ratio of the rate of useful heat output delivered by the complete heat pump unit (exclusive of supplementary heating) to the corresponding rate of energy input, in consistent units and as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Cooling capacity" means a measure of the ability of an air conditioner to remove heat from an enclosed space, as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Energy efficiency ratio (EER)" means the cooling capacity of an air conditioner in Btu per hour divided by the total electrical input in watts, as determined using the applicable test method in Section 1604(b) or 1604(c).
> "Heat pump" means an appliance, other than a packaged terminal heat pump, that consists of one or more assemblies; that uses an indoor conditioning coil, a compressor, and a refrigerant-to-outdoor air heat exchanger to provide air heating; and that may also provide air cooling, dehumidifying, humidifying, circulating, or air cleaning.
> "Packaged Terminal Air Conditioner" (PTAC) means a wall sleeve and a separate un-encased combination of heating and cooling assemblies that:
> (1) is intended for mounting through the wall and
> (2) includes a prime source of refrigeration, separable outdoor louvers, forced ventilation, and heating availability by hot water, steam, or electric resistance heat.

"Packaged Terminal Heat Pump" (PTHP) means a packaged terminal air conditioner that uses reverse cycle refrigeration as its prime heat source and that has a supplementary heat source of hot water, steam, or electric resistance heat.
"Room Air Conditioner" (RAC) means a factory-encased air conditioner that is designed:
(1) as a unit for mounting in a window, through a wall, or as a console, and
(2) for delivery without ducts of conditioned air to an enclosed space.
"Room air-conditioning heat pump" means a room air conditioner that is capable of heating by refrigeration.
"Seasonal energy efficiency ratio (SEER)" means the total cooling output of an air-cooled central air conditioner during its normal annual usage period for cooling, divided by the total electrical energy input in watt-hours during the same period, as determined using the applicable test method in Section 1604(c).

While PTAC units can also provide heat thru either in-unit or externally supplied sources, this paper does not evaluate efficiency of PTAC heating.

RAC Requirements

As stated in Section 1605.1 (b), code took effect as of Jan 1, 1990, several years before the advent of Energy Star. Code was revised as of Oct 2000 to the higher current standard. This enactment date was after the calendar year 2000 air conditioning season so energy savings and demand reduction due to this code change would not take effect until calendar year 2001[9].

Section 1605.1 (b) **Room Air Conditioners, Room Air-Conditioning Heat Pumps, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps.**
(1) **Room Air Conditioners and Room Air-Conditioning Heat Pumps.** The EER of room air conditioners and room air-conditioning heat pumps that are manufactured on or after the effective dates shown shall be not less than the applicable values shown in Table B-2. The EER of room air conditioners and room air-conditioning heat pumps that are labeled for use at more than one voltage shall be not less than the applicable values shown in Table B-2 at each of the labeled voltages.

Table 4: 1605.1 (b) Table B-2 Standards for Room Air Conditioners and Room Air-Conditioning Heat Pumps

Appliance	Louvered Sides	Cooling Capacity (Btu/hr)	Minimum EER or COP	
			Effective January 1, 1990	Effective October 1, 2000
Room Air Conditioner	Yes	< 6,000	8.0	9.7
Room Air Conditioner	Yes	≥ 6,000 - 7,999	8.5	9.7
Room Air Conditioner	Yes	≥ 8,000 - 13,999	9.0	9.8
Room Air Conditioner	Yes	≥ 14,000 - 19,999	8.8	9.7
Room Air Conditioner	Yes	≥ 20,000	8.2	8.5
Room Air Conditioner	No	< 6,000	8.0	9.0
Room Air Conditioner	No	≥ 6,000 - 7,999	8.5	9.0
Room Air Conditioner	No	≥ 8,000 - 19,999	8.5	8.5

Appliance	Louvered Sides	Cooling Capacity (Btu/hr)	Minimum EER or COP	
			Effective January 1, 1990	Effective October 1, 2000
Room Air Conditioner	No	≥ 20,000	8.2	8.5
Room Air Conditioning Heat Pump	Yes	< 20,000	8.5	9.0
Room Air Conditioning Heat Pump	Yes	≥ 20,000	8.5	8.5
Room Air Conditioning Heat Pump	No	< 14,000	8.0	8.5
Room Air Conditioning Heat Pump	No	≥ 14,000	8.0	8.0
Casement-Only Room Air Conditioner	Either	Any	*	8.7
Casement-Slider Room Air Conditioner	Either	Any	*	9.5
*Casement-only room air conditioners and casement-slider room air conditioners are not separate product classes under standards effective January 1, 1990. Such appliances, if manufactured before October 1, 2000, are subject to the applicable standards in Table B-2 for the other room air conditioners and room air-conditioning heat pumps based on capacity and the presence or absence of louvered sides.				

The Minimum EER or COP Effective October 1, 2000 column lists the current code requirements for C-RAC units. In Section 2.1, this work paper combines these various design and capacity EERs into a weighted mean EER for energy savings evaluation.

PTAC Requirements

Section 1605.1.2 defines Code requirements for the PT Units. For this work paper, these figures are only applicable to the determination of the LSLR Method for EER to Energy Savings Equations used to then determine energy savings for RACs[10] in Section 2.1.

> **Section 1605.1** (2) **Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps.** The EER and COP, as applicable, of packaged terminal air conditioners and packaged terminal heat pumps shall be not less than the applicable values shown in Table B-3.

Table 5: 1605.1 (2) Table B-3 (Partial) Standards for Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps

Appliance	Mode	Cooling Capacity (Btu/hr)	Minimum EER or COP
Packaged terminal air conditioners and packaged terminal heat pumps	Cooling	=< 7,000	8.88 EER
		> 7,000 and < 15,000	10.0 - (0.00016 x Cap.) EER
		>=15,000	7.6 EER

1.4 EM&V, Market Potential, and Other Studies

The Residential Appliance Saturation Survey (RASS) 2003 indicates an annual Unit Energy Consumption (UEC) of 240 kWh for RACs in the Southern California Edison (SCE) service area[11] and statewide:

"Room air conditioning has a UEC of 214 kWh and evaporative systems 684 kWh. These values are somewhat lower than previous studies and forecasting values used at the Energy Commission. One possible reason for the lower than average use is attributed to the Statewide

20/20 Program. Billing data for the Conditional Demand Analysis is from the second half of 2001, all of 2002, as well as 2003 and 2004 to include years when the 20/20 program was not available. UEC results have all been annualized and calibrated to 2002 service territory total usage. It is likely that the UECs reflect the 20/20 program impact and thus these air conditioning values should be considered conservative estimates."[12]

The RASS states:

"A similar (to central air conditioning) albeit more parsimonious specification will be used for room air conditioning (RACUSEht), except that a term will be used to reflect the number of room air conditioning units (RACCNTh). This stems from the assumption that total usage depends on the number of room air conditioners."[13]

The RASS states RAC:

"Unit Energy Consumptions are also fairly low relative to prior estimates, varying from 105 kWh for multi-family units in buildings with 5+ units to 227 kWh for single family homes and mobile homes."[14]

The RASS does not state:

1) Size, design or capacity of RACs analyzed,
2) EERs of RACs or
3) Square footage cooled.

