**Work Paper SCE13HC046**

**Revision 2**

**Southern California Edison Company**

**Commercial Economizer - Packaged DX Unit**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | AC-60978 Package System Economizer replacing System with no Economizer |
| **Measure Description:** | The measure for this work paper is an air-side economizer for commercial packaged DX systems. The installed economizer should be in accordance with Title 24 2013 Table 140.4-B. |
| **Base Case Description:** | The base case for this work paper is a commercial packaged DX system operating without an air-side economizer. For AC-60978, the system should be < 54 kBtu/h and for AC-64196 the system should be > 54 kBtu/h. |
| **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):** | 10 years; HVAC-addEcono |
| **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 |
| SCE13HC046.0 | No | 5/16/2012 | Ritesh Nayyar/ EMCOR Energy Services | Original work paper in 2013-2014 template |
| SCE13HC046.1 | No | 3/5/2014 | Joseph Ling/AESC | - New template for 2015 program year.  - Changed savings source from eQUEST prototype simulations to READI 1.04 DEER run D03-058. |
| No | 4/23/2014 | Cassie Cuaresma/SCE | -Work paper updated for reporting period effective 7/1/2014-12/31/2014  -Added new solution code for >65 kBtu/hr Package System Economizer  -Updated EUL. |
| No | 5/14/2014 | Joseph Ling/AESC | -Included additional language for applicable measure types.  -Adjusted measure cost amounts and included additional discussion of measure cost assumptions.  -Added HVAC Optimization QM requirements for basic and enhanced functionality requirements. |
| SCE13HC046.2 | No | 10/14/2014 | Cassie Cuaresma/SCE | - Added language clarifying NTG for Direct Install implementations.  - Added measure requirement language for AC-64196.  - Updated calculation attachment to latest template (v5). |
| No | 12/15/2014 | Joseph Ling/AESC | -Added AC-64196 as units >54 kBtu, Modified AC-60978 for units <54 kBtu  -Included start-up costs for measure.  -Included additional assumptions for cost estimates.  -Moved T24 Table 140.4-B (previously Table 2) to section 1.4.2, now Table 7.  -Additional formatting revisions as appropriate.  -Added Midstream Incentive Delivery. |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the energy savings achieved by installing an air side economizer on a packaged roof top unit of any capacity. Air side economizers help save energy by providing free cooling when ambient conditions are suitable to meet all or part of the space cooling load.

The measure case is any commercial building using packaged DX system with a fixed dry bulb, differential dry bulb, or enthalpy based economizer for its HVAC system. When the outside ambient dry bulb temperature is below the set point temperature (in the case of dry bulb controlled economizers), the economizer mode is activated, and the outside air dampers modulate between minimum and maximum position to bring in cool outside air.

The base case is one of the commercial building types with an HVAC system that does not have an air side economizer and therefore does not take advantage of free cooling when the ambient conditions are suitable.

Table 1 lists the core measure and the solution code associated with this work paper.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| AC-60978 | < 54 kBtu/hr Package System Economizer replacing System with no Economizer |
| AC-64196 | > 54 kBtu/hr Package System Economizer replacing System with no Economizer |

Measure Requirements for SCE’s Commercial HVAC Quality Maintenance Program

As part of an Advanced Digital Economizer Controls (ADEC) Upgrade, basic economizer functionality must be added, and/or restored as necessary. Basic economizer functionality is summarized as:

* All dampers are able to fully open and close and modulate accordingly to the appropriate positions based on ambient temperature (or enthalpy) control.
* Dampers move freely without binding.
* Return damper position is properly coordinated (e.g., interlocked) with the outside air damper.
* Economizer is capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load in the zone(s).
* Temperature and enthalpy sensor(s) is/are calibrated and correctly positioned to measure the temperature and enthalpy of the entering air from under the hood and in the air stream and, if required, return air from the return air duct.
* Economizer operation does not increase the building heating energy use during normal operation.
* Economizer operation and controls respond and modulate adequately based on temperature limits dictated by the applicable Energy Standards based on Climate Zone.
* High limit shut off/changeover control must be set within 2°F and 2 Btu/lb of the setpoints listed in Table 7.

Measure AC-64196 is subject to SCE inspection to ensure that the existing package system did not require an economizer at the time of original installation (per codes/standards). The Program will require proof that the existing system did not require an economizer at the time of original installation. The Program will determine the required documentation to prove/disprove this measure’s requirement.

