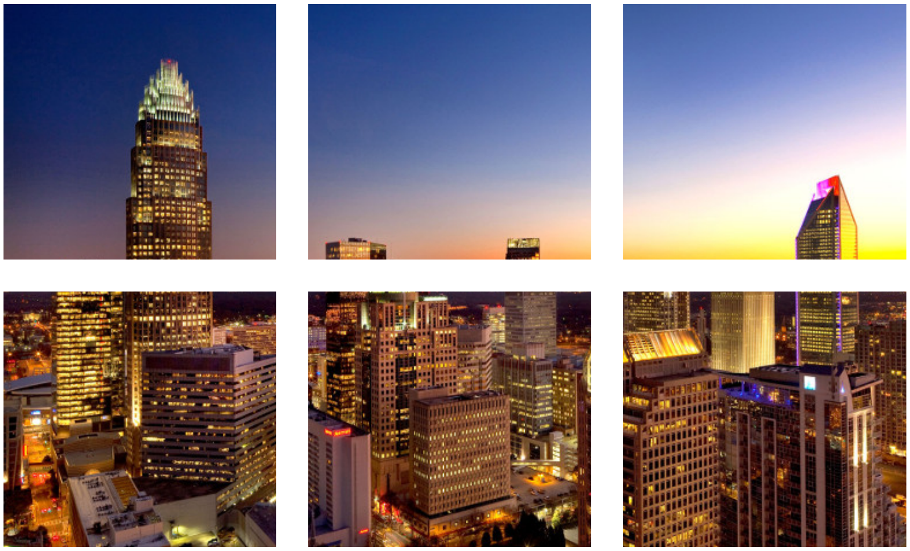

# 2015 NONRESIDENTIAL DOWNSTREAM ESPI DEEMED SPRINKLER IMPACT EVALUATION

## Final Report

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California Public Utilities Commission

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# 1 EXECUTIVE SUMMARY

## 1.1 NEED FOR STUDY

This report documents the activities undertaken by the Nonresidential Downstream Impact Evaluation of the 2015 investor owned utilities' (IOUs') energy efficiency programs for low pressure nozzles and micro conversion sprinklers. The overall goal of this study is to perform an impact evaluation on specific deemed sprinkler measures that were identified in the Efficiency Savings and Performance Incentive decision.[1]

In 2013, the California Public Utilities Commission (CPUC) developed the Efficiency Savings and Performance Incentive mechanism, which lays out various ways the IOUs can receive monetary incentives for the performance of their energy efficiency programs. One component of this mechanism is based on how much energy savings are derived over the life of the energy efficient equipment (lifecycle savings), or measures, that were installed through these programs.

The Efficiency Savings and Performance Incentive process identifies a list of energy efficiency measures that contribute the greatest levels of uncertainty among the portfolio of energy efficient measures offered by a given IOU. The CPUC and their consultants conduct research on these uncertain measures to estimate their lifecycle savings. A component of the Efficiency Savings and Performance Incentive mechanism then pays incentives to the IOUs based on these evaluated energy savings values.

## 1.2 ENERGY EFFICIENCY MEASURES STUDIED

This study evaluates three of the energy efficiency measures with high levels of uncertainty that were offered by the 2015 IOU energy efficiency programs: Agricultural Low Pressure Sprinkler Nozzles, Drip Irrigation and Micro Conversion Sprinklers. These energy efficient sprinkler measures were only offered through Pacific Gas and Electric's (PG&E) energy efficiency programs. Prior to these evaluations, the IOU's submitted a claim for the amount of energy they believe the uncertain measures will save. The sprinkler measures represent roughly 2.3% of the total kW demand and 0.7% of the total kWh energy savings claimed by all of PG&E's program measures, over the life of the measures.

[1] D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism.
http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF
http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Shareholder+Incentive+Mechanism.htm

## 1.3 APPROACH

The study's objective was to evaluate PG&E's energy savings claim for the sprinkler measures and to conduct research that develops revised estimates of savings. This study looks at the energy demand (kW) and consumption (kWh) savings provided over the lifetime of the measures. In order to develop a revised savings estimate, telephone surveys and on-site visits were conducted with a sample of customers that installed one of the sprinkler measures. The data collected as part of these activities include information on how the sprinklers are used, and how the sprinklers affect the energy consumption of related equipment. These data are used to support the estimate of first-year and lifecycle energy consumption (kW) and demand (kW) savings associated with the installed sprinklers.

The evaluation then compares the initial savings claim made by PG&E to this evaluation's results developed using the data collected on site. The initial savings claim is often times referred to as ex ante savings, because this is the savings value before (ex ante) the project is undertaken. The evaluation savings value is then referred to as the ex post savings, because this is the savings value developed after (ex post) the evaluation.

The ratio of the ex post (evaluation estimated) to ex ante (deemed program claim) savings is referred to as the "realization rate," or the rate at which ex ante savings are realized through the evaluation.

The evaluation also examines how successful the IOU programs were in influencing customers to install energy efficient measures that would not have been installed if the programs had not existed. Customers that would have installed the same energy efficient equipment in the absence of the program are considered free riders. They are referred to as free riders because they are receiving incentives from the programs for actions they would have undertaken without the program's existence. Gross program savings is the total amount of savings, including the savings associated with free riders. Net program savings is the total amount of savings that is "net" of free ridership, or excluding savings associated with free riders. Therefore, the evaluation examines both the "gross" amount of savings derived among all participants, and the savings that is generated "net" of free riders.

This evaluation also developed estimates of the ratio between the net and gross levels of savings (the net-to-gross ratio or NTGR). To estimate the NTGR, the telephone survey includes several questions regarding the program's influence on the customer's decision to install the energy efficient equipment. The survey examines various factors related to the program and other non-program factors, as well as asking the customer what they would likely have done in the absence of the program.