Without this information it is difficult to compare the RASS information to other sources in this work paper. There appears to be some questioning even in the RASS verbiage as to the accuracy of the UEC RAC figures.

The RASS estimates about 20 percent of SCE homes have room air conditioners. The SCE Residential Room Air-Conditioner Recycling Scoping Study (Scoping Study)[15] estimates 50% of those homes have units ten years old or more, similar to the RASS estimate of 47% of homes that have units more than nine years old. The average age of room air conditioners in RASS data is calculated to be 7.71 years.

For a Weighted Mean RAC (WM-RAC) that provides 12,906 Btu of cooling and averaging estimated energy savings for all climate zones, replacing a Jan 1990 code RAC with an Energy Star RAC produces a total annual 397.7 kWh/WM-RAC unit savings (From Table 17). This number compares with the 372.2 kWh/ room air conditioner unit annual savings reported for multifamily housing in the Low-Income Energy Efficiency (LIEE) program[16].

1.5 Base Cases for Savings Estimates: Existing & Above Code

The base case is a C-RAC that meets the Federal Standard EER requirements. For this work paper, Customer Savings and Above Code Savings estimates are the same and are based on the Energy Star EERs as defined in **Table 6**: Energy Star Qualified RAC Eligibility. Customer Savings from early retirement of existing RAC (vintage code to current code) are only counted in the separate Room Air Conditioner Recycling Work Paper.

Federal Standard and Energy Star Energy Efficiency Ratio (EER) requirements are detailed in **Table 6**.[17] As Title 20 has adopted these Federal Standard EERs, this paper refers to the Federal Standards as Title 20 code.

Table 6: ENERGY STAR Qualified Room Air Conditioner (RAC) Eligibility

Capacity (Btu/Hr)	Federal Standard EER, with louvered sides	ENERGY STAR EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, without louvered sides
< 6,000	≥ 9.7	≥ 10.7	≥ 9.0	≥ 9.9
6,000 to 7,999				
8,000 to 13,999	≥ 9.8	≥ 10.8	≥ 8.5	≥ 9.4
14,000 to 19,999	≥ 9.7	≥ 10.7		
≥ 20,000	≥ 8.5	≥ 9.4		
Casement	**Federal Standard EER**		**ENERGY STAR EER**	
Casement-only	≥ 8.7		≥ 9.6	
Casement-slider	≥ 9.5		≥ 10.5	
REVERSE CYCLE				
Capacity (Btu/Hr)	**Federal Standard EER, with louvered sides**	**ENERGY STAR EER, with louvered sides**	**Federal Standard EER, without louvered sides**	**ENERGY STAR EER, without louvered sides**
< 14,000	n/a	n/a	≥ 8.5	≥ 9.4
≥ 14,000			≥ 8.0	≥ 8.8
< 20,000	≥ 9.0	≥ 9.9	n/a	n/a
≥ 20,000	≥ 8.5	≥ 9.4	n/a	n/a

1.6 Base Case & Measure Effective Useful Lives

A table in the ASHRAE HVAC Equipment Handbook indicates the Effective Useful Life (EUL) for window unit RACs is ten years and fifteen years for all other air conditioning units and heat pumps. However, a footnote to that same table also indicates this data from Akalin (1978) "may be outdated and not statistically relevant. Use this data with caution until enough updated data are accumulated in Abramson et. al."[18].

The Association of Home Appliance Manufacturers (AHAM) web site includes a 1996 survey by National Family Opinion, Inc. (NFO) stating the EUL for RACs is 12 years. The NFO's basis for EUL is: "age of an appliance when it is replaced because it cannot be repaired or costs too much to repair. (This does not infer the appliance will be without repair during its lifetime.)"[19].

The Table of Discarded Window/Wall (RAC) AGE (DWWAGE) by Window/Wall (RAC) ADDed (WWADD)[20] from the RASS 2003 data of homes that replaced their old wall/window RAC with a new unit, 20.59% of replaced units were up to ten years old, 38.71% were 11 to 20 years old and the remaining 40.70% units were more than 20 years old. Based on the RASS

2003 study, this paper uses a new RAC EUL for the SCE region of the half life of these units: 15 years.

1.7 Net-to-Gross Ratios for Different Program Strategies

This work paper covers customer driven appliance Replace on Burnout (ROB) and New Construction of RACs in residential installation. Per the CPUC Energy Efficiency Policy Manual and on the DEER web site the Net-to-Gross (NTG) ratio is 0.80 for all programs except the Residential Contractor program. For Residential Contractor replaced units, the NTG ratio is 0.89.[21]

Table 7: Net-to-Gross Ratios

Residential Construction	Program Approach	NTG
Multifamily unit	Residential Contractor Program	0.89
All unit	All other residential programs	0.80

Section 2. Calculation Methods

No study was available to quantify either where in what type of residence one or more RACs may be located or how many people may be in what size of how much conditioned space.

DEER Measure ID D03-099 Run IDs (DEER Calcs)[22] is the only DEER measure evaluating similar equipment cooling performance in EER. This measure evaluates PT units installed in the DEER two story building model Lodging-Motel. The construction elements used in the Lodging-Motel model are similar to residential construction elements. The measure also randomly loads PTAC units with mixed interior and exterior floors, walls and ceilings and mixes operating hours between none, 12 hour and 24 hour operation.

The randomness of PTAC unit installation and operation provides something of a reasonable basis for estimating RAC energy savings. However, the DEER PTAC 24-hour usage distribution (percentage of the motel that is actively being cooled: Figure 1) does not match a typical residential air conditioning end use profile. Therefore, RAC power demand was estimated at full power demand during a three day heat wave in the SCE service area.

