**Work Paper SCE13HC044**

**Revision 2**

**Southern California Edison Company**

**Economizer Repair for Entertainment Centers**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | AC-50089 24 Hour Entertainment Center Economizer Repair Maintenance  AC-89808 Restore Degraded Economizer |
| **Measure Description:** | The measure case for this work paper is a fully functional and code-compliant economizer. |
| **Base Case Description:** | The base case for this work paper assumes an average between a fully closed air-economizer (e.g., 0% open) and a Title-24 compliance air-economizer providing minimum ventilation requirement. |
| **Energy Impact Common Units:** | Per ton |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life (years):** | 5.0 years |
| **Measure Application Type:** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratios:** | Refer to NTG in Section 1.4. |
| **Important Comments:** | This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately. |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC044.0 | No | 05/25/2012 | Andres Fergadiotti/SCE | Updated to latest template 2013 v0.1 from WPSCNRHC0044.0 |
| SCE13HC044.1 | Yes | 1/15/2013 | Jason Wang/SCE | Added DEER 2011 measure: Restore Degraded Economizer (D03-060) |
| SCE13HC044.2 | No | 2/26/2014 | Keith Valenzuela/AESC | -New template. |
| No | 4/22/2014 | Cassie Cuaresma/SCE | -Work paper updated for reporting period effective 7/1/2014-12/31/2014 |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the repair of faulty and degraded air-economizers installed in large central air handlers. There are two measures—one that is specifically for “24-Hour Entertainment Centers” (e.g. 24-hour fitness centers), and one that applies to multiple non-residential building types.

1.1.1 24 Hour Entertainment Center Economizer Repair Maintenance

**Base case description:** HVAC systems with long life and low maintenance (in some cases) may operate with faulty air-economizers with non-modulating outside-air dampers that operate at a fixed position (a) limiting the amount of outside-air required for ventilation and (b) limiting the energy savings associated with free cooling permitted when the average ambient temperature and/or enthalpy are lower than those in the occupied space.

A degraded and faulty air-economizer system may not allow enough ventilation, operating fixed anywhere between 0% and minimum required ventilation (e.g., 36% open). The base case for this work paper assumes that the air-economizer has degraded over time, it is non-functional, and operates fixed at 18% open.

The base case assumption for this work paper is based on the average between a fully closed air-economizer (e.g., 0% open) and a Title-24 compliance air-economizer providing minimum ventilation requirement as well as general experience on HVAC Design, energy auditing, and building commissioning from the author. The Economizer Damper Test Interim Results from CPUC Work Order 32 Impact Evaluation Research Study noted an EM&V study that found a majority of existing units (55%) have dampers open from 10 to 30%, which supports the base case assumption of 18% open [415].

Further, it is acknowledged that there might be cases in which faulty air-economizers may operate fixed at other than 18% open or supply excessive ventilation rates (e.g., fixed at 80% open or similar) or where occupancy designations in the building are slightly different than the ones from the prototype building leading to slightly different ventilation requirements.

Calculations in this work paper are representative of typical conditions found in a 24 hour exercise center (gymnasium).

**Measure case description:** The measure case economizer is fully functional, code-compliant, and may incorporate all the requirements listed in Section 1.4.2.

1.1.2. Restore Degraded Economizer (DEER 2014 measure)

**Base case description (from DEER 2014):** The baseline economizer operation is assumed to have degraded over time and has a high limit of 55 degrees and 60 percent maximum outside air fraction [26].

**Measure case description (from DEER 2014):** The measure economizer has a high limit of 68 degrees and 100 percent maximum outside air fraction [26].