These survey question responses determine how likely the program has influenced the customer's decision to install the equipment, and conversely, how likely the participant was a free rider. The NTGR is estimated as the ratio of the savings that is net of free ridership to the total gross savings.

The ultimate goal of this evaluation is to estimate ex post net lifecycle energy and demand savings. This value is the savings estimated by the evaluation (ex post), which is generated by the program over the life of the measures (lifecycle) that are installed, minus (net) the free riders.

## 1.4 RESULTS

The results of the evaluation are provided in the tables below. Shown are the ex post and ex ante net lifecycle savings values (kWh and kW), the realization rates (ratio of ex post to ex ante), and the corresponding NTGR. The savings are a function of crop type, crop age and pre-project irrigation method. Each of these variables can affect irrigation requirements and subsequent savings from micro-nozzle and drip irrigation installations. Because of the variability that can occur among the participant population from year to year with respect to these parameters, these realization rates are representative of the conditions observed in this evaluation, and are indicative of program performance of substantially similar program designs and operating conditions. Recommendations are provided in this study that would help improve the accuracy reliability of future ex ante estimates.

**TABLE 1-1: EX ANTE AND EX POST NET LIFECYCLE KWH SAVINGS, REALIZATION RATES AND NET-TO-GROSS RATIOS**

| Energy Efficiency Measure | Net Lifecycle kWh Savings | | Net Realization Rate (Ex Post/Ex Ante) | Net-to-Gross Ratio |
|---|---|---|---|---|
| | Ex Ante (Claimed) | Ex Post (Evaluated) | | |
| Sprinklers | 29,129,972 | 3,000,735 | 10% | 0.47 |

**TABLE 1-2: EX ANTE AND EX POST NET LIFECYCLE KW SAVINGS, REALIZATION RATES AND NET-TO-GROSS RATIOS**

| Energy Efficiency Measure | Net Lifecycle kW Savings | | Net Realization Rate (Ex Post/Ex Ante) | Net-to-Gross Ratio |
|---|---|---|---|---|
| | Ex Ante (Claimed) | Ex Post (Evaluated) | | |
| Sprinklers | 18,483 | 1,386 | 7% | 0.46 |

Overall, the evaluation found that the sprinkler measures only achieved 10% and 7% of PG&E's claimed kWh and kW savings over the life of the measures, respectively. There are a number of reasons for this low realization rate:

- The evaluation conducted on-site visits and/or telephone surveys on 25 customers that installed sprinkler measures. Four of the 25 projects were determined to be ineligible for program participation and therefore resulted in zero savings.

- Two projects involved the installation of micro-nozzles on a field which featured no electrically-powered irrigation previously.
- Two projects involved a field that was not irrigated previously.

- The evaluation found that, on average, the sprinklers operated 25% fewer hours annually than assumed by PG&E.
- Evaluators determined that, before the project installation, eight sites were irrigated using a method different from what PG&E assumed, reducing the overall savings value by more than one third.
- The evaluators found various other reasons related to how the corresponding water pumping equipment was used that differed from PG&E's assumptions that lead to further reductions in energy savings by approximately a quarter, overall.

These factors led to an overall reduction in energy and demand savings by 90% or more. Section 4 of the report discusses these factors in greater detail.

## 1.5 RECOMMENDATIONS

Beginning in 2016, PG&E no longer offered the low pressure sprinkler nozzle or micro conversion measures, only the sprinkler to drip irrigation measure is being offered. Based on the low realization rate of savings for these measures, the evaluators agree with discontinuing these two measures. Currently, savings are estimated by PG&E by applying a fixed (or deemed) per unit savings value to the quantity of sprinkler measures that are installed. Because of the number of variables involved with a given sprinkler project, and the uncertainty surrounding each variable, PG&E should consider determining savings using a calculated approach. This would allow for estimates of savings to be more customized to a customer's specific circumstances, and improve the reliability of their ex ante savings claim.

The approach to estimating energy savings for sprinkler measures is based on an engineering algorithm that incorporates a number of parameters, including pre-project crop type, pre-project crop age and pre-project irrigation method. Each of these variables can significantly affect irrigation requirements and subsequent savings from micro-nozzle and drip irrigation installations. Many of the recommendations below provide more insight into how the IOUs might better characterize these variables and avoid savings overestimates in the future. Section 7 discusses these recommendations and the supporting findings in more detail.

- The program must perform more careful data collection and screening of applicants to avoid ineligible projects. The initial application process should include documented proof of the following: existing crop type and age, planned crop type, existing irrigation method, as well as relevant photographs and a prior year's worth of electric billing data for the affected irrigation pump. As discussed in Section 4, four of the 25 sampled projects were determined to be ineligible for program participation and should not have had associated savings claims.

- The program should utilize an interactive savings calculator that can account for the different water requirements of various crop types and ages. As discussed in Section 4, six of the 25 sampled projects involved a switch in crop type at the time of the project installation. Three of the 6 projects featured conversions to either almonds or walnuts, which are notably more water-intensive crops. Higher water requirements lead to higher irrigation pumping requirements, possible increases in electric consumption and reduced savings values.
- The recommended program savings calculator above should account for the pre-project irrigation method to accurately predict the impact on energy consumption by converting to micro-nozzles or drip irrigation installations. As discussed in Section 4, eight of the 25 sampled projects involved a pre-project irrigation method different from that reflected in the ex ante savings assumptions, which resulted in lower realized savings.
- Operating pumping efficiency (OPE) testing paperwork should be included with the application to confirm program eligibility and more accurately characterize the affected pump. None of the sampled participants could produce OPE paperwork required for participation in the prescriptive program. OPE greatly affects the estimated savings value. Furthermore, program eligibility requirements should specify a minimum OPE value.

## 1.6 CONTACT INFORMATION

The ED Project Manager for this study was Mr. Robert Hansen. Itron served as the Prime Contractor managing this study, led by Mr. Brian McAuley.