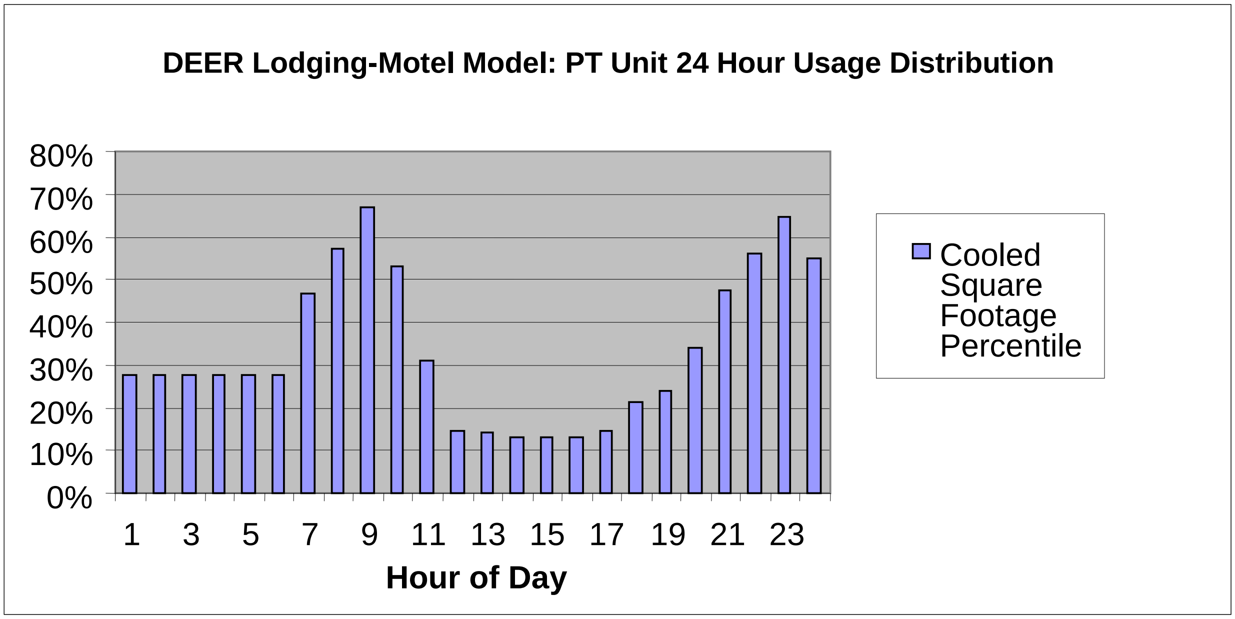

Figure 1 Hotel Room PTAC Usage[23]

2.1 Energy Savings Estimation Methodologies

This work paper takes DEER data for PT units and uses the LSLR Method to establish an EER to energy savings equation for each motel building vintage in each SCE climate zone. By weighing the equation slope and Y intercept by motel building population data for each vintage in a climate zone a vintage weighted mean EER to energy savings equation is established for each climate zone.

To determine a single RAC cooling capacity with C-RAC and ES RAC EERs, this work paper establishes the following. For each cooling capacity range in British thermal units (Btu) all unique RAC units listed in the Energy Star web site are counted for each design type with that number divided by the total RACs of the same capacity. Using the percentage of units SCE rebated (SCE Rebate Scale) for each Btu range and translating the SCE ranges to match the Title 20 code Btu ranges, this work paper establishes an cooling capacity weighted mean RAC for evaluation in each climate zone. Using the same SCE Rebate Scale this paper further weights the design weighted mean EERs to establish EERs for the WM-RAC. Using the energy savings equation, this paper estimates energy savings for both codes and Energy Star RAC in each climate zone.

LSLR Method for Equations

The DEER Calcs provide estimated energy savings for replacing vintage PT units with PT units that meet T24 minimum EER code requirements and 20% higher efficiency EER PT units.

The first point is set at the X-axis intercept (no energy savings) DEER base case EER found in the DEER Calcs: Base Case Description. This point represents the existing PT units in each

DEER model which meet each building vintage's Nonresidential Compliance Manual For California's 2005 Energy Efficiency Standards (Title 24)[24] code requirements, if any.

1) DEER building vintage Title 24 construction code EER: X_1;
   YE_1 - energy savings equal zero (X_i – X-axis Intercept),

The second point represents the fact the Title 24 code requires the building vintage PT units be upgraded on replacement to at least the current Title 20 EER figure. This upgrade produces the code energy savings (ECImpact).

2) DEER Basis 2000 Title 20 code EER: X_2; YE_2 - ECImpact

The third point is the DEER measure energy savings (EImpact).

3) DEER measure EER: X_3; YE_3 - EImpact

Using these figures for each vintage and climate zone and LSLR Method, an equation expressing energy savings for various EERs is established. The following variables are used in the LSLR Method:

X_a is any EER value,
YE_a is the corresponding energy efficiency savings to the X_a figure,
n is the total number of data points (n = 3 for these calculations), and
Σ is the Greek Letter sigma that stands for summation. Equation (1) is an example:

$$\Sigma(X_a) = X_1 + X_2 + X_3 \qquad (1)$$

Equation (2) is used to determine a linear slope (SE):

$$SE = (n^*\Sigma(X_a{}^*YE_a) - \Sigma(X_a)^*\Sigma(YE_a))/(n^* \Sigma(X_a{}^2)\text{- } (\Sigma X_a)^{\,2} \qquad (2)$$

Once SE is determined, the Y intercept (YE_i) where EER equals zero can be determined by Equation (3):

$$YE_i = (\Sigma(YE_a) - S * \Sigma(X_a))/n \qquad (3)$$

By determining SE and YE_i, this paper establishes an EER to energy savings equation for each building vintage within a climate zone (Equation (4)):

$$YE_a = YE_i + SE * X_a \qquad (4)$$

Data and calculations for all forty of the SE and YE_i values are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method & Vintage Weighing[25].

Example 1 - LSLR Method for Equations

Determine the Slope (SE) and Y intercept (YE_i) for the EER to energy savings equation for a 12,000 Btu PTAC unit installed in a motel built before 1978 in the City of Long Beach.

DEER Measure ID D03-099 Run ID CMtl0675PTAC2 provides estimated energy savings for replacing a vintage PT unit with a PT unit that meets T24 current minimum EER code requirements and 20% higher efficiency EER PT unit installed in a motel built before 1978 in the City of Long Beach. The DEER common units are Cooling Tons (CTon) or 12,000 Btu. DEER energy savings are in kilowatt-hour (kWh) per CTon.

The first point is set at the X-axis intercept (no energy savings) DEER base case EER found in the DEER Calcs: Base Case Description. This point represents the existing PT units in each DEER model which meet each building vintage's Title 24 code requirements, if any.

