Work Paper PGE3PHVC156

**Revision 2**

**Pacific Gas & Electric**

**Condenser Coil Cleaning**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | HV290, HV291, HV292, HV293 |
| **Measure Description** | Clean condenser coils on qualifying units. |
| **Base Case Description** | Uncleaned, functional condenser coil. |
| **Units** | Per ton cooling capacity, Cap-Tons. |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | $32.38/ton |
| **Incremental Measure Cost ($/unit)** | N/A |
| **Effective Useful Life** | 3 years (DEER EUL ID: HVAC-ClnCondCoils) |
| **Measure Installation Type** | Retrofit Add-on (REA) |
| **Net-to-Gross Ratio** | 0.73 (DEER NTGR ID: NonRes-sAll-mHVAC-RCA) |
| **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** |
| Revision 0 | 06/01/2012 | Tai Voong (PG&E) | Update WP Format |
| Revision 0 | 8/28/2012 | Tai Voong (PG&E) | At-A-Glance Measure List: Changed Building Vintage, Unit Definition from “Ton” to “Cap-Tons” and added Building Type “RES”. |
| Revision 1 | 7/11/2013 | Christopher Li (PG&E) | * Revised savings, NTG, and ISR to comply with ED’s Disposition on the HVAC Quality Maintenance/AirCare Plus Workpapers dated on the March 2, 2013 and May 16, 2013 disposition. * Only the PG&E executive summary savings template was updated. Workpaper language will be updated later. * For updated Savings values, see file PGE3PHVC156 R1\_CondenserCoilCleaning(chl7v2).xlsx |
| Revision 2 | 10-8-15 | Matt Tyler (CLEAResult), Sherry Hu (PG&E) | * Work paper was updated according to Workpaper Disposition for Nonresidential HVAC Rooftop Quality Maintenance3 and WO328 * Removed measure code S46 and added four. |

# 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 statewide work paper details cleaning condenser coils on existing nonresidential split-system and unitary HVAC equipment. This is one of eight that cover specific HVAC Quality Maintenance (QM) treatments formerly combined into the measures described in the Revision 0 version of the June 26, 2012 Work Paper PGECOHVC138 Nonresidential HVAC RTU Quality Maintenance[[1]](#endnote-1) and the Revision 3 version of the December 26, 2014 Work Paper SCE13HC037 Comprehensive Commercial HVAC Rooftop Unit Quality Maintenance[[2]](#endnote-2). All HVAC Quality Maintenance treatments are now covered by the following work papers:

* Airflow Adjustment (To be completed in 2016)
* Condenser Coil Cleaning (PGE3PHVC156R2)
* Economizer Controls (PGE3PHVC152R3)
* Economizer Repair (PGE3PHVC151R2)
* Evaporator Coil Cleaning (PGE3PHVC158R2)
* Refrigerant Charge Adjustment (PGE3PHVC160R2)
* Unoccupied Fan Control (PGE3PHVC157R2)
* *Programmable Thermostat (PGE3PHVC153R3)*

Separation of this HVAC QM treatment, Condenser Coil Cleaning, into a statewide measure in this work paper was performed using guidance from the document WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance[[3]](#endnote-3)(Disposition) and supplementary spreadsheet: 20132014-CommercialHVACMaintenance-SavingsValues-April2013-v1-2.xlsx[[4]](#endnote-4). Both are referenced in more detail later in this document.

Table Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Clean condenser coils on qualifying units. |
| Existing Condition | Uncleaned, functional condenser coil. |
| Code/Standard | N/A |
| Industry Standard Practice | Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems[[5]](#endnote-5) |

Table Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  |  | HV290 | Condenser Coil Cleaning on AC Unit with Gas Heat |
|  |  |  | HV291 | Condenser Coil Cleaning on AC Only Unit |
|  |  |  | HV292 | Condenser Coil Cleaning on Heat Pump |
|  |  |  | HV293 | Condenser Coil Cleaning on Variable Volume AC Unit with Gas Heat |

This statewide work paper supports HVAC QM programs as well as HVAC tune-up programs in multiple programs and service territories. Refer to programs that offer the measure for specific restrictions and guidelines in addition to those described herein.

The target market for this measure is non-residential buildings served by unitary direct expansion (DX) and split systems which do not serve process or refrigeration loads. The measure is defined for all non-residential building types and all 16 California climate zones. Savings are calculated for a weighted average of seven Database for Energy Efficient Resources (DEER15[[6]](#endnote-6)) vintages using utility-specific weightings.