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# 2 INTRODUCTION AND OVERVIEW OF STUDY

This report documents the activities undertaken by the Nonresidential Downstream Impact Evaluation of the 2015 IOUs' energy efficiency programs for low pressure nozzles and micro conversion sprinklers.[2] The overall goal of this study is to perform an impact evaluation on specific deemed sprinkler measures that were identified in the Efficiency Savings and Performance Incentive (ESPI) decision.[3]

This report is informed by Attachment 2 and 3 of the ESPI decision for program year (PY) 2015 and details the goals and objectives of the impact evaluation to meet those requirements. Likewise, the report will discuss the researchable issues, information on the measure groups evaluated as well as the data sources used, the approach for sampling, the verification analysis and the methods used to determine ex post energy and demand impacts. Finally, the report will present the results and findings from the analysis that can then be used to update the net-to-gross ratios (NTGR), and the gross and net first year and lifecycle savings for the measures detailed in the ESPI decision.

## 2.1 EVALUATION RESEARCH OBJECTIVES

The objective of the impact evaluation was to perform a measure and/or measure-parameter impact evaluation, utilizing new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for specific deemed sprinkler measures identified in the ESPI decision. Attachment 2 of the ESPI decision provides an overview of the portfolio parameters that have been identified as potentially requiring ex post verification.

It is important to note that the parameters associated with these measures represent potential areas of focus and that the ex post evaluation is not limited in scope to any specific parameters. The evaluation team has determined, with guidance from the CPUC, what measures and measure-parameters are subject to ex post evaluation. This determination is based on a number of factors, which will be presented in more detail throughout this report:

- **Sprinklers – low pressure nozzles and micro conversions** (PGE only)
  - The energy savings associated with these measures are unclear and only the low pressure nozzle measure has been previously studied. Impact assumptions require verification.

[2] This report focuses on the ESPI measures that were identified for the 2015 program cycle.

[3] D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Shareholder+Incentive+Mechanism.htm

A number of research objectives have been targeted in order to develop net and gross ex post impacts for the measures detailed above. For this evaluation, a gross realization rate (GRR) approach has been utilized, where site-specific gross ex post impacts have been estimated from a sample of participants. These site-specific gross ex post impacts were then compared to the ex ante claim from the tracking data to develop a ratio of ex post to ex ante savings.

The following tasks have been performed, by collecting new primary data from participant phone surveys and/or on-site verification analyses, in order to develop the realization rates. A more detailed description of the impact methodologies follows in Section 3, given that the approach is site-specific and the objectives are predicated on the types of measures (or projects) being evaluated, but to summarize:

- Confirm installations (verification). This step includes on-site verification of measure installations that represent a significant percentage of ex ante claimed savings.
- Determine pre-project characteristics – crop type, crop age, irrigation method/schedule and acreage and post-installation project characteristics.
- Estimate participant free-ridership to support the development of net-to-gross ratios and net savings values.
- Based on the above, estimate first year and lifetime gross and net ex post impacts (kW and kWh) for sprinkler measures.

## 2.2 STUDIED MEASURE GROUPS

The sprinkler measures listed on the ESPI Uncertain List for 2015 are aggregate measure groups that are comprised of 4 unique measure names. PG&E is the only utility for which this measure is on the ESPI Uncertain List. As presented in Table 2-1, there were three main types of deemed agricultural sprinklers rebated in PG&E in 2015 – low pressure nozzles, drip irrigation and micro conversions. Overall, 36 sites participated in 2015 across the four measure categories. The micro conversion and drip irrigation measures represent roughly 96% of the lifecycle kWh savings for the sprinkler measure in PG&E and 32 of 36 participating sites. Table 2-2 presents the sprinkler measures' contribution to PG&E's 2015 portfolio lifecycle gross ex ante kW and kWh savings (as well as the statewide (SW) contribution).

**TABLE 2-1: 2015 EX ANTE KWH GROSS LIFECYCLE SAVINGS BY SPRINKLER MEASURE TYPE**

| Measure Name | N | Lifecycle Ex Ante Gross kWh Savings | Percent LC kWh Savings |
|---|---|---|---|
| Sprinkler Nozzle Low Pressure - Permanent | 4 | 337,500 | 1% |
| Sprinkler To Drip Irrigation - Field/Vegs (Well And Non Well) | 3 | 1,520,000 | 3% |
| Sprinkler To Micro, Field/Veg | 14 | 24,507,258 | 50% |
| Sprinkler To Micro, No Well, Deciduous | 15 | 22,522,695 | 46% |
| **Total Sprinklers** | **36** | **48,887,453** | **100%** |

**TABLE 2-2: PERCENTAGE OF 2015 EX ANTE KW AND KWH LIFECYCLE SAVINGS FOR SPRINKLER MEASURE BY PORTFOLIO**

| 2015 ESPI Measure | Percent of Portfolio Lifecycle kW Savings | | Percent of Lifecycle kWh Savings | |
|---|---|---|---|---|
| | SW | PGE | SW | PGE |
| Sprinklers | 0.96% | 2.29% | 0.29% | 0.73% |

As evidenced above, the sprinkler measures that were identified in the ESPI decision represent roughly 2.29% of PG&E and 0.96% of statewide portfolio lifecycle portfolio ex ante kW savings, respectively. Given the contribution to ex ante savings and the uncertainty surrounding several of the impact parameters associated with these measures, the evaluation team has conducted phone interviews and on-site verification for a sample of the measures that were rebated in 2015. Given the much more significant level of ex ante savings associated with drip irrigation and micro conversion sprinklers, the evaluation team has evaluated these measures exclusively. (Note that low pressure sprinkler nozzles were evaluated in 2014).