1) DEER building vintage Title 24 construction code EER: $X_1 = 6.80$;
   YE_1 is where energy savings equal zero: (X_i – X-axis Intercept): $YE_1 = 0$ kWh/CTon,

The second point represents the fact the Title 24 code requires the building vintage PT units be upgraded on replacement to at least the current Title 20 EER figure. This upgrade produces the code energy savings ECImpact.

2) DEER Basis 2000 Title 20 code EER: X_2; = 8.56; ECImpact $YE_2 = 277.691$ kWh/CTon

The third point is the DEER measure energy savings (EImpact).

3) DEER measure EER: X_3; = 10.27; EImpact $YE_3 = 709.349$ kWh/CTon

Using these figures and LSLR Method, an equation expressing energy savings for various EERs is established. The following variables are used in the LSLR Method:

X_a is any EER value,
Y_a is the corresponding energy efficiency savings to the X_a figure,
n is the total number of data points (n = 3 for these calculations), and
Σ is the Greek Letter sigma that stands for summation.

Variables for Equation (2) are:

$\Sigma(X_a) = X_1 + X_2 + X_3 = 6.80 + 8.56 + 10.27 = \mathbf{25.63}$

$\Sigma(X_a^2) = (X_1 * X_1) + (X_2 * X_2) + (X_3 * X_3)$
$= (6.80 * 6.80) + (8.56 * 8.56) + (10.27 * 10.27) = \mathbf{224.987}$

$\Sigma(YE_a) = YE_1 + YE_2 + YE_3 = 0 + 277.691 + 709.349 = \mathbf{987.040}$

$\Sigma(X_a*YE_a) = X_1 * YE_1 + X_2 * YE_2 + X_3 * YE_3$
$= 6.8 * 0 + 8.56 * 277.691 + 10.27 * 709.349 = \mathbf{9{,}662.049}$

Equation (2) is used to determine the linear slope (SE):

$SE = (n*\Sigma(X_a*Y_a) - \Sigma(X_a)*\Sigma(Y_a))/(n* \Sigma(X_a^2) - (\Sigma X_a)^2$
$= (3 * 9{,}662.049 - 25.63 * 987.040) / (3 * 224.987 – (25.63 * 25.63)$
$\mathbf{= 204.196}$

Once S is determined, the Y intercept (YE_i) where EER equals zero can be determined by Equation (3):

$YE_i = (\Sigma(YE_a) - SE * \Sigma(X_a))/n = (987.040 - 204.196 * 25.63) / 3$
$\mathbf{= -1415.502}$

By determining SE and YE_i, the EER to energy savings equation (Equation (4)) is:

$YE_a = YE_i + SE * X_a = \mathbf{-1415.502 + 204.196} * X_a$

Data and calculations for the SE and YE_i values and a graph of the resulting equation are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method Example+Graph[26].

Vintage Weighted Mean Equations

Using the YE_{ia} for each building vintage (YE_{i1} thru YE_{i5}) allows the vintage weighted mean (YE_{vwm}) for all vintages in a climate zone to be determined. The Commercial End Use Saturation[27] surveys (CEUS) provides a basis for a total number of buildings (NLOCS) per each building vintage within the same climate zone. This work paper uses DEERCD building type MTL (Motel) and establishes a variable $NLOCS_a$ which is the NLOCS value for a particular vintage within the same climate zone. Thus, $NLOCS_1$ thru $NLOCS_5$ are the total number of buildings for each building vintage oldest to newest. Equation (5) calculates the weighted mean YE_i (YE_{vwm}) for all vintages of the building per climate zone:

$$YE_{vwm} = (\Sigma(NLOCS_{a*}\ YE_{ia})) / \Sigma(NLOCS_a) \qquad (5)$$

In a similar way, using the slope SE_a for each building vintage of a climate zone (SE_1 thru SE_5) the vintage weighted mean slope (SE_{vwm}) can be determined (in equation (5): YE becomes SE).

By determining YE_{vwm} and SE_{vwm}, this paper establishes an equation of EER to energy savings for each climate zone (Equation (6)):

$$YE_a = YE_{vwm} + SE_{vwm} * X_a \qquad (6)$$

Data and calculations for all YE_{vwm} and SE_{vwm} values are detailed in DEER Measure D03-099 Lodging-Motels.xls: Sheet: LSLR Method & Vintage Weighing[28]. The resulting values are listed in Table 8.

Table 8: Vintage Weighted Mean Slopes & Y Intercepts

Vintage Weighted Mean Slopes & Y Intercepts			
DEER Values		Energy Savings:	
Climate Zone City	CA T24 CZ:	Weighted Slope	Weighted Y Intercept
		SE_a	**YE_{ia}**
Long Beach	6	183.835	-1,297.400
El Toro	8	229.651	-1,624.025
Burbank	9	216.026	-1,537.142
Riverside	10	204.380	-1,458.538
Fresno	13	202.615	-1,423.334
China Lake	14	187.204	-1,323.838
El Centro	15	272.872	-1,912.036
Mt. Shasta	16	147.093	-1,033.533

Example 2 - Vintage Weighted Mean Equation

Given the slopes (SE_a) and Y intercepts (YE_{ia}) for each DEER vintage of motel built in Long Beach, find the vintage weighted mean linear slope, Y intercept and the EER to energy savings equation on a cooling ton basis.

For the slope calculation, the required data from the "LSLR Method & Vintage Weighing" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[29] are the CEUS Weight Factors $NLOCS_a$ and the LSLR Method Slopes SE_a for each building vintage. Multiplying the SE_a by the respective $NLOCS_a$ produces the Vintage Weighting Factor (SE_a * $NLOCS_a$) for each vintage. Values for these variables are shown in Table 9.

Table 9: Example 2 - Climate Zone 6 Vintage Weighted Mean Linear Slope Calculations

For Motels in Long Beach Climate Zone 6:				
Buildings Vintages	**Vintage Order**	**CEUS Weight Factors**	**LSLR Method Slopes**	**Vintage Weighting Factors**
		$NLOCS_a$	**SE_a**	**(SE_a *$NLOCS_a$)**
Built before 1978	1	254	204.196	51,866
Built between 1978 and 1992	2	107	164.463	17,598
Built between 1993 and 2001	3	14	77.640	1,087
Built between 2002 and 2005	4	10	76.968	770
Built 2006 and later (measures as retrofit for nonresidential)	5	4	47.907	192
	Totals (Σ):	389		71,512

Equation (5) modified to calculate the weighted mean SE (SE_{vwm}) for all vintages of the building type per climate zone is:

$SE_{vwm} = (\Sigma(NLOCS_a * SE_a)) / \Sigma(NLOCS_a) = 71{,}512 / 389 = \mathbf{183.835}$

For the Y intercept calculation, the required data from the "LSLR Method & Vintage Weighing" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[30] are the CEUS Weight Factors $NLOCS_a$ and the LSLR Method Y intercepts YE_{ia} for each building vintage. Multiplying the YE_{ia} by the respective $NLOCS_a$ produces the Vintage Weighting Factor (YE_{ia} * $NLOCS_a$) for each vintage. Values for these variables are shown in Table 10.

