**Work Paper PGE3PAGR113**

**Revision 2**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Scroll Compressor**

**Measure Code R161**

***EnSave Inc.***

# At a Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **R161** |
| **Measure Description:** | Scroll Compressor |
| **Energy Impact Common Units:** | Each |
| **Base CaseDescription:** | Reciprocating Compressor |
| **Base Case Energy Consumption:** | Source: EnSave Calculations |
| **Measure Energy Consumption:** | Source: EnSave Calculations |
| **Energy Savings ((Base Case – Measure) x Interactive Effects)** | Source: EnSave Calculations |
| **Costs Common Units:** | Scroll Compressor installed. Include Source |
| **Base Case Equipment Cost ($/unit):** | $2,022  Source: Market survey in Feb 2013 |
| **Measure Equipment Cost ($/unit):** | $2,424  Source: Market survey in Feb 2013 |
| **Measure Incremental Cost ($/unit):** | $402 |
| **Effective Useful Life (years):** | RefgWrhs-ScrollComp, 12 years  Source: DEER2016 |
| **Measure Application Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratios:** | NTGR = 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” |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 3/14/2007 | Original short form work paper based on proposal estimates for the CA Multi Measure Farm Program. | EnSave, Inc. |
| Revision 1 | 4/2/2008 | Updated with data from the CA Multi Measure Farm Program installations. | EnSave, Inc. |
| Revision 2 | 5/16/08 | Updated to standard Long Form. | EnSave, Inc. |
| Revision 3 | 8/13/09 | Updated for revised DEEP 2009-2011 post Bridge Funding Period. | EnSave, Inc. |
| Revision 4 | 11/17/09 | Updated with references to the most recent EM&V study conducted on the 2004-2005 CA Multi Measure Farm Program. | EnSave, Inc. |
| Revision 5 | 11/24/09 | Updated Sections 1-4 to include more complete reference source descriptions. | EnSave, Inc. |
| Revision 6 | 12/9/09 | Updated kWh and kW savings based on per 00 gallon savings factor from the most recent EM&V study conducted on the 2004-2005 CA Multi Measure Farm Program. | EnSave, Inc. |
| Revision 7 | 12/22/09 | Corrected common unit definitions and EUL; updated kW savings based on revised on-peak coincidence factors. | EnSave, Inc. |
| Revision 8 | 2/11/10 | Redefined common unit definitions and associated data and descriptions. | EnSave, Inc. |
| Revision 9 | 2/25/10 | Revised unit abbreviations (minor edits). | EnSave, Inc. |
| Revision 10 | 3/1/10 | Updated At A Glance table format. | EnSave, Inc. |
| Revision 11 | 3/5/10 | Minor text corrections and clarifications. | EnSave, Inc. |
| Revision 12 | 2/3/12 | Updated measure equipment costs, measure incremental costs, measure installed costs, and installation labor costs. Changed costs common units. | EnSave, Inc. |
| Revision 13 | 6/8/12 | Updated work paper for 2013-2014. | EnSave, Inc. |
| Revision 14 | 2/8/2013 | Updated from hybrid measure based on 100 gallons per day of milk production to deemed measure based on average kWh savings per Scroll Compressor Installed. Includes changes at:   * At a Glance Summary * Section 2.1 Energy Savings Estimation Methodologies * Section 2.2 Demand Reduction Estimation Methodologies   Updated format for both Summary At A Glance pages.  Updated NTG value and reference at A-A-G pages and Section 1.7.  Added signature page.  Removed embedded files, now to be separate files, updated file names & references.  Various formatting updates | EnSave, Inc. |
| PGE3PAGR113  Revision 0 | 2/14/2013 | Re-named from WPenNRPR0005, Rev 14 as per PG&E review request | EnSave, Inc. |
| PGE3PAGR113  Revision 1 | 5/7/2014 | Updated to new compliance template | Mark Tiemens, PG&E |
| PGE3PAGR113  Revision 2 | 1/1/2016 | Updated to the latest ex ante format for 2016. Changed full measure cost to incremental cost. | Linda Wan, PG&E |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

This measure saves energy by replacing standard efficiency reciprocal compressors with high efficiency scroll compressors on milk cooling systems. There are numerous configurations of milk cooling systems on California dairies, but all use some form of mechanical vapor-compression refrigeration.

## 1.2 Product Technical Description

Scroll compressors use two interlocking scroll lobes, one stationary and one moving in an orbiting circular path, to compress refrigerant vapor in an aerodynamically more efficient way than a piston/cylinder/valve configuration of a reciprocal compressor. Scroll compressors have higher initial efficiency, have fewer moving parts, and are quieter than reciprocal compressors. In addition, their efficiency actually increases over time, while a reciprocal compressor degrades.

## 1.3 Measure Application Type

This measure is considered ROB (replace on burnout) as there is only a single baseline used for savings evaluation.

## 1.4 Product Base Case and Measure Case Data

Base case for this measure is a reciprocating compressor installed on the milk bulk tank refrigeration system.