The evaluation team has used the above data collection methods to estimate NTGRs and levels of free-ridership and has employed a gross realization rate (GRR) approach to estimate gross savings for rebated drip and micro conversion sprinklers. The GRR refers to the approach of estimating site specific savings values for a sample of participants, and developing a realization rate of savings (the ratio of aggregate ex post savings to aggregate ex ante savings for the sample) and applying the GRR to the ex ante savings value for the population to estimate ex post population level savings.

## 2.3 OVERVIEW OF IMPACT EVALUATION APPROACH

For micro-nozzle and drip irrigation conversions, the general approach used to estimate ex post gross savings first considered all available data. The challenge in calculating pumping savings is determining the pump head pressure (or associated loading level) of the pre-existing irrigation system's pump(s). In order to characterize the pre-conversion pump operation, evaluators relied on pre-project utility bills and interval meter ("smart meter") data when available. However, as many participating farms featured conversions in crop type and/or irrigation method at the time of the measure installation, a fair comparison of pre- and post-project utility meter data required normalization by the amount of water delivered before and after the conversion.

Two methods were employed by evaluators, depending on the availability, quality, and comparability of pre/post utility consumption data. For every sampled project, the evaluators administered an engineering telephone survey to collect detailed information needed to ensure fair pre/post comparison of relevant parameters. For projects with information that could not be obtained during the survey, evaluators followed up with a visit to the site in order to inspect a selection of the installed equipment and gain clarity on information not collected during the phone survey.

The remainder of this report will discuss how relevant impact parameters were evaluated for the ESPI micro-nozzle and drip irrigation measures, along with the following:

- Section 3 discusses the data sources that were utilized to estimate each of the individual measure parameters, the sample design, and resulting data used in the evaluation.
- Section 4 presents the methods used for estimating each individual impact parameter, including the installation rate, the pre- and post-project annual operating hours, and reduction in irrigation discharge pressure.
- Section 5 presents the net-to-gross analysis and resulting NTGRs.
- Section 6 presents the final study results, including a discussion of the gross and net realization rates and total population level ex post energy savings values.
- Section 7 presents the conclusions and recommendations.
- Appendix A presents the participant telephone survey and on-site data collection instrument.
- Appendix B presents the site reports and discrepancy analysis.
- Appendix C presents supporting materials for the net-to-gross-analysis.
- Appendix AA presents the standardized high level savings for both gross and net first year and lifecycle.

- Appendix AB presents the standardized per unit savings for both gross and net first year and lifecycle.
- Appendix AC presents the summary of recommendations for the Response to Recommendations (RTR).

# 3 DATA SOURCES AND DATA COLLECTION

## 3.1 DATA SOURCES

A number of data sources were utilized to support the development of each impact parameter in order to update impact parameter values, installation rates and NTGRs for the ESPI micro-nozzle and drip irrigation measures researched in this study. The impacts associated with the irrigation measures rely exclusively on new primary data collection: (1) in-depth engineering interviews with facility staff to evaluate the gross impacts associated with those measures, and (2) new phone surveys to evaluate NTGRs. The various sources of data are discussed in more detail below.

### 3.1.1 Engineering Review

Verification data was collected to support installation rates, farm characteristics (acreage, number of irrigation "sets"[4], trees per acre), crop characteristics (type, age), irrigation characteristics (pre-project method, frequency, seasonality, typical duration per irrigation), pump characteristics (quantity of affected irrigation pumps, rated horsepower, pump control method, pre/post discharge pressure), and irrigation system characteristics (method, manufacturer, model, and rated flowrate in gpm). A copy of the engineering phone interview script has been included as Appendix A.

In order to ensure fair comparison between pre- and post-project electric usage, the phone interview data collection and subsequent site analysis focused on the following five parameters:

- **Crop type** – Ex ante savings assumptions reflected identical crops in pre and post cases. However, evaluators determined that six projects in the sample involved a switch in crop type at the time of the nozzle installation. As different crop types feature different water requirements, this information is highly important to ensure a fair pre/post comparison.
- **Crop age** – For deciduous crops in particular, the older the crop, the more water generally required[5]. As a number of sampled projects involved the planting of young almond or walnut trees at the time of the rebated project, data on the age of the trees during pre- and post-billing periods was crucial in ensuring a fair comparison.

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4 An irrigation set is a portion of the total acreage irrigated at a time. For example, a 100-acre farm might rotate irrigating four sets of 25 acres to limit the pump horsepower requirement per irrigation.

5 In some situations, the root structures of older trees can be sufficiently deep to tap into the groundwater without any pumping required. However, for the sample of sites visited in this study, and given the current water sensitivities in California, the groundwater was too deep for this possibility.

- **Irrigation method** – Per program workpapers, ex ante savings calculations reflected an assumption of high-pressure sprinkler irrigation before the project. However, evaluators encountered 12 projects in the sample that featured different irrigation methods, such as flood irrigation.
- **Irrigation patterns –** Information on irrigation frequency (irrigations by month or by season) and irrigation duration (hours irrigated at a time) was collected for pre- and post-configurations to estimate pre- and post-project annual water requirements.
- **Field acreage** – Per program eligibility requirements, new (or expanded portions of) farms could not participate in the program. Collection of this acreage information ensured fair normalization by irrigated field size.

### 3.1.2 On-Site Data Collection

Evaluators scheduled site visits at a selection of participating farms for which the engineering phone interview was incomplete and/or key impact parameters were uncertain after the phone interview. These site visits allowed evaluators to further verify the equipment operation as well as visually inspect the installed equipment. On-sites were conducted between November and January, as the evaluation kicked off relatively late in the growing season (interviews began in September). While onsite, field staff inspected a selection of rebated nozzles and acreage to ensure installation and operability while collecting key information on pumping system characteristics and operating patterns.

### 3.1.3 Utility Meter Data

The PA provided monthly utility consumption data for all sampled projects and 15-minute interval ("smart meter") kW data for 19 projects in the sample. When utility bills were comprehensive and showed operating patterns consistent with phone interview responses, the evaluators leveraged this data to characterize pre- and post-project electric usage.