Table 10: Example 2 - Climate Zone 6 Vintage Weighted Mean Y Intercept Calculations

For Motels in Long Beach Climate Zone 6:				
Buildings Vintages	**Vintage Order**	**CEUS Weight Factors**	**LSLR Method Y intercepts**	**Vintage Weighting Factors**
		$NLOCS_a$	**YE_{ia}**	**(YE_{ia} *$NLOCS_a$)**

Built before 1978	1	254	-1,415.502	-359,537
Built between 1978 and 1992	2	107	-1,220.122	-130,553
Built between 1993 and 2001	3	14	-545.310	-7,634
Built between 2002 and 2005	4	10	-540.586	-5,406
Built 2006 and later (measures as retrofit for nonresidential)	5	4	-389.487	-1,558
Totals (Σ):		389		-504,689

Equation (5) calculates the weighted mean YE_i (YE_{vwm}) for all vintages of the building type per climate zone:

$YE_{vwm} = (\Sigma(NLOCS_{a*}\ YE_{ia})) / \Sigma(NLOCS_a) = -504{,}689 / 389 = \mathbf{-1{,}297.400}$

For Motels in Long Beach Climate Zone 6, the EER to energy savings Equation (5) is:

$YE_a = YE_{vwm} + SE_{vwm} * X_a = \mathbf{-1{,}297.400} + \mathbf{183.835} * X_a$

MS Excel versions of Table 9 and Table 10 are shown in the "Vintage Weighted Mean Example" sheet of "DEER Measure D03-099 Lodging-Motels.xls"[31].

RAC EER Design Variance Weighted Mean Values

The Energy Star Web site[32] provides a list of available Energy Star RACs from 5,000 to 28,000 Btu/hr cooling capacity. This list includes various design details like which RACs have reverse cycles (Heat Pumps), side louvers and or casement-only or slider style units. Title 20 Table B-2 lists code EERs based on those design details for various cooling capacity ranges. Counting the available unique units with each of these design characteristics and cooling capacities provides a design weighing factor to determine a design weighted mean RAC EER for the Title 20 Table B-2 cooling capacity ranges. This work paper adds together the counts of unique units with similar RAC EER & cooling capacities and then finds a design variance weighted mean EER for each Title 20 Table B-2 cooling capacity range. The resulting EERs are shown in **Table 11**.

Table 11: EER Weighted Mean by Unit Design for Cooling Capacity

EER Weighted Mean by Unit Design for Cooling Capacity		
Cooling Capacity (Btu/hr)	**Effective January 1, 1990**	**Effective October 1, 2000**
< 6,000	8.00	9.69
≥ 6,000 - 7,999	8.50	9.64
≥ 8,000 - 13,999	8.77	9.27
≥ 14,000 - 19,999	8.78	9.65
≥ 20,000	8.22	8.50

Complete tables of Energy Star Product Listings and calculations for Unique Unit Design Weighted Mean EERs are listed in Appendix A: RAC EER Design Variance Weighted Mean and in the "EER Weighting by Unique Units" sheet of MS Excel Workbook "Energy Star RACs-20070802.xls"[33].

Example 3 - RAC EER Design Variance Weighted Mean Values

Count the RACs with capacities equal to or greater than 8,000 and less than 13,999 Btu by unique design features listed in the Energy Star web site to determine the number of Unique Unit (UUs) RACs. Find the EER Weighted Mean Factor for each type of these UU designs and the weighted mean EER for all of these UU RAC units.

Example 3 column & row references can be found in Table 12 below. The Energy Star web site lists four unique designs for RACs with capacities equal to or greater than 8,000 and less than 13,999 Btu: standard RACs with & without louvered sides and heat pumps with & without louvered sides (columns (A) & (B) in T-X). Also listed are the Jan 1990 and Oct 2000 minimum EERs for each of these designs (columns (C) & (D)).

Counting the number of unique RACs listed in the Energy Star Product Listing[34] results in the numbers in column (E). Column (F) shows the addition of ten 8,000 Btu casement units from Row 27 to Row 11 which have identical EERs with the results of the addition in column (G) and subtotal of all the 8,000 and less than 13,999 Btu manufacturer RACs.

For Row 11: (G) = (E) + (F) = 310 + 10 = **320**

Column (H) is the column (G) number divided by the column (G) subtotal resulting in the percentile of each unique design relative to the total number of unique designs:

Row 15 Column (G) Subtotal: Σ(G) = 320 + 193 + 20 + 19 = **552**

For Row 11: (H) = (G) / Σ(G) = 320 / 552 = **0.58 or 58.0%**

Columns (I) & (J) are the Minimum EERs (columns (C) & (D)) multiplied by the percentile.

For Row 11: (I) = (C) * (H) = 9.0 * 0.58 = **5.22**
(J) = (D) * (H) = 9.8 * 0.58 = **5.68**

Summing column (I) results in the design weighted EER of 8.77 for the Jan 1990 Code.

Row 15 Column (I) Subtotal: Σ(I) = 5.22 + 2.97 + 0.31 + 0.28 = **8.77**

Summing column (J) results in the design weighted EER of 9.27 for the Oct 2000 Code.

Row 15 Column (J) Subtotal: Σ(J) = 5.68 + 2.97 + 0.33 + 0.29 = **9.27**

Table 12: Example 3 - RAC Design Weighted Mean Values

	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)				EER Weighted Mean Factors by Unit Design for Capacity	
Row:	Appliance	Louvered Sides	Minimum EER							
			Effective Jan 1990	Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	Effective Jan 1990	Effective Oct 2000
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G) / Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
	For Capacities ≥ 8,000 - 13,999 Btu/hr									
11	RAC	Yes	9.0	9.8	310	10 from Row 27	320	58.0%	5.22	5.68

12	RAC	No	8.5	8.5	193	None	193	35.0%	2.97	2.97
13	RAC Heat Pump	Yes	8.5	9.0	20	None	20	3.6%	0.31	0.33
14	RAC Heat Pump	No	8.0	8.5	19	None	19	3.4%	0.28	0.29
15						**Subtotal:**	**552**	**Weighted EERs:**	**8.77**	**9.27**
	For Casement RACs the only available capacity is 8,000 Btu/hr									
26	Casement-Only RAC	Either	(1)	8.7	0	None	0			
27	Casement-Slider RAC	Either	(1)	9.5	10	Add 10 to Row 11	0			
				Totals:	1032		1032			
Notes:										
(1)	Not a separate class until Oct 2000.									