In addition to the basic requirements above, which are very similar to previous economizer functional requirements in the Program, ADEC is also intended to provide enhanced functionality beyond that of “standard” economizer controllers. The enhanced control functionality requirements for a system to qualify for ADEC incentives are as follows:

* The economizer controller shall have the capability of displaying the current value of each sensor OR be connected and able to communicate with existing Energy Management System (EMS) in facility.
* The economizer controller shall have the capability of manually initiating the cooling mode so that the operation of compressors, economizers, and exhaust fans can be independently tested and verified OR be connected and able to communicate with existing EMS in facility
* If the high-limit control is fixed dry-bulb and/or fixed enthalpy then the control shall have an adjustable (or selectable) set point.
* Economizer controller shall have a BACnet/IP open protocol and be fully compatible with existing EMS in facility.
* Economizer controller shall be housed in a weather proof NEMA 4X enclosure.

## 1.2 Technical Description

All commercial building types served by packaged DX units, 24 in total, were considered for this work paper. There is no size restriction in terms of unit cooling capacity. All of these building types are served by packaged rooftop units with DX cooling and furnace heating.

To qualify for an incentive, the HVAC system type should be a Packaged DX unit with furnace heating or heat pump system. The customer must provide documentation showing that the economizer type on the HVAC system will be controlled per the prescribed device type and high limits dictated in Table 7, per Title 24. Also, the economizer must be capable of providing simultaneous mechanical cooling when the economizer cannot satisfy the load alone. This measure is also applicable to economizers with differential dry bulb and fixed enthalpy + fixed dry bulb control types. Savings associated with these differing control strategies are expected to be greater than those determined by DEER which assumes a single dry bulb with a minimum high limit of 68 F (e.g., Econo with Econo-Lockout=NO, DB limit = 68, Max OSA = 100%). Therefore, the DEER measure used in this work paper results in a conservative savings estimate for the alternate control types described in Table 2.

Measure savings were determined by DEER measure D03-058, which applies to both new and existing buildings. Only existing building types were considered for this work paper.

## 1.3 Measure Application Type

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2014. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

The program/install type for the above measure is:

* Retrofit Add-On (REA).

The delivery methods for this work paper are:

* Financial Support / Down-Stream Incentive – Deemed.
* Financial Support / Direct Install
* Midstream Programs / Mid-Stream Incentive

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

READI 1.0.5 [26] contains a reference to the DEER 2005 measure runs for adding a commercial economizer to a packaged DX system. Measure savings are sourced from these runs for all building types and SCE climate zones.

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | No |
| DEER Version | DEER 2014 1.0.5 |
| DEER Run ID and Measure Name | D03-058 Economizer – Packaged System |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 3 below.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| 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 |
| 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-HTR-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Com | Any | DirInstall | 0.85 |
| Ind-Default-HTR-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Ind | Any | DirInstall | 0.85 |
| Agricult-Default-HTR-di | All other EEM with no evaluated NTGR; direct install to hard-to-reach only. | Ag | Any | DirInstall | 0.85 |

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

Note that for the direct install delivery mechanism, a distinction between hard to reach and non-hard to reach markets will be made on a project by project basis. This work paper shows the NTG associated with a hard to reach direct install delivery mechanism and the defaulted NTG value, where in fact, a measure offered through direct install and is not “hard to reach” will receive a default NTG value.

**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 workpaper 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 4 below.

Table 4 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | GSIAValue\* |
| Def-GSIA | Default GSIA values | Com | Any | Any | 1 |

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. 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 workpaper refer the Excel calculation template.

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measure Case UseCategory | HVAC |
| Measure Case UseSubCats | Space Cooling |
| Measure Case TechGroups | HVAC Air Distribution |
| Measure Case TechTypes | Air Economizer |
| Base Case TechGroups | HVAC Air Distribution |
| Base Case TechTypes | Non-DEER |

### 1.4.2 Codes and Standards Analysis

An air-side economizer is mandated by Title 24 2013 for any cooling fan system with a total mechanical cooling capacity over 54,000 Btu/hr. Although Title 24 2013 standards require air-side economizers for these system types, Title 24 2013 standards are not invoked by the installation of this retrofit add-on measure.