Table 1 lists the applicable measure names and solution codes.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| AC-50089 | 24 Hour Entertainment Center Economizer Repair Maintenance |
| AC-89808 | Restore Degraded Economizer |

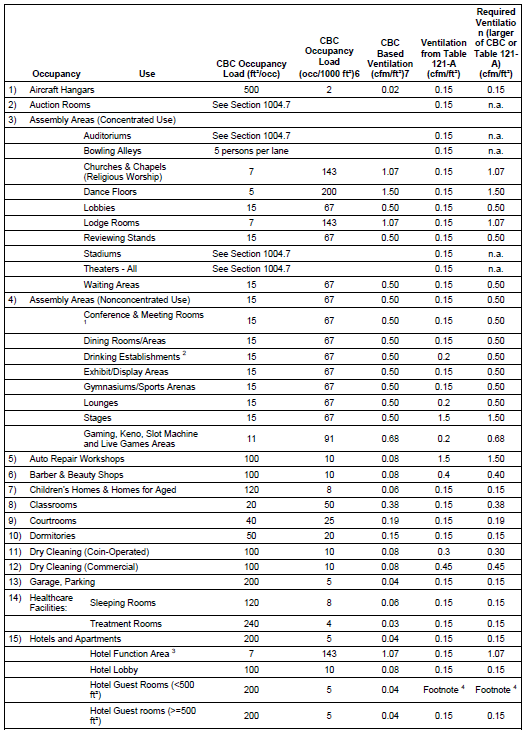
## 1.2 Technical Description

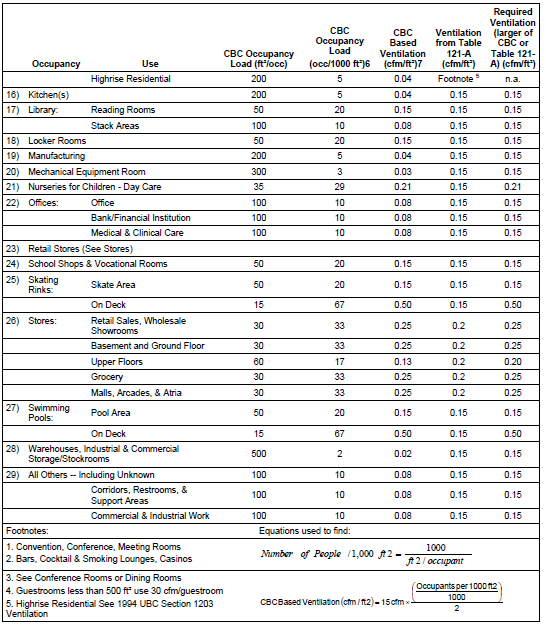
Air-economizers should be installed on air conditioners to help save energy by providing free cooling when ambient conditions are suitable to meet all or part of the space cooling load. Economizers are capable of modulating the outdoor air, return air, and relief air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling. Enthalpy controls (vs. dry-bulb temperature controls) are generally used to help ensure that unwanted moisture is not introduced into the space in hot/humid climates.

**HVAC system:** For this building type, the prototype HVAC system (packaged rooftop, single zone, DX cooling, gas heating) is expected to have a total design cooling capacity between 80 and 110 tons. Depending on zone configuration and/or characteristics of the building, these facilities may employ either a single HVAC system or multiple HVAC systems.

**Ventilation requirements:** Based on ventilation requirements dictated by the 2013 Building Energy Efficiency Standards-Nonresidential Compliance Manual [355] including fitness center/gymnasium occupancies (see Table 2), it is estimated that a functional economizer system serving this type of occupancy and in compliance with the Energy Standards would deliver a minimum ventilation rate in the order of 36% of the total system flow.

Table 2 Required Minimum Ventilation Rate per Occupancy





## 1.3 Measure Application Type

For 24 Hour Entertainment Center Economizer Repair Maintenance:

* The delivery mechanism is Financial Support-Direct Install.
* The program type/install type is Retrofit – Add-on (REA).

For Restore Degraded Economizer:

* The delivery mechanism is Financial Support / Down-Stream Incentive – Deemed.
* The program type/install type is Retrofit – Add-on (REA).

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

For 24 Hour Entertainment Center Economizer Repair Maintenance:

This specific measure is included in the Database for Energy Efficient Resources (DEER) 2014(Version 1.0.5) [386]; however, DEER does not contain any specific provisions for Fitness Center building types and a 24-hour load profile.

For Restore Degraded Economizer:

This specific measure is included in the Database for Energy Efficient Resources (DEER) 2014 (Version 1.0.5) [386].

