**Work Paper PGECOAGR111**

**Sprinkler to Drip Irrigation**

**Revision 6**

**Pacific Gas & Electric Company**

**Customer Energy Efficiency Department**

**Sprinkler to Drip Irrigation**

**Measure Codes A266**

# At-A-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **A266 Sprinkler to Drip Irrigation, Field Vegetable** |
| **Measure Description:** | This measure replaces high pressure sprinkler irrigation with micro (or drip) irrigation system. |
| **Energy Impact Common Units:** | Per Acre |
| **Base Case Description:** | Source: DEER 2005 - D03-972, D03-973  High-pressure, impact- type sprinkler irrigation (50 psi or higher operating pressure). |
| **Base Case Energy Consumption:** | Varies. |
| **Measure Energy Consumption:** | Varies. |
| **Energy Savings (Base Case – Measure)** | Varies.  Source: DEER 2005 - D03-972, D03-973  The energy savings depends on climate zone. |
| **Costs Common Units:** | Per Acre |
| **Base Case Equipment Cost ($/unit):** | $87/acre  Source: Sample Costs to Produce and Harvest Romaine Hearts. UC Cooperative Extension – Agricultural Issues Center. 2015 |
| **Measure Equipment Cost ($/unit):** | $285/acre  Source: Sample Costs to Produce and Harvest Romaine Hearts. UC Cooperative Extension – Agricultural Issues Center. 2015 |
| **Incremental Measure Cost ($/unit):** | $280/acre  Source: Sample Costs to Produce and Harvest Romaine Hearts. UC Cooperative Extension – Agricultural Issues Center. 2015 |
| **Effective Useful Life (years):** | Source: DEER 2016  20 years, Agr-DripIrr |
| **Program Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratios:** | NTGR=0.6, Agric-Default>2yrs  Source: DEER 2016 |

# Document Revision History

**Revision # Date Description Author (Company)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision 0** | **03/12/08** | **Original workpaper:**  **Sprinkler to Drip Irrigation PGECO AGR111 R0.doc** | **Julia Thompson and Karen Maoz (Kema Services, Inc.)** |
| **Revision 1** | **08/03/09** | **Sprinkler to Drip Irrigation PGECO AGR111 R1.doc** | **Alina Zohrabian (PG&E)** |
| **Revision 2** | **03/04/10** | **Sprinkler to Drip Irrigation PGECO AGR111 R2.doc** | **Alina Zohrabian (PG&E)** |
| **Revision 3** | **6/15/12** | **Revision 3 Workpaper: Sprinkler to Drip Irrigation PGECOAGR111 R3.doc**  **Updated NTG Value**  **Removed RET language and replaced with ROB**  **Updated Section 1.2 DEER Differences Analysis** | **Andrew Wieszczyk (PG&E)** |
|  | **8/28/12** | **Nomenclature Update** | **Justin Westmoreland (PG&E)** |
|  | **6/18/14** | **Updated to new compliance template** | **Steve Fok (PG&E)** |
| **Revision 4** | **01/01/15** | **Removed measure code A268 and A269.**  **Updated Full Measure Cost** | **Steve Fok (PG&E)** |
|  | **10/16/15** | **Ex Ante format applied to all measures. Expiry Date for A268 and A269 of 12/31/2014.**  **Updated Full Measure Cost with the results from the 2015 State Water Efficiency and**  **Enhancement Program Report.** | **Jim Wyatt (PG&E)** |
| **Revision 5** | **4/15/2016** | **Updated ex ante format** | **Linda Wan (PG&E)** |
| **Revision 6** | **5/20/2016** | **Updated costs for base case, measure case, and incremental measure.** | **Linda Wan (PG&E)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the rationale for the “sprinkler to drip irrigation” measure as listed in the PG&E Small Business Agricultural Rebate Catalog, part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program. PG&E offers incentives to non-residential customers for installing qualifying lighting, refrigeration, air-conditioning, food service, and agricultural equipment.

***Catalog Description***

SPRINKLER TO DRIP IRRIGATION

**Requirements**:

* Customer must have electricity distributed by PG&E to the installation address.
* Must convert from a high-pressure, impact-type, sprinkler irrigation system (50 psi operating pressure or more at the sprinkler head) to a micro-irrigation system.