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | Section 144 (1) | July 1, 2014 |

Table 7 Air Economizer High Limit Shut Off Control Requirements[[1]](#footnote-1)

|  |  |  |
| --- | --- | --- |
| Device Typea | Climate Zones | Required High Limit (Economizer Off When):b |
| Fixed Dry Bulb | 1,3,5,11-16 | TOA>75°F |
| 2,4,10 | TOA>73°F |
| 6,8,9 | TOA>71°F |
| 7 | TOA>69°F |
| Differential Dry Bulb | 1,3,5,11-16 | TOA>TRA°F |
| 2,4,10 | TOA>TRA-2°F |
| 6,8,9 | TOA>TRA-4°F |
| 7 | TOA>TRA-6°F |
| Fixed Enthalpyc + Fixed Drybulb | All | hOA>28 Btu/lbc or TOA>75°F |

* 1. Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls may not be used in any climate zone unless used in conjunction with the devices and setpoints listed. For example, a Fixed Enthalpy + Fixed Dry Bulb control may also use a Dew Point limit.
  2. Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.
  3. At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

### 1.4.3 Non-DEER Study Review

### 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 7 below identifies the value/methodology used for the measures in this work paper.

The EUL of the measure is capped at the remaining useful life of split and package equipment (DEER EUL\_ID’s HVAC-airAC and HVAC-airHP) , or a third of 15 years, as it is likely that the economizer would be removed with the equipment once it reaches the end of its remaining useful life.

Table 8 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HVAC-airAC | Non-Residential | HVAC-Miscellaneous | Package System Economizer replacing System with no Economizer | 5 | N/A |

# Section 2. Energy Savings & Demand Reduction Calculations

Table 8 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

Table 9 READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-60978 | < 54 kBtu/hr Package System Economizer replacing System with no Economizer |  |
| AC-64196 | > 54 kBtu/hr Package System Economizer replacing System with no Economizer |  |

# 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 9 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 10 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Agricultural | Large\_Retail\_Store | Economy\_cycle-Ret |
| Assembly | Large\_Office | Economy\_cycle-Ret |
| Education - Community College | College\_University | Economy\_cycle-Ret |
| Education - Primary School | Small\_Office | Economy\_cycle-Ret |
| Education - Relocatable Classroom | Small\_Office | Economy\_cycle-Ret |
| Education - Secondary School | Small\_Office | Economy\_cycle-Ret |
| Food Store | Small\_Office | Economy\_cycle-Ret |
| Grocery | Small\_Office | Economy\_cycle-Ret |
| Health/Medical - Clinic | Small\_Office | Economy\_cycle-Ret |
| Health/Medical - Hospital | College\_University | Economy\_cycle-Ret |
| Health/Medical - Nursing Home | Small\_Office | Economy\_cycle-Ret |
| Industrial | Large\_Office | Economy\_cycle-Ret |
| Lodging - Hotel | Small\_Office | Economy\_cycle-Ret |
| Manufacturing - Bio/Tech | Large\_Office | Economy\_cycle-Ret |
| Manufacturing - Light Industrial | Large\_Office | Economy\_cycle-Ret |
| Misc - Commercial | Misc.\_Commercial | Economy\_cycle-Ret |
| Office - Small | Small\_Office | Economy\_cycle-Ret |
| Restaurant - Fast-Food | Restaurant | Economy\_cycle-Ret |
| Restaurant - Sit-Down | Restaurant | Economy\_cycle-Ret |
| Retail - Single-Story Large | Large\_Retail\_Store | Economy\_cycle-Ret |
| Retail - Small | Small\_Retail\_Store | Economy\_cycle-Ret |
| Storage - Conditioned | Large\_Retail\_Store | Economy\_cycle-Ret |
| Transportation - Communication - Utilities | Large\_Retail\_Store | Economy\_cycle-Ret |
| Warehouse - Refrigerated | Large\_Retail\_Store | Economy\_cycle-Ret |

# Section 4. Base Case & Measure Costs

The 2010-2012 WO017 Ex Ante Measure Cost Study – Itron was reviewed and evaluated for cost source on measure; however, this study does not support the subject measure. Hence, all cost documentation on measure was obtain from the 2014 RS Means Mechanical Cost Data [413] and 2014 RS Means Commercial Renovation Cost Data [414].

## 4.1 Base Case Cost

The base case is a commercial building without an economizer for the HVAC system. Therefore, the base case cost for this work paper is zero.