Participating contractors must ensure the customer facility is physically located within the service territory of the Investor Owned Utility (IOU) administering the program, and that the customer receives electric services from that IOU. Other terms and conditions are set by individual programs.

This measure requires field documentation of the existing conditions that verify the measure was necessary and that the measure was successfully applied.

## 1.2 Technical Description

Dirty or fouled condenser coils restrict air flow, reduce heat transfer efficiency and compressor efficiency, and can increase compressor run time. Coil cleaning eliminates air blockages between fins and can remove leaves, dust, grime, and other contaminants from the fin and tube heat transfer surfaces thus improving heat transfer efficiency, decreasing compressor run time, and increasing efficiency.

## 1.3 Installation Types and Delivery Mechanisms

An installation type describes the program scenario in which the measure is applied, thus guiding energy savings and measure cost methodology. The installation type for this measure is Retrofit Add-on (REA) since the baseline is the existing unit as described in **Table 3**.

Table Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |
| Retrofit First Baseline Only (REF) | Above Customer Existing | N/A | EUL | N/A |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

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. See **Table 4** and **Table 5** below for descriptions of available delivery methods and incentive methods, respectively.

**SCE Delivery Mechanism:** Financial Supportpaired withDirect Install, Down-Stream Incentive – Deemed, or Mid-Stream Incentive

**PG&E Delivery Mechanism:** Financial Support paired with Direct Install or Mid-Stream Incentive

Table Delivery Method Descriptions

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Appliance Turn-in and Recycling | The program motivates customers, through financial incentives, to recycle appliances that are functional but inefficient. This prevents the continued use of those appliances, by both the current owner and potential future owners. |
| Audit/Information/Testing Services | The program performs a free assessment of a customer’s facility and provides the customer with information and guidance on energy efficiency opportunities. |
| Commissioning and Retrocommissioning | The program modifies or repairs existing equipment to ensure that it works as intended. |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Innovative Design | The program funds new ideas that meet reasonable scientific scrutiny for potential energy savings. These innovative measures typically have small market penetration (less than 5%) or are targeted toward relatively unreached market segments. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |
| Performance Based | The program offers financial incentives that vary based on the energy efficiency performance of specific projects. |
| Up-Stream Programs | See Up-Stream Incentive and Up-Stream Buy Down in the Incentive Method table. |

Table Incentive Method Descriptions

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| 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. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, with specific requirements to pass down the incentive to the end use customer. Such an incentive buys-down the cost of an efficient measure for the end-use customer by at least the amount of the financial incentive. |
| Giveaway | The program provides customers with energy efficiency equipment or services for free. |
| Exchange/Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| On-bill Finance/Loan | The program offers financing for the cost an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The Database for Energy Efficient Resources (DEER) was referenced on November 19, 2015 for any 2016 updates that would impact this measure. No relevant updates were noted and a full Code Update for 2016 has not yet been presented on deeresources.com. This measure is not included in the Database for Energy Efficient Resources (DEER15).

Table DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Work Paper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes, with modifications; see §2 |
| DEER Version | DEER 2015, READI v2.2.0 |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTGR values were obtained using the DEER READI tool[[7]](#endnote-7). The relevant NTGR values for the measures in this work paper are shown in **Table 7**.

Table Measure Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| NonRes-sAll-mHVAC-RCA | HVAC Maintenance: Refrigerant Charge Adjustment (RCA) | Com | Any | NonUpStrm | 0.73 |

**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 relevant IR values for the measures in this work paper are in **Table 8** below.

Table Installation Rates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 REA measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are shown in **Table 9** below.

Table EUL and RUL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-ClnCondCoils | Clean Condenser Coils - Commercial | Com | Service | 3 | 1 |

### 1.4.2 Codes and Standards Analysis

These maintenance measures are not governed by either state or federal codes and standards. The document Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems5 may be used by QM programs as a guide for measure implementation. Only licensed California contractors will participate in the program. As required by the California State Licensing Board, contractors will be responsible for meeting all applicable codes. In general, maintenance and repairs do not require permits.

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

Two studies of significant importance to the measure development in this work paper are described in the following section.

### 1.5.1 WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance3

Completion date: 5-2-2013

Author: California Public Utilities Commission, Energy Division

This Disposition outlines revision requirements to the existing work papers that cover discrete roof-top unit (RTU) QM service tasks and suites of service tasks for non-residential QM programs. Of direct concern in this work paper, the Disposition collectively assigns 25% of the DEER Refrigerant Charge Adjustment (RCA) energy and demand unit energy savings (UES) to the three non-RCA treatments which include Condenser Coil Cleaning, Evaporator Coil Cleaning, and Air Flow Adjustment. The Disposition further splits the initial 25% DEER RCA UES, assigning 50% to Condenser Coil Cleaning, 25% to Evaporator Coil Cleaning, and 25% to Airflow Adjustment. The three resulting UES multipliers to be applied to DEER RCA UES are given below.