Table 3 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | DEER does not contain any specific provisions for Fitness Center building types and a 24-hour load profile. |
| DEER Version | DEER 2014 Version 1.0.5 |
| DEER Run ID and Measure Name (Sample) | Index# 105430169 (D03-060): Economizer Maintenance |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 4 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 4 below.

Table 4 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Agric-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Ag | Any | All | 0.6 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | All | 0.6 |
| Ind-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Ind | Any | All | 0.6 |

\*Denotes that the column is taken from the DEER NTG Table.

**Installation Rate**

The installation rate (IR) is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the work paper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 5 below.

Table 5 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | GSIAValue\* |
| Com-AC-PGE | Non-Res AC Replacement; Annual Installation Rate | Com | Any | NonUpStrm | 1 |
| Com-AC-SCE | Non-Res AC Replacement; Annual Installation Rate | Com | Any | NonUpStrm | 1 |

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the work papers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the work paper refer the Excel calculation template.

Table 6 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | Space Cooling |
| Measure Case TechGroups | HV\_AirDist |
| Measure Case TechTypes | AirEcono |
| Base Case TechGroups | HV\_AirDist |
| Base Case TechTypes | AirEcono |

### 1.4.2 Codes and Standards Analysis

According to the 2013 Building Energy Efficiency Standards (Section 140.4e) [355], prescriptive requirements on air economizers obligates that “each cooling fan system that has a design total mechanical cooling capacity over 54,000 Btu/hr shall include an air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air.” Refer to the Standards for additional information.

Additionally, the Standards include requirements on “high limit shutoff controls” complying with TABLE 140.4-B of the Standards. These high limits are based on fixed Outside Air (OSA) temperature or differential between OSA and Return Air (RA) temperatures or fix enthalpy or differential between outside and return enthalpies. Requirements vary based on Climate Zone.

Mechanical outdoor ventilation requirements are detailed in the Title-24 2013 Non-Residential Compliance Manual [355]. The Manual states that the mechanical outdoor ventilation must be provided for all spaces normally occupied that are not naturally ventilated. The Standards require that a space conditioning system provide outdoor air equal to or exceeding the ventilation rates required for each of the spaces that it serves.

Table 2 identifies the required minimum ventilation rate per occupant per the Title-24 2013 Non-Residential Compliance Manual. Table 7 identifies the applicable code for this measure.

Table 7 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | 2013 Building Energy Efficiency Standards, Section 140.4 Prescriptive Requirements for Space Conditioning Systems  2013 Non-Residential Compliance Manual, Table 4-3 Minimum Ventilation Requirements | July 1, 2014 |
| Title 20 (2010) | N/A | N/A |

### 1.4.3 Non-DEER Study Review

For 24 Hour Entertainment Center Economizer Repair Maintenance:

There was no statistical data found in DEER or any other associated references documenting air-economizer degradation and/or failure for establishing the base case. Further, in their “Non-Residential Weather Sensitive DEER Measure Descriptions,” the “Economizer Maintenance Measure” documents a base case with a degraded economizer and a high limit of 55 degree F (drybulb). Under this assumption, their base case air-economizer will operate at near closed position under most conditions and in most climate zones.

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, EUL\_Summary\_10-1-08.xls [213], was consulted. Table 8 below identifies the value/methodology used for the measures in this work paper.

Table 8 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HVAC-RepEcono | Non-Residential | HVAC | Repair Economizer | 5 | 1.7 |

# Section 2. Energy Savings & Demand Reduction Calculations

For 24 Hour Entertainment Center Economizer Repair Maintenance:

The energy savings and demand reduction were estimated by creating an energy simulation model for a 24-hour fitness center prototype, using eQuest (DOE 2.2). Simulation runs were repeated for both base case and measure under the same conditions for all eligible climate zones. Energy and demand results were normalized based on system cooling tonnage (kWh/Ton and kW/Ton). Gas savings were tabulated per Therm units.