RAC Population Weighted Mean Values

An SCE study[35] establishes a distribution of RAC unit cooling capacity for the SCE service area as listed in **Table 13**.

Table 13: SCE Service Area: RAC Cooling Capacity Distribution

Cooling Tons	BTU/hr	Percentage of Total RAC Units in SCE Service Area
0.5 to < 1.0	6,000 to <12,000	47%
1.0 to < 1.5	12,000 to <18,000	41%
1.5 to < 2.0	18,000 to 24,000	6%
> 2.0	> 24,000	6%

These unit cooling capacity ranges do not match Title 20 Table B-2 (

Table 4 in this work paper under: 1.3 Codes & Standards Requirements Analysis) so this work paper weighted the SCE area RAC distribution evenly over the Title 20 Table B-2 requirements as follows to establish a population Weighted Mean RAC (WM-RAC)[36].

Table 14: Basis for determining the Population Weight Mean RAC for SCE Service Area

Population Weighted Mean RAC Capacity			**Title 20**					
BTU/hr	**SCE Cooling Capacity Range BTU/ hr**	**% of Total RAC Units in SCE Service Area**	**Title 20 Cooling Capacity Range BTU/ hr**	**Title 20 Average Cooling Capacity BTU/ hr**	**Title 20: % of SCE Dist**	**SCE Count/ 100 RAC Units**	**Title 20 % Dist**	**Weighted Mean Factor BTU/hr**
	Column (A): From Table 13	**(B): From Table 13**	**(C): From Table 4**	**(D): Average of (C)**	**(E) = % of (B)**	**(F) = (B) * (E) *100**	**(G) = (F) / 100**	**(H) = (D) * (G)**
5000	6,000 to <12,000	47%	> 6,000	5000	14.3%	7	6.7%	336
6000			≥ 6,000 -	6500	28.6%	13	13.4%	873

7000			7,999					
8000			= 8,000 - 13,999	11000	57.1%	27	40.5%	4458
9000								
10000								
11000								
12000	12,000 to <18,000	41%			33.3%	14		
13000								
14000			≥ 14,000 - 19,999	16500	66.7%	27	29.3%	4840
15000								
16000								
17000								
18000	18,000 to 24,000	6%			33.3%	2		
19000								
20000			≥ 20,000	24000	66.7%	4	10.0%	2400
21000								
22000								
23000								
24000	> 24,000	6%			100.0%	6		
25000								
26000								
27000								
28000								
							Weighted Mean RAC BTU/hr:	**12,906**

For the SCE service area, the WM-RAC BTU/hr is 12,906. The following **Table 15** takes the EER Weighted Mean by Unit Design for Cooling Capacities figures from **Table 11** and further weights the EERs by the Title 20 % distribution from

Table 14[37].

Table 15: Basis for determining the Weight Mean RAC EERs for SCE Service Area

EER Weighted Mean by Unit Design for Cooling Capacity (from Table 11)			Energy Star EER	Title 20 % Dist (from Table 14)	Weighted Mean EER Factors		
Cooling Capacity (Btu/hr)	**Effective 1-Jan-90**	**Effective 1-Oct-00**			**Jan-90**	**Oct-00**	**Energy Star**
	Column (A)	**(B)**	**(C) = (B) * 1.1**	**(D) = Table 14: Col (G)**	**(E) = (A) * (D)**	**(F) = (B) * (D)**	**(G) = (C) * (D)**
< 6,000	8.0	9.7	10.7	6.7%	0.537	0.651	0.718
≥ 6,000 - 7,999	8.5	9.6	10.6	13.4%	1.141	1.289	1.423
≥ 8,000 - 13,999	8.8	9.3	10.2	40.5%	3.566	3.769	4.133
≥ 14,000 - 19,999	8.8	9.7	10.7	29.3%	2.581	2.845	3.139
≥ 20,000	8.2	8.5	9.4	10.0%	0.820	0.850	0.940
				Weighted Mean EERs:	**8.6**	**9.4**	**10.4**

For the SCE service area, WM-RACs are 12,906 BTU/hr units that would meet EERs of 8.6 after Jan 1990, 9.4 as of Oct 2000 or an Energy Star rating of at least 10.4.

Energy Savings for WM-RAC

Table 16 below lists the SCE climate zones and repeats the SE_{vwm} Weighted Slope and YE_{vwm} Weighted Y Intercept from Table 8. Using Equation (6), Columns (C), (D) and (E) show the resulting energy savings calculations for WM-RACs for Jan 1990 code, Oct 2000 code and Energy Star (10% above Oct 2000 code) for the SCE climate zones. Column (F) numbers are the total energy savings of upgrading from a Jan 1990 Code to Energy Star WM-RAC. Column (G) numbers are the energy savings for buying an Energy Star WM-RAC instead of a current (Oct 2000) C-RAC: the energy savings for this work paper. Column (H) is the energy savings for replacing an existing Jan 1990 code RAC with a C-RAC: the energy savings for the RAC Recycling work paper[38].

Table 16: WM-RAC Annual Energy Savings (AES)