## 4.2 Measure Case Cost

The measure case involves installing an economizer on an existing packaged DX system. Assumptions made include the material purchase of installing dampers, temperature sensor, economizer control module, and all relevant labor for design and installation of equipment necessary.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

Gross Measure Cost is the cost to install an energy efficient measure. The install type is a Retrofit Add-On (REA). Therefore, the Gross Measure Cost is given by the following equation:

Gross Measure Cost = Measure Equipment Cost + Measure Labor Cost

The gross measure cost for this work paper is calculated from 2014 RS Means Mechanical Cost Data [413] and 2014 RS Means Commercial Renovation Cost Data [414]. See Table 10 for a detailed description of the costs.

The proposed costs are based on the following assumptions: 1) the control system assumes that the room air temperature equivalent to the return air temperature. As a result, the installation of a new return air sensor is not included. 2) Metal work and modifications are not needed to retrofit the AC or HP unit and/or to accommodate economizer module onto existing package equipment. 3) Costs are assumed for a unitary economizer with no connection to existing controller. 4) Wiring is assumed to be integrated into the below cost and controller is assumed to be wired into retrofit system. 5) Start-up includes both functional testing and calibration of the installed equipment.

Table 11 Labor and Equipment Costs for Economizer Installation

Equipment Cost

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Item | Location | Unit Cost ($) | Unit | Qnty | Total Cost ($) | Resources |
| Variable Volume Modulating Motorized Damper, including Electric Motor | Outdoor Air Dampers - 24" x 12" | $143.00 | Ea | 2 | $286.00 | 2014 RSMeans Commercial Renovation Cost Data, 23 33 13.13 7560 & 7564 – Bare Material Cost |
| Return Air Dampers - 24" x 24" | $160.00 | Ea | 1 | $160.00 |
| Temperature Sensors | (Analog Input) Sensor for the Outdoor Air | $167.00 | Ea | 1 | $167.00 | 2014 RSMeans Mechanical Cost Data, 23 09 53.10 3560 – Bare Material Cost |
| Controller | Unitary Economizer Controller | $495.50 | Ea | 1 | $495.50 | 2014 RSMeans Mechanical Cost Data, 23 09 53.10 0890 – Bare Material Cost |
| Materials Subtotal | | | | | $1,108.50 |  |
| **Normalized equipment cost for a 65,000 Btu/hr (5.41 ton) unit** | | | | | **$204.90/ton** |  |
| Labor Cost | | | | | | |
| Variable Volume Modulating Motorized Damper, including Electric Motor | Outdoor Air Dampers - 24" x 12" | $54.50 | Ea | 2 | $109.00 | 2014 RSMeans Commercial Renovation Cost Data, 23 33 13.13 7560 & 7564 – Bare Material Cost |
| Return Air Dampers - 24" x 24" | $73.00 | Ea | 1 | $73.00 |
| Temperature Sensors | (Analog Input) Sensor for the Outdoor Air | $38.50 | Ea | 1 | $38.50 | 2014 RSMeans Mechanical Cost Data, 23 09 53.10 3560 – Bare Labor Cost |
| Controller | Unitary Economizer Controller | $53.50 | Ea | 1 | $53.50 | 2014 RSMeans Mechanical Cost Data, 23 09 53.10 0890 – Bare Labor Cost |
| Economizer Start-Up | Validate economizer operation and economizer damper modulation per temp. limits under cooling/heating | $105.00 | Ea | 1 | $105.00 | 2014 RSMeans Mechanical Cost Data, 23 09 23.10 4700 – Total Cost |
| *Labor Subtotal* | | | | | *$379.00* |  |
| ***Normalized labor cost for a 65,000 Btu/hr (5.41 ton) unit*** | | | | | ***$70.06/ton*** |  |
| **Gross Measure Cost** | | | | | **$274.96/ton** |  |

### 4.3.2 Incremental Measure Cost

The Incremental Measure Cost for a Retrofit Add-On (REA) install type is given by the following equation:

Incremental Measure Cost = Measure Equipment Cost + Measure Labor Cost

Based on the above equation the Incremental Measure Cost for this work paper is **$274.96/ton**.

# Attachments

1. 

# References



[26]

[31]

[213]

[351]

[413]

[414]

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |

1. Table adapted from: 2013 Building energy Efficiency Standards Table 140.4-B Air Economizer High Limit Shut Off Control Requirements [↑](#footnote-ref-1)