### 3.1.4 Participant Net-to-Gross Survey

An additional participant net-to-gross (NTG) survey was conducted at the end of each engineering interview to collect data useful for the NTG analysis and various other components of the evaluation. A copy of the participant phone survey script is included in Appendix A and a discussion of the NTG methodology is included in Appendix C.

## 3.2 ENGINEERING REVIEWS AND NTG SURVEY DATA COLLECTION

As mentioned above, the engineering interviews and supplemental site visits collected data to support a number of the impact parameters including the installation rates, annual operating hours, and reduction in discharge pressure for micro-nozzle and drip irrigation measures. As there were only 32 sites participating in the measure for the 2015 cycle, attempts were made to the customers of every site in the population. The 2015 Nonresidential Downstream Deemed ESPI Impact Evaluation Research Plan[6] for this study discusses the sample design in greater detail, but the resulting design focuses on developing estimates of key impact parameters that can be used to augment existing data in order to update ex ante net and gross kWh and kW savings values for each ESPI measure.

## 3.3 SAMPLE DESIGN

The census design for micro-nozzle and drip irrigation measures was generated using 2015 program participants. According to the ESPI decision, the kWh and kW savings associated with the installation of low-pressure sprinkler nozzles are unclear given uncertainties regarding the varying operating schedules and different discharge pressure requirements of affected irrigation pumps. As presented in Table 2-2, the ex ante statewide kW savings for agricultural measures represented 2% of PG&E’s portfolio level savings. As the most significant savings are generated from micro-nozzle and drip irrigation installations within PG&E service territory, the sample design only included sites within PG&E’s territory and with micro-nozzle and drip irrigation measures. Low pressure sprinkler nozzles were not evaluated, however this measure was evaluated in 2014.

Because of the relatively small population of PG&E micro-nozzle and drip irrigation participants, a census was attempted. Of the 32 participants in 2015 among these three measures, evaluators surveyed a total of 25 participants over the phone, seven of which were later visited onsite. Of the seven unevaluated projects, two were dropped due to customers refusing to participate while the remaining five were dropped from consideration after evaluators failed to make contact with facility staff following multiple outreach attempts to conduct telephone surveys.

The design and collected samples are presented below in Table 3-1 along with the percentage of ex ante lifecycle kWh represented in the sample. Overall, the achieved net and gross data collection for the sprinkler measures detailed above represent roughly 78% of total ex ante lifecycle kWh savings for the micro conversion and drip irrigation measures. Table 3-2 presents the data collection summary by measure name. The following sections will discuss the gross impact and net-to-gross analysis in more detail and will also discuss which site-measures were included in those final analyses.

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[6] http://www.energydataweb.com/cpucFiles/pdaDocs/1565/2015_ESPI%20Research%20Plan_Deemed_Final%2020160614.pdf

**TABLE 3-1: 2015 PGE SPRINKLER NET AND GROSS ACHIEVED DATA COLLECTION**

| PA | ESPI Measure | Net and Gross Analysis Sample Quotas | | |
|---|---|---|---|---|
| | | Quota | Collected | Lifecycle Gross kWh Savings |
| PGE | Sprinklers | 25 | 25 | 78% |

**TABLE 3-2: 2015 SAMPLED EX ANTE GROSS KWH LIFECYCLE SAVINGS BY SPRINKLER MEASURE TYPE**

| Measure Name | n | Lifecycle Ex Ante Gross kWh Savings | Percent LC kWh Savings |
|---|---|---|---|
| Sprinkler Nozzle Low Pressure - Permanent | - | - | - |
| Sprinkler To Drip Irrigation - Field/Vegs (Well And Non Well) | 3 | 1,520,000 | 100% |
| Sprinkler To Micro, Field/Veg | 10 | 17,238,808 | 70% |
| Sprinkler To Micro, No Well, Deciduous | 12 | 19,181,879 | 85% |

# 4 GROSS IMPACT METHODOLOGY

This section provides an overview of the methods used to estimate the key impact parameters and the NTGRs for the deemed micro-nozzle and drip irrigation ESPI measures identified for PY 2015.

## 4.1 OVERVIEW OF APPROACH

The primary objective of the impact evaluation was to perform a measure and measure-parameter impact evaluation, utilizing new primary evaluation data, in order to update existing gross and net savings estimates and inform future savings values for the micro-nozzle and drip irrigation measures identified in the ESPI decision. Researched parameters, including operating hours, changes in irrigation pump discharge pressures, installation rates, and estimates of free ridership, can be used to measure ex post performance for PY 2015. These parameters are discussed in more detail below. Unless otherwise indicated, all parameter-level averages have been weighted by project acreage, to ensure that the largest projects are fairly represented.

For micro-nozzle and drip irrigation conversions, the general approach used to estimate ex post gross savings first considered all available data. As discussed, the challenge in calculating pumping savings is determining the pump head pressure (or associated loading level) of the pre-existing irrigation system's pump(s). In order to characterize the pre-conversion pump operation, evaluators relied on pre-project utility bills and interval meter ("smart meter") data when available. However, as many participating farms featured conversions in crop type and/or irrigation method at the time of the nozzle installation, a fair comparison of pre- and post-project utility meter data required normalization by the amount of water delivered after the conversion.

Two methods for normalization were employed by evaluators, depending on the availability, quality, and comparability of pre/post utility consumption data. Regardless of the site level approach for generating gross ex post savings values, data collection activities remained consistent for each site. For every project, evaluators administered an engineering telephone survey to collect information needed to ensure fair pre/post comparison of relevant parameters. For projects with information that could not be obtained during the survey, evaluators followed up with a visit to the site in order to inspect a selection of the installed equipment and gain clarity on information not collected during the phone survey. Relevant parameters for which detailed information was gathered can be found in the following section while a breakdown of all/additional parameters can be found in Appendix B.