**Exclusions**:

* Not applicable to new plantings of vineyards or orchards unless a vineyard or orchard was the previous crop on the field.
* No drip tape systems less than 10 ml thick or less than 5 years warranty.

**Application Process**:

* Must include an Assessor’s Parcel Map or other documentation to verify acreage

|  |  |
| --- | --- |
| **Product Code** | **Description** |
| A266 | Sprinkler to Drip Irrigation, Field Vegetable |

***Program Restrictions and Guidelines***

***Terms and Conditions***

1. Customer must have electricity distributed by PG&E to the installation address
2. Must convert from a high-pressure, impact-type, sprinkler irrigation system (50 psi operating pressure or more at the sprinkler head) to a micro-irrigation system
3. Not applicable to new plantings of vineyards or orchards unless a vineyard or orchard was the previous crop on the field
4. No drip tape systems less than 10 ml thick or less than 5 years warranty.

The reason for the 3-rd restriction is to have a baseline for our energy calculation. If the previous crop is different from the one being planted there would not be a one to one comparison of energy needs. Other plantings might have different watering needs and it will be impossible to calculate the decrease in energy use if the previous crop is different from the one being planted.

The reason that this measure is not applicable for conversion from flood irrigation is that in average the energy use will increase and a full engineering analysis is required on case by case bases to prove the energy reduction. (Based on a report from Peter Canessa)[[1]](#endnote-1)

***Market Applicability***

This measure is applicable to sprinkler irrigated farmland in the PG&E service territory relying on electric water pumping to water crops.

The base case assumes a high-pressure, impact-type, sprinkler irrigation system that has at least 50 psi operating pressure or more at the sprinkler head.

## 1.2 Technical Description

This measure encourages non-residential customers to replace their high pressure, impact type, sprinkler irrigation system (50 psi operating pressure or more at the sprinkler head) to a micro-irrigation system.

Micro-irrigation systems consist of systems of above and below ground pipelines and / or hoses, delivering water under pressure, to specialized devices which deliver it directly to plants. The intent is to accurately supply small amounts of water on a frequent basis so as to maintain constant, comparatively high, root-zone soil moisture. In addition, micro-irrigation provides opportunities for very precise control of fertilizer applications. Other advantages may include reduced weed growth and diseases and increased flexibility in timing cultivation operations. Energy may be saved by converting from a sprinkler irrigation system to a micro-irrigation system by reducing operating pressure and higher potential irrigation efficiencies. Converting to a micro-irrigation system will tend to reduce the amount of required water and associated pumping.

Drip Tape: Drip tape (also commonly called “row-crop drip”) - very thin wall polyethylene tubing with a variety of emitter designs integrated with the tubing during manufacture. Drip tape comes in a variety of diameters, flow rates, emitter spacing, and wall thicknesses. Drip tape may be laid aboveground but is more commonly buried. Polyethylene hose may only be guaranteed for 7-10 years. Some growers report using buried drip tape up to 10 years but the norm is more like 2 to 4 years, and then only if it is 8 mil thickness or thicker. (Based on a report from Peter Canessa.)3 As a result, PG&E is allowing the use of drip tape systems with drip tape that is at least 10 ml thick or have a warranty of at least five years.

Definition of the five major crop types used: (Based on a report from Peter Canessa)3

1. Field crops - any crop for which a single, annual crop is grown each year.
2. Vegetable crops - short season fresh-vegetable crops where it is common to double-crop
3. Deciduous orchards - nuts (almond, walnut, pistachio), avocado, figs, and stone fruit
4. Citrus
5. Grape (wine, table, or raisin)

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

This measure is classified under Measure Application Type of “Replace on Burnout” (ROB).

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| REA  NC | Retrofit Add-On  New Construction | *measure applied during construction design phase as an*  *single baseline (above pre-existing), full measure costs required*  *alternative to a code-compliant standard design* |

## 1.4 Measure Parameters

### 1.4.1 DEER Differences Analysis

This workpaper matches with the DEER 2005 for climate zones 1-5 and 11-13 (Measure ID D03-972, 974, 975, 978, and 979) sprinkler to micro irrigation measure.[[2]](#endnote-2) For climate zone 16, we choose the more conservative number for savings from climate zones 1-5. However, DEER has savings data for well and non-well applications. Electric savings for this measure are taken as a weighted average of well and non-well energy savings from the DEER database.