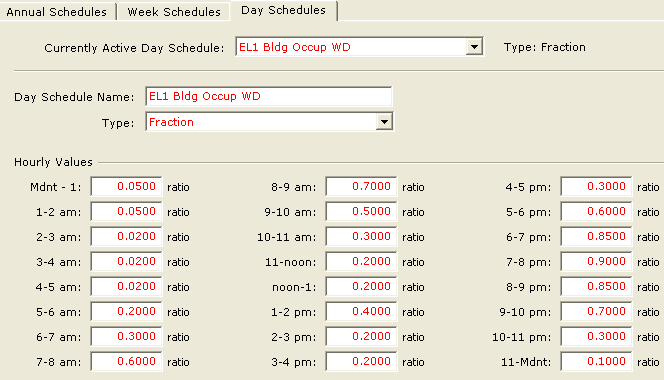
Key input parameters for the energy model are:

**General Building Parameters**

* Occupancy Type: Recreational (Fitness) Center
* Building Operating Schedule: Continuous, 24-Hours
* Code Compliance: Title 24
* Average Design Occupancy Density: 90 ft2/Occupant
* Building Area: 34,000 ft2
* No. of Floors: Single Story
* Average Equipment Load: 0.72 W/sqft
* Average Lighting Load: 0.95 W/sqft

The occupancy schedule in the building prototype was assumed to be typical of a Recreational (Fitness) Center with higher occupancy in the morning between 7:00 am and 9:00 am and during the late evening between 6:00 pm and 9:00 pm. The work paper attachments include occupancy profiles for 24-hour fitness centers that support these occupancy schedule assumptions [D]. The typical occupancy schedule (fraction of design occupancy) used in the simulation is summarized below in Table 9.

Table 9 Typical Occupancy Schedule



**HVAC System / Air-Economizer Control Parameters**

* Mechanical (HVAC) System: Rooftop Packaged, Single Zone, DX Cooling / Gas Heating
* Average Ventilation in Exercising Center / Gymnasium: 0.50 CFM/ ft2
* Average Ventilation in all other occupancies: 0.15 CFM/ ft2
* Air-Economizer Control: 68 Degree F DB high limit
* Temperature Setpoints (6:00 am to 10:00 pm): 75 deg. F Cooling / 69 deg. F Heating
* Temperature Setpoint (Setback - Night Time): 77 deg. F Cooling / 67 deg. F Heating
* Base Case: Non-functional economizer that operates fixed at 18% open
* Measure Case: Functional economizer that meets codes requirements described in Section 1.4.2

HVAC system (EER) efficiencies used for computing energy savings were determined per Title 24 Energy Standards as a function of system capacity, vintage, and climate zone. For each affected climate zone, system efficiencies were averaged through their capacity range (per vintage) as listed in the Title 24 Energy Standards and further adjusted (weighted) per vintage and climate zone based on 2008 DEER building vintage documentation. See Attachment 2 [ [[1]](#endnote-1)] for methodology in estimating weighted system efficiency. Table 10 summarizes estimated system (weighted) efficiency per climate zone.

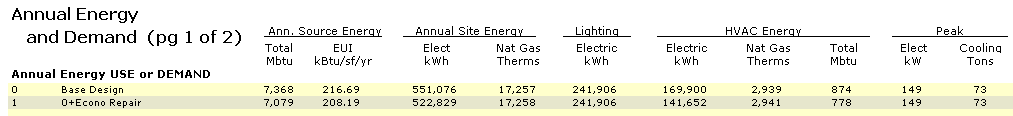
Table 10 Weighted (EER) Efficiency per Climate Zone

|  |  |
| --- | --- |
| Climate Zone | Weighted  (EER) Efficiency |
| CZ06 | 8.21 |
| CZ08 | 8.21 |
| CZ09 | 8.21 |
| CZ10 | 8.67 |
| CZ13 | 8.33 |
| CZ14 | 8.49 |
| CZ15 | 8.69 |
| CZ16 | 8.49 |

**Energy Savings & Demand Reduction Calculations Results**

A sample energy model simulation output for Climate Zone 6 is shown in Table 11:

Table 11 Annual Energy and Demand Summary



The results indicate that measure energy savings are primarily in HVAC (Electric) energy. The results also showed that there are no demand savings produced by the measure. Further, DEER peak demand reduction is zero in this work paper because the economizers do not operate during the DEER peak period. In most cases, gas consumption determined on the measure was slightly higher than that for the base case.