Each of the two evaluation methods are described below, in order of preference.

**1. Analysis of pre/post electric bills normalized to water consumption**

The evaluator's preferred method for assessing project impacts is characterized by the following formula:

$$\Delta E = \sum_{i=1}^{12}\left[\left(\frac{E}{V}\bigg|_{pre,i} - \frac{E}{V}\bigg|_{post,i}\right) \times V_{post,i}\right]$$

Where,

$\Delta E$ = Annual electric energy savings in kWh. This parameter represents the ex post savings objective of this study.

$E_i$ = Monthly electric energy consumption during month $i$, obtained via data requested from the IOU. Pre- and post-intervention consumption values are denoted with the subscripts $pre$ and $post$, respectively.

$V_i$ = Total volume of water delivered to the affected field during month $i$, in units of *acre-feet*. As many participating farms rely on private well water rather than municipally-owned and metered water supplies, historic water usage records were typically not available. Instead, evaluators gathered detailed information on field acreage, crop type, crop age, irrigation method, and irrigation schedule (as described above) to calculate the water requirement of the crop[7]. Normalization by the required acre-feet in pre- and post-intervention cases ensured a fair comparison between pre—and post-intervention electric consumption[8].

**2. Analysis of project impacts from discharge pressure reduction**

[7] Engineers attempted to collect survey data on irrigation runtime and frequency by month of the year, to determine the site-specific irrigation operating hours and subsequent water volume. However, in some cases, the interview data was insufficient, and the engineers referenced theoretical water requirement data from various sources (as a function of crop type, age, and location) to estimate the pre- and post-project water volumes for normalization in the energy savings calculation.

[8] The normalization also took into account the different water application efficiencies (the amount of water reaching the crop over the total amount of discharged water) of various irrigation methods, per the following reference: https://www.dropbox.com/s/jqbc1j92c4ckuln/Application%20Efficiencies%20-%20UCDavis%20-%20Sandoval%20Solis%20et%20al%202013%20-%20Report.pdf

When utility consumption data was incomplete or incomparable between pre/post cases, the evaluators assessed project impacts via calculation of the change in pumping power requirement from the micro-nozzle or drip irrigation system's reduction in pumping discharge pressure, as follows:

$$\Delta E = \frac{1.0241 \times (TDH_{pre} - TDH_{post})}{OPE} \times V_{annual}$$

$\Delta E$ = Annual electric energy savings (kWh per year). This parameter represents the ex post savings objective of this study.

$1.0241$ = Conversion constant (kWh / acre-foot / feet of head). Converts pump operating pressure difference and annual water requirement into electric energy impact seen at pump.

$V_{annual}$ = Total volume (acre-feet) of water delivered per year, calculated as the sum of the twelve monthly volumes in the previous evaluation method. As many participating farms featured conversions in crop type and/or irrigation method at the time of the project installation, this value was assumed to be the installed water requirement to ensure a fair comparison of pre- and post-project energy usage.

$TDH_{pre}$ = Total dynamic head (feet) of the pre-existing irrigation pumping system. This information was not available in PA tracking data; instead, the evaluators estimated this value from customer interviews and information on irrigation method, well depth, theoretical water requirement, and irrigation operating hours.

$TDH_{post}$ = Total dynamic head (feet) of the installed (low-pressure) irrigation pumping system. Several farmers monitor this value closely and provided rich information for evaluators to determine a representative value in the savings calculation. Evaluators noted this value via gauge reading when possible, but due to the timing of the study, the affected irrigation pump was often not operating at the time of the site visit.

$OPE$ = The pumping system's overall plant efficiency (unitless). Participating farms were required to complete an OPE assessment within a year of program application; OPEs of 45% or greater were required for program eligibility. Evaluators requested the most recent pump tests that would indicate post-project OPE; however, these records were typically not available from the participating farmer. OPE has been typically estimated by PAs between 45-55% based on field studies.

Non-coincident demand savings (in kW/acre) was calculated using similar equations and parameters presented above.

The remainder of this section will focus on the following:

- The approach for estimating each individual impact parameter, including the installation rate, annual operating hours, reduction in pumping discharge pressure and coincidence factor.

### 4.1.1 Installation Rates

The installation rate is defined as the ratio of affected acreage served by the installed equipment, as verified by the evaluators versus the affected acreage reported to the program administrator. The installation rate is estimated for each site based on data gathered during the engineering interview and on-site visit (where applicable). As part of the interviews and on-site visits, an objective of the evaluator was to attempt to identify and assess the quantity and operability of all equipment installed as well as the acreage of plot served by the irrigation system.

For the PY2013-14 cycle, evaluators visited 25 participating farms and determined an installation rate of 97%, and all site inspections corroborated the installation rate findings initially gathered over the phone. Therefore, as the installation rate was not a key driver of ex post savings in the prior cycle, evaluators relied on engineering phone interviews to determine installation rates for the 25 sampled projects in PY2015. Installation rates for 7 projects were corroborated via supplemental on-site visits.[9]

The key measure count identified during the interviews and visits is the acreage served by the rebated irrigation system currently installed and in working condition. Evaluators used a combination of interview questions, inspection, and review of project invoices to confirm the acreage served. The installation rate is calculated directly from this measurement. Additionally, when possible, the evaluator collected data on the quantity of rebated nozzles or length of drip tape.

$$IR = \frac{A_V}{A_R}$$

Where:

$IR$ = Installation Rate

[9] As discussed below, four sites were determined to be ineligible because they were using diesel fuel and are removed from some of the parameter level results presented below. However, these sites are included in the estimate of installation rates because the installed equipment is indicative of the type of equipment installed under eligible scenarios. Also note that none of these parameter level average values are used to calculate the realization rates, they are only for informational purposes. The realization rates are based on site-specific estimates of ex post savings, and ineligible sites are given zero ex post savings.

