**Work Paper SCE13PR006**

**Revision 1**

**Southern California Edison Company**

**Industrial Blower replacing Air Compressor**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | *PR-78447* |
| **Measure Description:** | Industrial blower |
| **Base Case Description:** | Existing customer air compressor |
| **Energy Impact Common Units:** | HP |
| **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):** | 15 (Motors-fan) |
| **Measure Application Type:** | RET |
| **Net-to-Gross Ratios:** | 0.85 (ET-Default) |
| **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 |
| SCE13PR006.0 | Yes | 04/04/2012 | Antonio Corradini/AESC | Original work paper for 2013 PC |
| SCE13PR006.1 | No | 6/19/2014 | Vincent Partusch/SCE | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  -Template Update |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the energy savings associated with replacing open blowing end uses using an existing compressed air system, with an industrial blower. The base case for this measure is a rotary screw compressor using load/unload controls and rated capacity between 25 and 500 HP, the size range of single stage lube injected rotary screw compressors included in SCE’s Online Application Tool. The range is applicable to all customer types listed below in section 1.1c. Energy and demand savings are reported in terms of specific energy (kWh/HP/year) and specific power (kW/HP). Table 1 shows the core measure description and its solution code.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| PR-78447 | Industrial blower replacing air compressor |

The existing compressed air system must meet the following requirements:

* It must be an electric driven rotary screw compressor, with a horse power rating between 25 HP and 500 HP.
* Systems with centrifugal compressors are eligible only if there are other trim compressors which are rotary screw or reciprocating compressors.
* The existing compressor(s) must be permanently installed. Portable compressors are not eligible for this measure.

Systems with steam turbine or engine driven compressors do not qualify.

The proposed industrial blower must be permanently installed and piped, if needed, to the end use. The maximum size of the installed blower must be 50 HP. Beyond that limit, customized calculations are necessary and the end use pressure must be assessed on a case by case. The size of the installed blower is independent of the customer type.

This measure is applicable only to the following building types:

* Agricultural
* Health/Medical - Hospital
* Health/Medical - Clinic
* Manufacturing - Bio/Tech
* Manufacturing - Light Industrial
* Industrial
* Misc - Commercial
* Retail - Single-Story Large
* Transportation - Communication - Utilities

## 1.2 Technical Description

This measure seeks to replace rotary screw air compressors with industrial blowers for applications which only require low air pressure. A rotary screw air compressor has two helical screws (rotors) that are designed to mesh together. These screws are rotated synchronously in opposite directions, trapping air at the inlet and forcing it up through the flutes to the outlet. This design allows for the production of very high air pressures, but also requires a great deal of energy. Much of this energy used to produce high pressure air is lost as heat. For end uses where less pressure is needed, such as most open blowing processes, an industrial blower is more appropriate and energy efficient. An industrial blower is a centrifugal fan that functions by drawing air into a rotating wheel in the axial direction, and expelling through an outlet in the direction of rotation.

Utilizing high pressure air for open blowing applications is generally an inefficient use of compressed air. Since typical open blowing processes are low pressure uses, higher pressure compressed air is not needed. Many of these typical inappropriate uses of compressed air can be replaced with industrial blowers. These are applications that can use air at low pressure (5 to 30 psig) instead of the 100 psig, or higher produced by a typical air compressor. The industrial blower will allow more efficient operation by providing air for low pressure uses at the required pressure, up to 20 psig. The industrial blower retrofit is not advised for higher pressure end uses.

Typical improper uses of compressed air include:

* Open blowing processes such as cabinet cooling, bearing cooling, drying, cleanup, draining compressed air lines, and cleaning jams on conveyors
* Sparging processes, such as aerating, agitating, oxygenating, or percolating liquid with compressed air
* Aspirating, where compressed air is used to induce the flow of another gas (such as flue gas).
* Atomizing, where compressed air is used to disperse or deliver a liquid to a process as an aerosol
* Diluted phase transport, where compressed air is used in transporting solids such as powdery material in a diluted format
* Vacuum generation, where compressed air is used with a venturi educator or ejector to generate a negative pressure mass flow
* Personnel cooling, where operators direct compressed air on themselves to provide ventilation (if the compressor is oil injected there are also health related issues with this practice

## 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 delivery methods that are available for the measures contained within this work paper are:

* Financial Support - Down-Stream Incentive – Deemed
* Partnership - Down-Stream Incentive – Deemed

The program/install type for the above measures is:

* Retrofit (RET)

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

Industrial blower type measures are not included in the 2014 Database for Energy Efficient Resources (DEER) READI tool v.2.0.1.