For Weighted Means RAC:		BTU/ hr:	12,906	Weighted Means EERs					
				8.6	9.4	10.4			
DEER Values		Annual Energy Savings (AES): (From Table X)		WM-RAC Total AES: (kWh/WM RAC)			WM-RAC Energy Star AES less: (kWh/Unit)		Code Differential AES: Oct 2000 less Jan 1990 (kWh/Unit) (Note 2)
Climate Zone City	CA T24 CZ:	SE_{vwm} Weighted Slope	YE_{vwm} Weighted Y Intercept	Code: Jan 1990	Code: Oct 2000	Energy Star	Code: Jan 1990	Code: Oct 2000 (Note 1)	
		Column (A)	(B)	(C) (Note 3)	(D) (Note 4)	(E) (Note 5)	(F) = (E) - (C)	(G) = (E) - (D)	(H) = (F) - (G)
Long Beach	6	183.835	-1,297.400	305.0	463.2	660.9	355.9	197.7	158.2
El Toro	8	229.651	-1,624.025	377.5	575.1	822.1	444.6	247.0	197.6
Burbank	9	216.026	-1,537.142	344.9	530.8	763.1	418.2	232.3	185.9
Riverside	10	204.380	-1,458.538	321.7	497.6	717.4	395.7	219.8	175.8
Fresno	13	202.615	-1,423.334	343.3	517.6	735.5	392.2	217.9	174.3
China Lake	14	187.204	-1,323.838	307.7	468.8	670.1	362.4	201.3	161.1
El Centro	15	272.872	-1,912.036	467.5	702.3	995.7	528.3	293.5	234.8
Mt. Shasta	16	147.093	-1,033.533	248.9	375.5	533.7	284.8	158.2	126.6
Notes:	(1)	Energy Star RAC energy savings: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit.							
	(2)	Residential RAC Recycling energy savings: Recycle a Jan 1990 Code Unit and replace with an Oct 2000 Code Unit.							
	(3)	(C) = ((B) + (A) * 8.6) / (12,000 / 12,906)							
	(4)	(D) = ((B) + (A) * 9.4) / (12,000 / 12,906)							
	(5)	(E) = ((B) + (A) * 10.4) / (12,000 / 12,906)							

Example 4 - Table 14 Calculations

As an example, the equation to determine the total annual energy savings for an RAC with a BTU/hr capacity of 12,906 and EER of 8.6 in the Long Beach climate zone is:

$YE_a = (YE_{vwm} + SE_{vwm} * X_a) * (\text{WM-RAC Capacity (BTU/hr)} / 12{,}000 \; ((\text{BTU/hr})/\text{Cooling Ton})$

$YE_a = (-1{,}297.400 \; (\text{kWh / Cooling Ton year}) + 183.835((\text{year-kWh/Cooling Ton year}) / (\text{BTU/W}))*8.6(\text{BTU/W})) * 12906(\text{BTU/hr})/(\text{WM-RAC Unit})) / (12000((\text{BTU/hr})/(\text{Cooling Ton}))$

$YE_a = 305.0$ kWh / year WM-RAC Unit

Averaging the last three columns of **Table 16** produces average annual energy savings for the Residential RAC Recycling and Energy Star RAC work papers and a combined total savings as shown in Table 17[39]. The total savings is comparable to the RAC energy savings from the LIEE program of PY 2001[40].

Table 17: Average Annual Energy Savings for a WM-RAC

For a WM-RAC rated at 12,906 Btu:	Average Annual Energy Savings (kWh/WM-RAC):
Residential RAC Recycling: Replace a Jan 1990 Code Unit with an Oct 2000 Code Unit	176.8
Energy Star RAC: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit	221.0
Total Savings: Replace a Jan 1990 Code Unit with an Energy Star Unit	397.7

2.2. Demand Reduction Estimation Methodologies

To derive the demand reduction, this work paper uses the Weighted Mean RAC of 12,906 Btu. The equation for EER is:

EER = Cooling Capacity (Btu/hr) / Power(Watts)

To determine Power in kW:

Power (kW) = [Cooling Capacity (Btu/hr) / EER] * [1 (kW) / 1000 (Watts)]

Power and Demand Reduction for the Weighted Mean EERs are shown in the following table:

Table 18: Weighted Mean RAC Demand Reduction

For Weighted Mean RAC 12,906 Btu / hr			
	Code: Jan 1990	**Code: Oct 2000**	**Energy Star**
EER	8.6	9.4	10.4
Power (kW)	1.501	1.373	1.241
Demand Reduction (kW)			
		Energy Star - Code: Oct 2000 (1):	0.132
		Code: Oct 2000 - Code: Jan 1990 (2):	0.128
Notes:	(1) Energy Star RAC Demand Reduction: Purchase an Energy Star Unit instead of an Oct 2000 Code Unit.		
	(2) Residential RAC Recycling Demand Reduction: Recycle a Jan 1990 Code Unit and replace with an Oct 2000 Code Unit.		

The Energy Star demand reduction is 0.132 kW for all climate zones in SCE's service area. This is based on the assumption that for a typical summer three day heat wave peak demand period RACs will operate at or above the 10 CFR Section 430.23(f) (2005) test condition of 95°F. As a result, the peak demand would be close to the same value for all units across different climate zones. This assumption simplifies the demand estimation process and also reduces any discrepancies due to under estimation of the potential demand reduction.

Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape.

The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A TOU load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's Total Resource Cost (TRC) benefit[41].

3.1 Base Case Load Shapes

The existing base case RAC energy use and peak demand load shapes would follow typical air conditioner hourly demand profile. Seasonal variations should follow the typical seasonal outdoor dry-bulb temperature variation for each climatic zone over a course of a year. The Load Shapes for this work paper are AC_Cooling-RC which is inclusive of both building type and climate zone.

3.2 Measure Load Shapes

The RAC measure would move the typical RAC hourly demand profile lower in all times except when load is zero when compared to the base system. Figure 2 and Figure 3 represent the TOU End Use Energy and Peak Demand factors for air conditioning: cooling RC measures that are embedded within the SCE E3 Calculator[42].

