Work Paper SCE13PR006

**Revision 3**

**Southern California Edison**

**Industrial Blower replacing Air Compressor**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | PR-78447 |
| **Measure Description** | Industrial blower |
| **Base Case Description** | Existing customer air compressor |
| **Units** | HP |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | 15 (Motors-fan) |
| **Measure Installation Type** | RET |
| **Net-to-Gross Ratio** | 0.85 (ET-Default) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 04/04/2012 | Antonio Corradini/AESC | Original work paper for 2013 PC |
| 1 | 6/19/2014 | Vincent Partusch/SCE | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  -Template Update |
| 2 | 02/01/2016 | Eduardo Munoz/SCE | New template update for 2016 program year  -Removed SCE building types  -No value modifications |
| 3 | 04/29/2016 | Ajay Wadhera/Solaris | * Added Office - Small building type in place of deleted BTs – Clinic, Misc. Commercial, TCU. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |
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Cal TF website: <http://www.caltf.org/>

# 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). The table below shows the core measure description and its solution code.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Industrial blower replacing air compressor |
| Existing Condition | Rotary screw compressor using load/unload controls and rated capacity between 25 and 500 HP |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | 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:

* Health/Medical - Hospital
* Manufacturing - Bio/Tech
* Manufacturing - Light Industrial
* Retail - Single-Story Large
* Office – Small (alternate for Clinic, Misc. Commercial, 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 pressure, 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 Installation Types and Delivery Mechanisms

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)

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

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

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | N/A |
| Reason for Deviation from DEER | Deer does not contain this type of measure |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| ET-Default | Emerging Technologies approved by ED through work paper review | All | Any | All | 0.85 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Motors-fan | HVAC Fan Motors | Com | HVAC | 15 | 5 |

### 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.

Code Summary

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

## 

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### 1.5.1 Non-DEER Study Review

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

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

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) [E]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.

The table below shows the demand savings from the measures covered in this work paper.

Demand Savings

|  |  |  |
| --- | --- | --- |
| **Building Type\*** | **Customer Annual Demand Savings (kW/HP)** | **Above Code Annual Demand Savings (kW/HP)** |
| Manufacturing – Bio/Tech | 1.83 | N/A |
| Manufacturing - Light Industrial | 1.83 | N/A |
| Health/Medical – Hospital | 1.83 | N/A |
| Retail-Single- Story Large | 1.83 | N/A |
| Office – Small | 1.83 | N/A |

\*Industrial, Agricultural, Health/Medical – Clinic, Miscellaneous – Commercial, Transportation – Communication – Utilities BTs were removed. Office – Small added for Cli, MiC, TCu.

The table below shows the energy savings from the measures covered in this work paper.

Annual Energy Savings

|  |  |  |
| --- | --- | --- |
| **Building Type\*** | **Customer Annual Electric Savings (kWh/HP)** | **Above Code Annual Electric Savings (kWh/HP)** |
| Manufacturing – Bio/Tech | 2,806.90 | N/A |
| Manufacturing - Light Industrial | 2,806.90 | N/A |
| Health/Medical – Hospital | 2,806.90 | N/A |
| Retail-Single- Story Large | 2,806.90 | N/A |
| Office – Small | 2,806.90 | N/A |

\*Industrial, Agricultural, Health/Medical – Clinic, Miscellaneous – Commercial, Transportation – Communication – Utilities BTs were removed. Office – Small added for Cli, MiC, TCu.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Health/Medical - Hospital | Industrial | Industrial |
| Manufacturing - Bio/Tech | Industrial | Industrial |
| Manufacturing - Light Industrial | Industrial | Industrial |
| Retail - Single-Story Large | Industrial | Industrial |
| Office - Small | Industrial | Industrial |

# Section 4. 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].

### 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 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| PR-78447 | RET | $1,618.76 | $1,618.76 | $1,618.76 |

# Attachments

1. 

2. 

3. 

4. 

5. 

6. 

# References



[355]

[422]

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