$A_V$ = Affected area (acres) verified by evaluators

$A_R$ = Affected area (acres) reported in program tracking system

In addition to identifying the amount of acreage affected by the rebated project, the auditor was also prepared to identify the quantity of nozzles that was:

- Failed and in place – The number of nozzles or length of drip tape currently installed but not in working condition (failed).
- Failed and replaced – The number of nozzles or length of drip tape that had been installed, but then had failed and was replaced with different nozzles.
- Removed and not replaced - The number of nozzles or length of drip tape that had been installed, but had been removed (either due to failure or other reasons), but was not replaced, such that the system was currently not irrigating as intended.
- In storage – The number of nozzles or length of drip tape that were received but had not yet been installed.

For the 25 sprinkler nozzle projects in the sample, the evaluators determined an installation rate of 99.6%, as one project was confirmed via site visit to have installed the rebated equipment on only a portion of the acreage reported to the program. Table 4-1 breaks down the installation rate by the categories defined previously.

**TABLE 4-1: DISPOSITION OF ESPI MICRO-NOZZLE AND DRIP IRRIGATION VERIFICATION**

| Measure | Sites | Received Rate | Failure Rate | Storage Rate | Removal Rate | Installation Rate |
|---|---|---|---|---|---|---|
| Micro-nozzle and Drip Irrigation | 25 | 100% | 0.0% | 0.4% | 0.0% | 99.6% |

### 4.1.2 Operating Hour Analysis

One of the primary inputs to the gross savings calculations is the number of annual hours that the irrigation pump operates. Savings from micro-nozzles and drip irrigation systems are theoretically realized during each hour of irrigation pump operation. This section will discuss the development of the annual operating hour value from site-level data collection and the analysis of interval data.

For each sampled project, annual operating hour estimates were triangulated among three different calculations, depending on data availability and quality:

1. Interval utility meter data provided 15-minute readings on irrigation pump kW; this data was averaged and extrapolated to estimate the annual operating hours of the pump. An example interval data snapshot is provided in Figure 4-1.

2. Engineering interviews collected information, per the data collection form in Appendix A, on customer-reported irrigation frequency and hours per irrigation, in order to estimate pre- and post-project irrigation pump runtimes.

3. Field staff noted the rated horsepower of affected irrigation pump(s) in the pre- and post-project configurations. If the pump(s) operated at constant speed, the annual utility consumption total divided by the kW rating of the pump(s) results in an estimate of annual full-load operating hours.

Because one or more of the three estimates above might not have encompassed a full year, the operating hours estimates typically needed to be extrapolated out to a full year of 8,760 hours. These extrapolations considered seasonal irrigation patterns and water requirements by crop type. For example, Central Valley farms with deciduous crops typically do not irrigate between the months of November and February.

**FIGURE 4-1: EXAMPLE INTERVAL METER DATASET: HOURLY KW FOR AUGUST 2015**

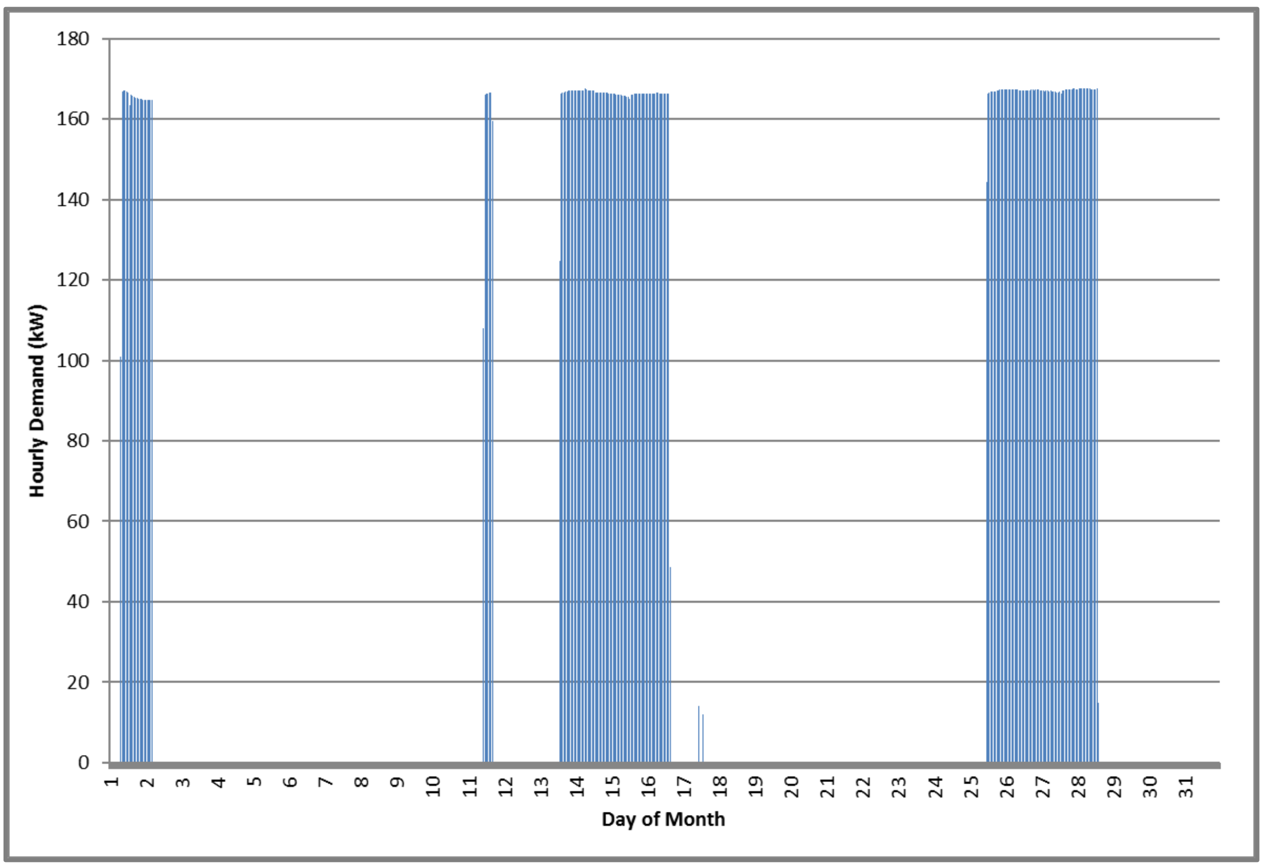

Figure 4-1 illustrates an example snapshot of the interval meter data received by evaluators. After applying the three-pronged operating hours approach described above for each sampled project, the evaluators determined an average irrigation operating hour value weighted by project acreage. Table 4-2 compares the ex ante operating hour assumptions, segmented by crop type, with ex post findings.