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 | Deer does not contain this type of measure |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | N/A |

**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. Air Blower Market Assessment Emerging Technologies Report [A] was used to verify and select the appropriate NTGR for this measure.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| ET-Default | Emerging Technologies approved by ED through work paper review | All | Any | All | 0.85 |

\*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 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 | Any | Any | Any | 1 |

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

**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 | Process Distribution |
| Measure Case UseSubCats | Manufacturing - Average quality air |
| Measure Case TechGroups | Air Compressor |
| Measure Case TechTypes | Blower |
| Base Case TechGroups | Air Compressor |
| Base Case TechTypes | Screw |

### 1.4.2 Codes and Standards Analysis

The 2013 Title 24 [355] requires that:

All new compressed air systems, and all additions or alterations of compressed air systems where the total combined online horsepower (hp) of the compressor(s) is 25 horsepower or more shall meet the requirements of Subsections 1 through 3. These requirements apply to the compressors and related controls that provide compressed air and do not apply to any equipment or controls that use or process the compressed air.

**EXCEPTION to Section 120.6(e):** Alterations of existing compressed air systems that include one or more centrifugal compressors.

**1. Trim Compressor and Storage**. The compressed air system shall be equipped with an appropriately sized trim compressor and primary storage to provide acceptable performance across the range of the system and to avoid control gaps. The compressed air system shall comply with Subsection A or B below:

A. The compressed air system shall include one or more variable speed drive (VSD) compressors. For systems with more than one compressor, the total combined capacity of the VSD compressor(s) acting as trim compressors must be at least 1.25 times the largest net capacity increment between combinations of compressors. The compressed air system shall include primary storage of at least one gallon per actual cubic feet per minute (acfm) of the largest trim compressor; or,

B. The compressed air system shall include a compressor or set of compressors with total effective trim capacity at least the size of the largest net capacity increment between combinations of compressors, or the size of the smallest compressor, whichever is larger. The total effective trim capacity of single compressor systems shall cover at least the range from 70 percent to 100 percent of rated capacity. The effective trim capacity of a compressor is the size of the continuous operational range where the specific power of the compressor (kW/100 acfm) is within 15 percent of the specific power at its most efficient operating point. The total effective trim capacity of the system is the sum of the effective trim capacity of the trim compressors. The system shall include primary storage of at least 2 gallons per acfm of the largest trim compressor.

**EXCEPTION 1 to Section 120.6(e)1:** Compressed air systems in existing facilities that are adding or replacing less than 50 percent of the online capacity of the system.

**EXCEPTION 2 to Section 120.6(e)1:** Compressed air systems that have been approved by the Energy Commission Executive Director as having demonstrated that the system serves loads for which typical air demand fluctuates less than 10 percent.

**2. Controls.** Compressed air systems with more than one compressor online, having a combined horsepower rating of more than 100 hp, must operate with a controller that is able to choose the most energy efficient combination of compressors within the system based on the current air demand as measured by a sensor.

**3. Compressed Air System Acceptance.** Before an occupancy permit is granted for a compressed air system subject to Section 120.6(e), the following equipment and systems shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA 7.13.

However, as the measures within this work paper are replacing existing air compressors with blower fans, Title 24 would not be applicable.

The 2014 Title 20 [422] Appliance Efficiency Standards do not cover compressed air systems.

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Applicable Code Reference** | **Effective Dates** |
| Title 24 (2013) | Section 120.6 (e) | July 1st, 2014 |
| Title 20 (2014) | N/A | N/A |

### 1.4.3 Non-DEER Study Review

SCE used a 2010 Air Blower Market Assessment report from its Emerging Technologies unit to support this measure. [A]

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2013-14 program cycle on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “DEER2014-EUL-table-update\_2014-02-05.xlsx” 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.

Although industrial blowers are fairly simple pieces of equipment, manufacturers do not specify the effective useful life of the measure if appropriate maintenance is followed. To obtain the EUL value the DEER14 update documentation, “DEER2014-EUL-table-update\_2014-02-05.xlsx” [436], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

DEER does not provide an EUL for industrial blowers; however, 15 years is the accepted EUL of an HVAC fan or motor retrofit, which is considered similar to that of an industrial blower. Therefore, this paper assumes that an industrial blower has a similar EUL of 15 years.