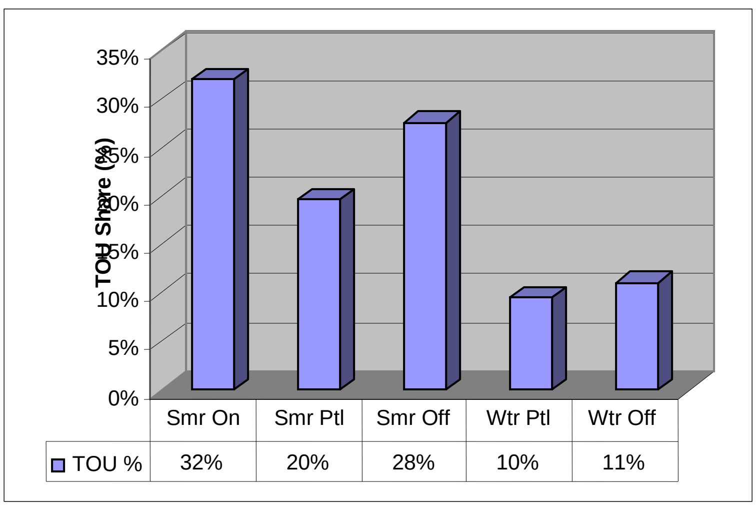

Figure 2: TOU AC Cooling-RC Energy Share

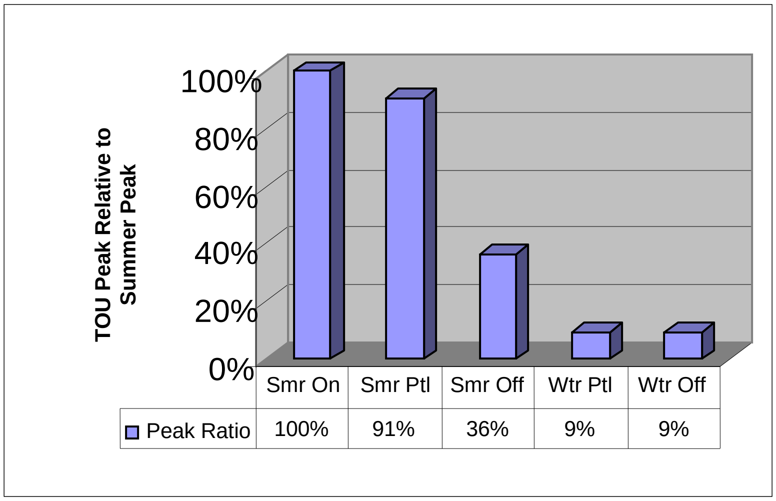

Figure 3: TOU Peak kW Factors

Section 4. Base Case & Measure Costs

The only difference in costs between the base case and measure costs would be for the greater cost of ES-RAC units over C-RAC units that simply meet Federal and State appliance standards. Other costs such as installation labor and materials are assumed to be identical. This work paper uses WM-RAC of 12,906 BTU/hr and provides average costs sourced from Consumer Reports Magazine for 9,800 to 12,500 BTU/hr units which may under price an actual WM-RAC unit.[43]

4.1 Base Case Costs

The base case costs are the purchase prices of C-RAC units that meet minimum Federal and State of California appliance standards. Base costs are estimated at $295.00[44].

4.2 Measure Costs

The measure costs are the greater cost of ES-RAC units that exceed the Federal EER appliance standards by at least 10%. Measure costs are estimated at $376.00[45].

4.3 Incremental & Full Measure Costs

The only cost differences are the extra capital costs of purchasing an Energy Star unit over a non-energy star unit. Thus the incremental cost is estimated at $81.00. Installation costs are presumed to be identical. To determine the full measure costs, this work paper presumes customers will self install RAC units and therefore the Full Measure cost is estimated at $376.00.

Appendices

Appendix A: RAC EER Design Variance Weighted Mean

RAC Design Variance EER Merge										
	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)				EER Weighted Mean Factors by Unit Design for Capacity	
			Minimum EER							
Row:	Appliance	Louvered Sides	Effective Jan 1990	Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	Effective Jan 1990	Effective Oct 2000
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G)/ Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
	For Capacities < 6,000 Btu/hr									
1	RAC	Yes	8.0	9.7	123	None	123	99.2%	7.9	9.6
2	RAC	No	8.0	9.0	1	None	1	0.8%	0.1	0.1
3	RAC Heat Pump	Yes	8.5	9.0	0	None	0	0.0%	0.0	0.0
4	RAC Heat Pump	No	8.0	8.5	0	None	0	0.0%	0.0	0.0
5						**Subtotal:**	**124**	**Weighted EERs:**	**8.0**	**9.7**
	For Capacities ≥ 6,000 - 7,999 Btu/hr									
6	RAC	Yes	8.5	9.7	98	None	98	90.7%	7.7	8.8
7	RAC	No	8.5	9.0	8	2 from Row 10	10	9.3%	0.8	0.8
8	RAC Heat Pump	Yes	8.5	9.0	2	Add 2 to Row 9	0	0.0%	0.0	0.0
9	RAC Heat Pump	No	8.0	8.5	0	None	0	0.0%	0.0	0.0
10						**Subtotal:**	**108**	**Weighted EERs:**	**8.5**	**9.6**
	For Capacities ≥ 8,000 - 13,999 Btu/hr									
11	RAC	Yes	9.0	9.8	310	10 from Row 27	320	58.0%	5.2	5.7
12	RAC	No	8.5	8.5	193	None	193	35.0%	3.0	3.0
13	RAC Heat Pump	Yes	8.5	9.0	20	None	20	3.6%	0.3	0.3
14	RAC Heat Pump	No	8.0	8.5	19	None	19	3.4%	0.3	0.3
15						**Subtotal:**	**552**	**Weighted EERs:**	**8.8**	**9.3**
	For Capacities ≥ 14,000 - 19,999 Btu/hr									
16	RAC	Yes	8.8	9.7	143	None	143	94.7%	8.3	9.2
17	RAC	No	8.5	8.5	3	None	3	2.0%	0.2	0.2
18	RAC Heat Pump	Yes	8.5	9.0	5	None	5	3.3%	0.3	0.3
19	RAC Heat Pump	No	8.0	8.0	0	None	0	0.0%	0.0	0.0
20						**Subtotal:**	**151**	**Weighted EERs:**	**8.8**	**9.7**

RAC Design Variance EER Merge										
	Cells in Blue Arial font are from Title 20 Table B-2				Energy Star Product Search Unique Units (UU)				EER Weighted Mean Factors by Unit Design for Capacity	
			Minimum EER							
Row:	Appliance	Louvered Sides	Effective Jan 1990	Effective Oct 2000	No. of UUs	Adjust-ments to equiv. EERs	Adjust-ed No. of UUs	% of UUs per Cap	Effective Jan 1990	Effective Oct 2000
	Column (A)	(B)	(C)	(D)	(E)	(F)	(G) = (E)+(F)	(H) = (G)/ Subtotal	(I) = (C)*(H)	(J) = (D)*(H)
	For Capacities ≥ 20,000 Btu/hr									
21	RAC	Yes	8.2	8.5	92	None	92	94.8%	7.8	8.1
22	RAC	No	8.2	8.5	0	None	0	0.0%	0.0	0.0
23	RAC Heat Pump	Yes	8.5	8.5	5	None	5	5.2%	0.4	0.4
24	RAC Heat Pump	No	8.0	8.0	0	None	0	0.0%	0.0	0.0
25						**Subtotal:**	**97**	**Weighted EERs:**	**8.2**	**8.5**
	For Casement RACs the only available capacity is 8,000 Btu/hr									
26	Casement-Only RAC	Either	(1)	8.7	0	None	0			
27	Casement-Slider RAC	Either	(1)	9.5	10	Add 10 to Row 11	0			
	Total for all Capacities:				**1032**		**1032**			
Notes:										
(1)	Not a separate class until Oct 2000.									

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