* Condenser Coil Cleaning UES Values multiplier = 0.125
* Evaporator Coil Cleaning UES Values multiplier = 0.0625
* Air Flow Adjustment UES Values multiplier = 0.0625

### 1.5.2 HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report[[8]](#endnote-8)

Completion date: 1-28-2014

Author: DNV GL

This document (WO32) is a study of statewide, third-party, and local programs targeting unitary HVAC systems during the 2010-2012 program cycle, including Commercial Quality Maintenance (CQM). WO32 study evaluated gross energy savings and installation rates through activities including on-site field evaluations, sampling and monitoring the performance and energy use of units enrolled in the programs before and after CQM maintenance, and additional laboratory testing of existing HVAC units. The study highlights findings for key quality maintenance treatments (and parameters) including, but not limited to, recognition of typical damper leakage characteristics, non-functional economizer conditions and performance, and adjusting refrigerant charge.

The economizer damper leakage observed during laboratory testing suggests that existing economizers are generally allowing 15% outdoor airflow with closed dampers, 20% outdoor airflow with the commonly applied “finger open” methodology for minimum ventilation, and 62% outdoor airflow with dampers completely open. The damper leakage findings can greatly vary energy savings results and have been incorporated into building energy modeling methodology referenced in §2.

## 1.6 Data Quality and Future Data Needs

Additional study of the impacts of condenser coil cleaning may be warranted. The improvements that condenser coil cleaning can bestow on HVAC system efficiency are highly dependent on the existing condition of the coil. Claims range to as high as 25% energy savings and are realistic for highly fouled or clogged coils. The Disposition UES multiplier of 0.125 results in very conservative savings. For example, estimated demand savings range from 0.14% to 1.4% savings based on nominal system capacity. These values very likely underestimate savings for an HVAC system with moderately to extremely fouled condenser coils.

# Section 2. Calculation Methodology

Energy savings and demand reduction estimations for Condenser Coil Cleaning are determined herein according to the prescriptive method presented in the Disposition. The Disposition states that UES values for Condenser Coil Cleaning shall be derived from DEER RCA UES values by applying the multipliers described in the previous section. However, current DEER RCA UES values were determined without understanding of packaged unit damper leakage findings described in WO328. Because of these factors, new modeling was performed using DEER RCA savings methods to calculate updated RCA UES values. That work is presented in the draft Revision20 Work Paper PGE3PHVC160 Refrigerant Charge Adjustment (RCA)[[9]](#endnote-9) and its results are the source of RCA UES values used in this Work Paper to determine Condenser Coil Cleaning UES values.

Multiple-stage RCA UES values are presented in the RCA Work Paper, however the Condenser Coil Cleaning measure will only use UES values for single-stage RTUs.

Because the starting point for calculating Condenser Coil Cleaning UES values is vintage-weighted RCA UES values, there is no discussion in this work paper of base case and measure case calculations.

## 2.1 Electric Energy Savings Estimation Methodologies

Electric energy savings are calculated by applying the Disposition mandated multiplier of 0.125 for Condenser Coil Cleaning to single-stage vintage weighted electric energy UES value from the RCA Work Paper.

A sample calculation using a PG&E territory vintage-weighted small office (OfS) prototype with AC and Gas Heat located in climate zone 16 is provided below.

Because both the RCA and Condenser Coil Cleaning are Retrofit Add-on measures only a single baseline calculation is required. See the RCA Work Paper for electric energy estimation methodologies used to calculate RCA UES values.

## 2.2 Demand Reduction Estimation Methodologies

Demand reduction savings are calculated by applying the Disposition mandated multiplier for Condenser Coil Cleaning of 0.125 to single-stage vintage weighted electric energy UES value from the RCA Work Paper.

A sample calculation using a PG&E territory vintage-weighted small office (OfS) prototype with AC and Gas Heat located in climate zone 15 is provided below.

0.016

Because both the RCA and Condenser Coil Cleaning are Retrofit Add-on measures, the incremental cost is equal to the gross measure cost and only a single baseline calculation is required. See the RCA Work Paper for electric energy estimation methodologies used to calculate RCA UES values.

## 2.3 Gas Energy Savings Estimation Methodologies

There are no natural gas energy savings associated with this measure.