Table 7 EUL Value

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| Motors-fan | Com | HVAC | HVAC Fan Motors | 15 | 5 |

# Section 2. Energy Savings & Demand Reduction Calculations

This measure saves energy and reduces electric demand by utilizing an industrial blower to provide air for low pressure end uses at the required pressure instead of using an air compressor, which is a less efficient source. Additionally, since typical open blowing processes are low pressure uses, higher pressure compressed air is not needed. The differences between the energy savings are due to end user operating pressure and operating hours. Climate zones do not influence this measure’s energy savings.

Compressing air from atmospheric pressure of 14.7 psia to 100 psig (114.7 psia) increases the pressure by a factor of almost 8. According to the USDOE’s Compressed Air Challenge, approximately 85% of the energy used in the compression process becomes heat, which is usually wasted. [B]

Many of the typical inappropriate uses of compressed air can be replaced with industrial blowers. Energy and demand savings result from these applications using air at low pressure (5 to 30 psig) instead of high pressure (100 psig or higher, typically produced by an air compressor).

Peak demand reduction using DEER methodology is calculated as the average demand from 2 pm until 5 pm during a three day period defined separately for each Climate Zone. This analysis assumes that the system operates at constant load and constant performance during normal operating hours, which include the 2 pm to 5 pm DEER peak period, for the applicable building types. Consequently, the base and measure case specific power (kW/HP) were obtained by dividing the respective specific energies by the DEER operating hours. The savings are calculated in kW and kWh saved per HP of blower installed.

The following assumptions define calculation inputs and outputs:

* The baseline compressor pressurizes the air at 100 psig and runs at 100% of full load capacity, which is the most efficient point.
* The baseline compressor efficiency is 18.1 kW/100 acfm, which is the AirMaster+ (Version 1.2.3) [F]default full load efficiency for a 100 HP single stage lubricant injected rotary screw compressor using load/unload controls, rated at 100 psig. Please note that most systems do not run at 100% load, and therefore, are less efficient. With this assumption, the savings are calculated in a conservative manner.
* Fan type blowers could develop pressure from a few inches of water gauge to 35 psig for certain industrial applications. The average value of 10 psig is used for the industrial building type and 5 psig is used for the other building types.
* Baseline (compressed air) and measure (industrial blower) air flow requirements are equivalent in terms of actual cubic feet per minute (acfm).
* Savings are evaluated in terms of kWh/HP/year and kW/HP, based on rated HP of the installed blower.
* The annual hours of operation for light industrial and all other users (1,534 hrs) are based on half of the DEER defined operating hours since the system does not operate for the entire building operating hours. With this assumption, the savings for light industrial and all other users are calculated in a conservative manner. The operating hours for industrial (7,752 hrs) are based on assumed operation of 24 hrs/day year-round minus six weeks of maintenance. [C]
* The demand savings are coincident with the DEER peak.

Energy savings calculations use the following equations that define base case annual usage and measure case annual usage:

* Compressor kW (at 100 psig) = 18.1 kW/100 acfm
* Blower kW (at 5 psig) = 2.94 kW. The author used a regression based on manufacturer information[C] for different types of blowers delivering pressure form 5 psig to 20 psig. The regression was developed with kW/100 acfm as the dependent variable and pressure as the independent variable, which resulted in a robust R square value of 85%. Thus, the equation was considered appropriate to represent the power of the industrial blowers. For a blower delivering 10 psig, the blowing power is 5.94 kW. For a blower delivering 5 psig, the blower power is 2.94 kW. The 10 psig pressure is an average between the 20 psig of high pressure blower and the few inches of w.g. of HVAC type fan used to replace improper compressed air use.

The differences in kW to deliver 100 CFM were then compared. The baseline compressor is assumed to have an efficiency of 18.1 kW/100 acfm, while the proposed blowers have efficiencies of 5.94 kW/100 acfm at 10 psig (for the industrial building type) and 2.94 kW/100 acfm at 5 psig (for all other building types), based on the correlation described above. The savings results in kW/100 acfm were then multiplied by the average ratio of brake horse power (HP) to delivered air (acfm) determined from manufacturers’ specifications, so that energy savings are reported on a kWh/HP basis and peak reduction is expressed in a kW/HP of installed blower capacity.

Table 8 shows the demand savings from the measures covered in this work paper.