Table 12 summarizes energy and demand savings estimates for all affected climate zones using Annual Site Energy. Building energy simulation and Climate Zone files used in developing energy and demand saving calculations included in this work paper are enclosed in Attachment 3 [[[2]](#endnote-2)] and Attachment 4 [[[3]](#endnote-3)] respectively.

Table 12 Energy and Demand Savings Estimates Summary



Note that energy and demand estimates on this prototype are sensitive to numerous building characteristics including but not limited to occupancy density, profiles, and designations, ventilation rates, internal loads, and building envelope. Calculations in this work paper are representative of typical conditions determined for a 24-hour exercise center (gymnasium). Energy and demand savings estimates on less conventional 24-Hour Recreational Centers would require separate evaluations.

For Restore Degraded Economizer:

Table 13 contains the data files for measures that are taken directly from DEER 2014 Version 1.0.5, using the READi tool. These results have not been modified and are only being included in the work paper for reference.

**Table 13 READi Tool Outputs**

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-89808 | Restore Degraded Economizer |  |

This work paper is only applicable to the building types available in DEER 2014 Version 1.0.5 READI; these building types are listed below in Table 14.

Table 14 Building Types

|  |
| --- |
| Building Type |
| Education - Community College |
| Education - Secondary School |
| Education - University |
| Health/Medical - Hospital |
| Health/Medical - Nursing Home |
| Lodging - Hotel |
| Office - Large |
| Retail - Multistory Large |

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the “Economy\_cycle-Ret” load shape. See Table 15 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 15 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Assembly | Large\_Office | Economy\_cycle-Ret |
| Education - Community College | College\_University | Economy\_cycle-Ret |
| Education - Secondary School | Small\_Office | Economy\_cycle-Ret |
| Education - University | College\_University | Economy\_cycle-Ret |
| Health/Medical - Hospital | College\_University | Economy\_cycle-Ret |
| Health/Medical - Nursing Home | Small\_Office | Economy\_cycle-Ret |
| Lodging - Hotel | Small\_Office | Economy\_cycle-Ret |
| Office - Large | Large\_Office | Economy\_cycle-Ret |
| Retail - Multistory Large | Large\_Retail\_Store | Economy\_cycle-Ret |

# Note that the Assembly building type was used as the closest representative building type for a 24-hour Entertainment (gymnasium) Center. System loading by time-of-use (TOU) period was also considered when selecting the load shapes.

# Section 4. Base Case & Measure Costs

For 24 Hour Entertainment Center Economizer Repair Maintenance:

Direct Install measures use program tracking systems for measure costs. Therefore costs for this measure are not calculated in this section.

## 4.1 Base Case Cost

For Restore Degraded Economizer:

The base case cost is $0.00 since no change is being made.

## 4.2 Gross Measure Cost

For Restore Degraded Economizer:

The measure case cost is taken from the DEER 2008 Measure Cost Summary Table [215]. The ID is D08-NE-HVAC-Econo-Mnt: Repair economizer to operate at Title 24 requirements. There is no equipment cost associated with this measure ($0.00), and the labor cost is $73.65.

For REA, GMC is represented by the equation below:

*GMC = Measure Equipment Cost + Measure Labor Cost*

*= $0.00 + $73.65*

*=* ***$73.65***

## 4.3 Incremental Measure Cost

For Restore Degraded Economizer:

The Incremental Measure Cost is the same as the Gross Measure Cost.

# Attachments

1. 

1. 
2. 
3. 

1. 
2. 
3. 

# References



[26]

[31]

[386]

[351]

[213]

[215]

[355]

1. [] Attachment 2 – DEER2008 Building Weights & Efficiency [↑](#endnote-ref-1)
2. [] Attachment 3 – WP Building Simulation File4.zip [↑](#endnote-ref-2)
3. [] Attachment 4 – WP Climate Zone Files.zip

   [D] Attachment 7 – SCE13HC044.2 Fitness Center Occupancy Profile.xlsx [↑](#endnote-ref-3)