## 2.4 Vintage Weighted Average

Vintage weighting procedures are not used directly in this Work Paper. Instead, utility-specific, vintage-weighted RCA UES values are used to directly calculate corresponding utility-specific, vintage-weighted Condenser Coil Cleaning UES values.

# Section 3. Load Shapes

Load shapes are used for portfolio lifecycle cost analysis. A load shape indicates the distribution of a measure’s energy savings over one year. A load shape is a set of fractions summing to unity, with one fraction per hour (or other time period). Multiplying a savings value by the load shape value for any particular hour yields the energy savings for that particular hour.

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 **Table 10** below.

Table Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Assembly | DEER:HVAC\_Split-Package\_AC, DEER:HVAC\_Split-Package\_HP | NON\_RES |
| Education - Primary School |
| Education - Secondary School |
| Education - Relocatable Classroom |
| Education - Community College |
| Education - University |
| Grocery |
| Health/Medical - Nursing Home |
| Health/Medical - Hospital |
| Lodging – Hotel |
| Lodging - Motel |
| Manufacturing – Bio/Tech |
| Manufacturing – Light Industrial |
|  |
| Office - Large |
| Office - Small |
| Restaurant - Fast-Food |
| Restaurant - Sit-Down |
| Retail - Multistory Large |
| Retail - Single-Story Large |
| Retail - Small |
| Storage - Conditioned |
| Warehouse - Refrigerated |

# Section 4. Costs

Costs for this measure are covered in the *2010-2012 WO017 Ex Ante Measure Cost Study Final Report* [[10]](#endnote-10) (Measure Cost Update) and are used in this Work Paper. The DEER Measure Cost Data Users Guide [[11]](#endnote-11) was also referenced. . Because both the RCA and Condenser Coil Cleaning are Retrofit Add-on measures, the incremental cost is equal to the gross measure cost.

## 4.1 Base Case Cost

The base case is the customer’s existing equipment without Condenser Coil Cleaning; therefore the base case cost is $0.00.

## 4.2 Measure Case Cost

The 2010-2012 WO17 Ex Ante Measure Cost Study provides costs per-ton for cleaning condenser coils. The costs per-ton cooling for cleaning condenser coils are $6.73 for material and $25.65 for labor.

## 4.3 Full and Incremental Measure Cost

Table Full and Incremental Measure Cost Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

Table Full and Incremental Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| REA | $6.73 +$25.65 = $32.38 | $6.73 +$25.65 = $32.38 | N/A |

# Attachments

# References

1. Judith Jennings, et al, Pacific Gas and Electric Company (2012,06,26). Work Paper PGECOHVC138 Nonresidential HVAC RTU Quality Maintenance,. [↑](#endnote-ref-1)
2. Andres Fergadiotti, Southern California Edison (2014,12,26). Work Paper SCE13HC037 Comprehensive Commercial HVAC Rooftop Unit Quality Maintenance [↑](#endnote-ref-2)
3. California Public Utilities Commission, Energy Division, WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance, 5-2-2013. [↑](#endnote-ref-3)
4. California Public Utilities Commission, Energy Division, Spreadsheet: *20132014-CommercialHVACMaintenance-SavingsValues-April2013-v1-2.xlsx,*submitted as addendum to WORKPAPER DISPOSITION FOR Non-Residential HVAC Rooftop Quality Maintenance. [↑](#endnote-ref-4)
5. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and Air Conditioning Contractors of America. (© ASHRAE and ACCA, 2008). *Standard 180-2008, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems*. [↑](#endnote-ref-5)
6. Database for Energy Efficient Resources, http://www.deeresources.com/index.php/deer-versions/deer2015-code-update [↑](#endnote-ref-6)
7. James J. Hirsch & Associates. READi tool, V2.0.2. Developed for California Energy Commission. [↑](#endnote-ref-7)
8. DNV GL, HVAC Impact Evaluation FINAL Report WO32 HVAC – Volume 1: Report, Prepared for California Public Utilities Commission, Energy Division, 1-28-2014 [↑](#endnote-ref-8)
9. Draft PGE3PHVC156 Revision 2 Refrigerant Charge Adjustment (RCA) Work Paper. Date?? [↑](#endnote-ref-9)
10. Itron. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. San Francisco, CA (2014, May 27). Retrieved 8/26/2015 at http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf. [↑](#endnote-ref-10)
11. DEER Measure Cost Data Users Guide found on www.deeresources.com under DEER2011 Database Format hyperlink, DEER2011 for 13-14, spreadsheet ‘SPTdata\_format-V0.97.xls’. [↑](#endnote-ref-11)