Table 8 Demand Savings

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Customer Annual Demand Savings (kW/HP)** | **Above Code Annual Demand Savings (kW/HP)** |
| Industrial | 1.47 | N/A |
| Manufacturing – Bio/Tech | 1.83 | N/A |
| Manufacturing - Light Industrial | 1.83 | N/A |
| Agricultural | 1.83 | N/A |
| Health/Medical – Hospital | 1.83 | N/A |
| Health/Medical – Clinic | 1.83 | N/A |
| Miscellaneous-Commercial | 1.83 | N/A |
| Retail-Single- Story Large | 1.83 | N/A |
| Transportation - Communication - Utilities | 1.83 | N/A |

Table 9 shows the energy savings from the measures covered in this work paper.

Table 9 Annual Energy Savings

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Customer Annual Electric Savings (kWh/HP)** | **Above Code Annual Electric Savings (kWh/HP)** |
| Industrial | 11,377.59 | N/A |
| Manufacturing – Bio/Tech | 2,806.90 | N/A |
| Manufacturing - Light Industrial | 2,806.90 | N/A |
| Agricultural | 2,806.90 | N/A |
| Health/Medical – Hospital | 2,806.90 | N/A |
| Health/Medical – Clinic | 2,806.90 | N/A |
| Miscellaneous-Commercial | 2,806.90 | N/A |
| Retail-Single- Story Large | 2,806.90 | N/A |
| Transportation - Communication - Utilities | 2,806.90 | N/A |

# 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 Industrial load shape. See Table 10 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 | Industrial | Industrial |
| Health/Medical - Hospital | Industrial | Industrial |
| Health/Medical - Clinic | Industrial | Industrial |
| Manufacturing - Bio/Tech | Industrial | Industrial |
| Manufacturing - Light Industrial | Industrial | Industrial |
| Industrial | Industrial | Industrial |
| Misc - Commercial | Industrial | Industrial |
| Retail - Single-Story Large | Industrial | Industrial |
| Transportation - Communication – Utilities | Industrial | Industrial |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

For this measure category, the base case cost is assumed to be zero because these are discretionary modifications (retrofit) to the customers’ existing equipment. The alternative is to make no changes to their existing system.

## 4.2 Measure Case Cost

### The Measure Costs were estimated using averaged values from multiple manufacturers and from RSMeans[D]. GMC is represented by the equation below:

### GMC = Measure Equipment Cost + Measure Labor Cost

### Table 11 Measure Cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | Unit | Material | Labor | Cost |
| Industrial blower replacing air compressor | HP | $1,502.49 | $116.27 | \*$1,618.76 |

### \*Note: The measure cost shown above was obtained using data from the 2012 edition of RS Means Mechanical Cost Data and OEM retailers.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

### For retrofits, the gross measure cost (GMC) is the full cost of the measure to purchase and install, as shown in Table 11.

### 4.3.2 Incremental Measure Cost

For deemed retrofit measures, the Incremental Measure Cost (IMC) is equal to the gross measures cost; however to support program planning the delta between the measures cost and a representative base case is calculated below. The information in this section is not intended to be used for reporting purposes, but rather to provide guidance in determining program level incentives only. The incremental measure cost can be calculated as follows:

[Equation 1] ∆cost/unit:

The IMC (∆cost/unit) is defined as the difference in costs between the base case and the measure equipment. For this measure, the base case costs were assumed to be zero, as the representative base case would be the Customer's existing equipment as is. The estimated measure cost is for a standard industrial blower, and the Customer would not elect to install a smaller air compressor in lieu of an industrial blower. The measure equipment costs are shown below.

X = Base Case Equipment & Labor Cost = $0/HP

Y = Measure Equipment & Labor Cost = $1,618.76/HP

∆cost/unit = Y- X = $1,618.76

**Attachments**

1. 

2. 

3.

4.

5.

6. 

**References**



[31]

[351]

[355]

[422]

[436]

[A] Design and Engineering Services, Air Blower Market Assessment, ET 10SCE4010 Report, December 7, 2010,

<http://www.etcc-ca.com/images/stories/et10sce4010\_air\_blower\_market\_assessment.pdf>

[B] Compressed Air Challenge. Improving Compressed Air System Performance, a Sourcebook for Industry. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Page 17.

[C] See attached Sempra Energy steam work paper: *SteamTrap Workpaper (11Dec06).doc*

[D] See attached Gardner Denver and Atlas Copco pdf documents

[E] See cost tab in attached file: *SCE13PR006 Industrial Blower Savings and Cost Calculations.xls*

[F] See attached Air Master (AM) + baseline efficiency compressor report

# 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 |