## 1.4.1 DEER Base Case and Measure Case Information

Table 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 value was obtained using the DEER READI tool v 2.3.0. The relevant NTG value for the measure in this work paper is in the table below:

Table 2 Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| 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 | Any | 0.6 |

**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 value was obtained using the DEER READI tool v 2.3.0. The relevant IR value for the measure in this work paper is in the table below:

Table 3 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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:

Table 4 Effective and Remaining Useful Life

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| RefgWrhs-ScrollComp | Refrigeration Scroll Compressors for Bulk Tanks | Com | ProcRefrig | 12 | 4 |

## 1.4.2 Codes & Standards Requirements Base Case and Measure Information

There are no applicable state or federal codes that dictate or restrict the energy saving potential of this measure.

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

An EM&V study was completed for this measure as part of the California Multi Measure Farm Program by kW Engineering, and was summarized in a report dated March 15, 20072. This study focused on the installation of high efficiency options for five measures associated with milking at small, independent dairies. Evaluation results are based on calculations completed using data collected through end-use metering.

## 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

There are no further data or calculations provided for the support of the measures in this workpaper.

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

Value: 26,729 annual kWh / Scroll Compressor installed.

The equation used for this measure is as follows:

The factor of 1.75 kWh savings per day per 100 gallons of daily milk production is based on an EnSave analysis of EM&V data for the 2004-2005 California Multi Measure Farm comparing kWh/100 gallons of daily milk production for dairies with scroll compressors to those with reciprocating compressors. [provided as an Excel file, “EM&V Calc Scroll Compressor SC PGE3PAGR113” in the References section].

This annual 638.75 kWh savings per 100 gallons per day of milk production is then multiplied by the average daily milk production per Scroll Compressor unit, 41.846 hundred gallons per day, in the DEEP Measures Installed 06-08 SC Excel file listed in the References section.

This value is also seen in the Excel object referenced above.

Scroll compressors are assumed utilized every day of the year, owing to the nature of dairy operations.

## 2.2. Demand Reduction Estimation Methodologies

Value: 0.0 peak kW savings

There is no anticipated demand reduction associated with this measure.

A scroll compressor unit is more efficient in cooling the milk, however, typically the rated system capacity and the compressor horsepower for a scroll unit is comparable to the reciprocating compressor that it replaces. Thus the demand reduction kW is negligible as a result of this measure.

## 2.3. Gas Energy Savings Estimation Methodologies

There are no gas energy savings associated with this measure.Section 3. Load Shapes

## 3.1 Base Cases Load Shapes

Base case Load Shape is the same as measure load shape.

## 3.2 Measure Load Shapes

Measure is an agricultural measure so the agricultural load shape is assumed in the E3 calculator

# Section 4. Base Case & Measure Costs

## 4.1 Base Cases Costs

Base case costs are for similar sized reciprocating compressors.

Table 5 Base Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| R161 | ROB | Average cost for reciprocating compressors | $2,022 | $516 | n/a | $2,583 |

*All costs are noted as $ per measure unit*

Value: $2,583 per Reciprocating Compressor installed.

*Note*: Material costs from the February 2013 sample were found to average $2,022 per Reciprocating Compressor in the 5hp to 10hp range. Labor and installation costs shown here are taken from the Measure Case Costs as $561 and are considered to be a zero-sum when comparing the Base Case and Measure Case costs.

## 4.2 Measure Case Costs

The Measure Case Costs are based on Excel-based analysis of measure installations in 2006-2008 as per reference: “DEEP Measures Installed 06-08 SC WPenNRPR0005”

Table 6 Measure Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| R161 | ROB | Average cost for scroll compressors installed | $2,424 | $561 | n/a | $2,985 |

*All costs are noted as $ per measure unit*

Value: $2,985 per Scroll Compressor installed. The measure cost is derived from a short market survey in February of 2013.

*Note*: Material costs from sample were found to be $2,424 per Scroll Compressor installed. Labor and installation costs from sample were found to be $561.

Data used to determine average costs is found in referenced Excel file.

## 4.3 Incremental & Full Measure Costs

Incremental costs are used for this measure since the base case is a reciprocating compressor.

Incremental cost = $402; Measure Case Cost $2,985 - Base Case Cost $2,583

# References

1. kW Engineering, “Evaluation, Measurement and Verification Report California Multi-Measure Farm Program 1354-04 and 1360-04”, prepared for California Public Utilities Commission, March 15, 2007
2. [www.dairyfarmenergy.com](http://www.dairyfarmenergy.com), DLTech, Inc. company website
3. “EM&V Calc Scroll Compressor SC PGE3PAGR113” Excel-based analysis of measure installations in 2004-2005.
4. “Measure Cost Data SC PGE3PAGR113” – Measure cost information from DEEP 2006-2012, NYSERDA, MAESTRO, and NY Disaster Relief programs.
5. “DEEP Measures Installed 06-08 SC PGE3PAGR113” Excel-based analysis of measure installations in 2006-2008.
6. Comparison of compressor costs

# Attachments

1 – PGE3PAGR113 R2 EMV Calc Scroll Compressor SC.xlsx

2 - PGE3PAGR113 R2 Measure Cost Data SC.xlsx

3 - PGE3PAGR113 R2 DEEP Measures Installed 2008-2008.xlsx

4 - PGE3PAGR113 R2 Comparison of Compressor Costs.xlsx