This measure was not included in the DEER 2011 update; however, DEER 2005 still represents the best data currently available. As a result, DEER 2005 values will continue to be used until better data is available.

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG value for the measure in this work paper is in the table below.

Table 1 Net to Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Agric-Default>2 | All other EEM with no evaluated NTGR; existing EEM 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. The relevant IR value for the measure in this work paper is in the table below.

Table 2 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 3 Effective and Remaining Useful Life

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Agr-DripIrr | Sprinkler to Drip/Micro Irrigation | Com | Ag | 20 | 6.7 |

Micro-irrigation systems are a combination of many sub-systems, including a pumping plant, filters, mainline and manifold piping, and the system of distribution tubing and emission devices. It is assumed that the system life is that of the pumping system and main pipelines to be 20 years1.

### 1.4.2 Codes & Standards Requirements Analysis

California State Water Code requires landowners to obtain a permit or conditional waiver for runoff. One way to minimize runoff is a drip irrigation system.[[3]](#endnote-3) However, there is no code requirement for micro (drip) irrigation.

## 1.5 EM&V, Market Potential, and Other Studies

Only one reference was made to evaluation of the sprinkler to drip irrigation measure. It was a retention study completed in 2003 that confirmed the 20 year EUL.[[4]](#endnote-4)

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

Electric savings in this measure are taken as the average of well and non-well energy savings from the DEER database as shown in the equation below. The pumping energy use per acre foot of water is related to the delivery of water to the field irrigation system and the boost energy required to operate the system itself. The delivery pumping energy use is only associated with well systems. Therefore, there is a difference in energy use between well and non-well water sources. The number of well (groundwater) systems have grown in the state due to other water demands, need for reliable and flexible water supplies, and higher costs and environmental concerns with surface water conveyance and storage[[5]](#endnote-5). The exact distribution of well to non-well systems is not known. According to a report for the California Energy Commission, the total irrigation groundwater energy requirement in an average year is 4,745 GWh and 821.8 GWh for surface water. Therefore, the distribution of the amount of agricultural pumping energy between surface (non-well) and groundwater (well) is 15% and 85%, respectively.[[6]](#endnote-6)



Example of saving for climate zone 1-5, measure A266:



These savings are presented in kWh/Acre of land. The savings are the difference in annual energy consumed between the high pressure, impact type sprinkler irrigation system to more efficient micro irrigation system.

DEER has provided savings numbers for four crop types: citrus trees, deciduous trees, field and vegetable crops, and vineyards. The citrus tree irrigation measure currently is not a catalog measure, but program manager is advised to ask sales and service reps to see if there is customer interest to add this measure for 2009-2011 program years. DEER does not provide saving number for climate zone 16; therefore, the saving number for climate zone 16 is the more conservative number from climate zones 1-5. Table-2 provides the energy savings information from DEER for non-well and well applications.4

Table 4 Annual kWh/Acre-year savings for converting from sprinkler to micro irrigation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Region** | **Climate Zones** | **Field/Vegs (kWh/Acre-yr)** | | **Field/Vegs (kWh/Acre-yr)** |
|  |  | Non Well | Well | Blended Savings |
| Central Valley | 11,12,13 | 422 | 484 | 475 |
| Coastal | 1,2,3,4,5 | 277 | 324 | 317 |

## 2.2. Demand Reduction Estimation Methodologies

Demand reduction estimations for this measure are taken directly from the DEER database where they are presented in Watts/Acre of land. These values are independent of well and non-well systems since the energy savings is due to the reduction in applied water. The savings are the difference in power demand between the high pressure, impact type, and sprinkler irrigation system to more efficient micro irrigation system.

DEER has provided KW/Acre savings for all climate zones except Z16 and four crop types, citrus trees, deciduous trees, field and vegetable crops and orchards and vineyards. Table-3 provides demand savings from DEER4. For saving numbers of climate zone 16, we used a more conservative number from climate zones 1-5.

Table 5 kW/Acre savings for converting from sprinkler to micro-irrigation

|  |  |  |
| --- | --- | --- |
| **Region** | **Climate Zones** | **Field/Vegs (kW/Acre)** |
| Central Valley | 11,12,13 | 0.377 |
| Coastal | 1,2,3,4,5 | 0.286 |

## 2.3. Gas Energy Savings Estimation Methodologies

There are no gas savings associated with this measure.

# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical *agricultural pumping* end use load shape.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The measure load shape for this measure is determined by the E3 calculator based on the applicable *agricultural* market sector and the *pumping* end-use.

# Section 4. Base Case & Measure Costs

The University of California Cooperative Extension Agriculture and Natural Resources – Agricultural Center released, *Sample Costs to Produce and Harvest Romaine Hearts in the Central Coast Region (Monterey, Santa Cruz, and San Benito Counties)* in 2015[[7]](#endnote-7). It is believed that this cost study is similar to most typical sprinkler and drip irrigation systems. The base case costs and measure costs in this work paper are sourced directly from this cost study.

## 4.1 Base Cases Costs

The base case equipment cost is $87 per acre, which includes the sprinkler setup/irrigate 4x and the sprinkler system. The base case labor cost is $81 per acre. The total base case cost is $168 per acre.

Table 6 Base Case Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Description** | **Labor ($ Per Acre)** | **Equipment ($ Per Acre)** | **Total ($ Per Acre)** |
| **Sprinkler** | Setup/Irrigate | 81 | 72 | 153 |
| System | 0 | 15 | 15 |
|  |  |  | **Total** | 168 |

## 4.2 Measure Costs

The measure case equipment cost is $285 per acre, which includes the laser level, the drip setup/irrigate and the drip system. The measure case labor cost is $163 per acre. The total base case cost is $448 per acre.

Table 7 Measure Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Description** | **Labor ($ Per Acre)** | **Equipment ($ Per Acre)** | **Total ($ Per Acre)** |
| **Drip** | Laser Level (1x per 2 Crops) | 0 | 20 | 20 |
| Setup/Irrigate | 163 | 236 | 399 |
| System | 0 | 29 | 29 |
|  |  |  | **Total** | 448 |

## 4.3 Incremental & Full Measure Costs

The incremental measure cost for ROB is $280 per acre and the difference between measure costs and the base case costs.

Table 8 Incremental Measure Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Description** | **Labor ($ Per Acre)** | **Equipment ($ Per Acre)** | **Total ($ Per Acre)** |
| **Base Case** | Sprinkler Irrigation | 81 | 87 | 168 |
| **Measure Case** | Drip Irrigation | 163 | 285 | 448 |
|  |  |  | **IMC** | 280 |

The full measure cost is $448 per acre and the same cost as the measure cost.

Table 9 Full Measure Costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Description** | **Labor ($ Per Acre)** | **Equipment ($ Per Acre)** | **Total ($ Per Acre)** |
| **Base Case** | Sprinkler Irrigation | 0 | 0 | 0 |
| **Measure Case** | Drip Irrigation | 163 | 285 | 448 |
|  |  |  | **FMC** | 448 |

Table 10 Full and Incremental 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

# References

1. - Peter Canessa report on “SPRK2MICRO”, page 20, page 1, page 8 [↑](#endnote-ref-1)
2. - “2004-2005 Database for Energy Efficiency Resources (DEER) Update Study”, prepared for Southern California Edison, prepared by Itron, Inc., December 2005 (Measure ID D03-972, 973, 974, 975, 978, and 979). [↑](#endnote-ref-2)
3. - Central Valley Regional Water Quality Control Board, Fact Sheet of Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Land, July 2006. <http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/general_prog_info/irrlands_disch_fact_sht.pdf> [↑](#endnote-ref-3)
4. - “6th Year Retention Study of Pacific Gas & Electric Company’s 1996 and 1997 Energy Efficiency Incentives Program, Agricultural Sector Measures,” March 2003. [↑](#endnote-ref-4)
5. - <http://cetehama.ucdavis.edu/Agriculture/Groundwater_Management.htm> [↑](#endnote-ref-5)
6. - “California Agricultural Water Electrical Energy Requirements,” prepared for Public Interest Energy Research Program, December 2003. [↑](#endnote-ref-6)
7. The University of California Cooperative Extension Agriculture and Natural Resources – Agricultural Center. *Sample Costs to Produce and Harvest Romaine Hearts in the Central Coast Region (Monterey, Santa Cruz, and San Benito Counties)*. 2015. Page 10-11. [↑](#endnote-ref-7)