**TABLE 4-2: COMPARISON OF EX ANTE AND EX POST OPERATING HOURS BY MEASURE**

| Measure | Sites[10] | Ex Ante Operating Hours | Mean Ex Post Operating Hours |
|---|---|---|---|
| Micro-nozzle and Drip Irrigation: Field/veg | 9 | 1,260 | 656 |
| Micro-nozzle and Drip Irrigation: Deciduous | 12 | 2,222 | 2,253 |

Overall, irrigation pumps at participating farms operate 25% fewer hours annually than reflected within ex ante savings assumptions.

### 4.1.3 Discharge Pressure Analysis

A key variable affecting the sprinkler nozzle replacement savings is the reduction in discharge pressure experienced by the irrigation pump. Evaluators gathered information on this parameter using two primary methods:

1. Engineering interviews regarding pre- and post-intervention discharge pressures – Farmers typically monitor these values closely, to ensure no overwatering, which can lead to crop disease. Evaluators noted their pre/post discharge pressure estimates during phone interviews and site visits.
2. Gauge reading of affected irrigation pump(s) in post-project configuration – During site visits to selected farms, field staff noted the discharge pressure of the irrigation pump(s) when operating.

Table 4-3 compares the ex ante discharge pressure reduction assumption with the ex post finding for both micro-nozzle and drip irrigation measures.

[10] The evaluators determined that four sampled projects were ineligible because they were using diesel fuel. These four ineligible projects have been excluded from the parameter-level analysis.

### TABLE 4-3: COMPARISON OF EX ANTE AND EX POST DISCHARGE PRESSURE REDUCTION

| Measure | Sites | Ex Ante Discharge Pressure Reduction | Mean Ex Post Discharge Pressure Reduction |
|---|---|---|---|
| Micro-nozzle and Drip Irrigation | 21[a] | 20.0 psi | -0.1 psi |

[a] The four ineligible projects have been excluded from this parameter-level analysis.

Overall, affected irrigation pumps experienced a discharge pressure reduction 100% lower than reflected within ex ante savings assumptions. As irrigation discharge pressure can vary greatly among irrigation methods, evaluators examined the effect of pre-project irrigation method on ex post discharge pressure reduction, as shown in Table 4-4. While ex ante savings reflect an assumption of high-pressure sprinkler nozzles in the pre-project configuration, the evaluators determined that only 13 projects in the sample converted from this irrigation method.

### TABLE 4-4: DISCHARGE PRESSURE REDUCTION BY PRE-PROJECT IRRIGATION METHOD

| Pre-Project Irrigation Method | Sites[1] | Ex Ante Discharge Pressure Reduction | Mean Ex Post Discharge Pressure: Pre-Project | Mean Ex Post Discharge Pressure: Post-Project | Mean Ex Post Discharge Pressure Reduction (Pre minus Post)[4] |
|---|---|---|---|---|---|
| High-pressure sprinkler nozzles | 13 | 20.0 psi | 50.8 psi | 39.6 psi | 11.2 psi |
| Flood/furrow[2] | 3 | 20.0 psi | 10.8 psi | 30.0 psi | -19.2 psi |
| Drip tape[3] | 5 | 20.0 psi | 30.0 psi | 34.3 psi | -4.3 psi |

[1] The four ineligible projects have been excluded from this parameter-level analysis.

[2] While past program applications could not be found online, an example catalog of program offerings indicates that flood irrigation was an acceptable baseline for low-pressure nozzle eligibility (page 2): http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/agriculture/AgFood-EM_Agriculture_Irrigation_Fact_Sheet.pdf

[3] Some farmers indicated that they regularly replace their old drip irrigation systems with new drip irrigation systems.

[4] A negative pressure "reduction" indicates an increase in discharge pressure at the pump.

Sites that irrigated as the IOUs assumed, via high-pressure sprinkler nozzles, resulted in a discharge pressure reduction 43% less than assumed in ex ante savings. Farms that used flood or drip irrigation methods before the project experienced an overall increase in discharge pressure requirement on average at the irrigation pump. With all other parameters equal (e.g., pre/post crop type), an increase in discharge pressure requirement results in an increase in required pumping energy. Therefore, the flood/furrow and drip tape irrigation projects generally resulted in negative energy savings[11].

[11] Of the 12 projects that did not feature the ex ante assumption of high-pressure nozzles in the pre-project case, evaluators determined that 5 such projects involved a crop switch. However, the savings analysis normalized the pre-project characteristics to reflect the water requirement of the post-project crop. Therefore, we believe

## 4.2 COINCIDENCE FACTOR ANALYSIS

Demand savings realized during the peak coincident period were not anticipated by the IOUs for the micro-nozzle and drip irrigation measures[12]. However, by analyzing the interval utility data for the 19 farms with smart meters, the evaluators determined that the affected irrigation pumps partially operate during the peak period, as indicated in Table 4-5.

### TABLE 4-5: COMPARISON OF EX ANTE AND EX POST COINCIDENCE FACTOR

| Measure | Sites | Ex Ante Coincidence Factor | Mean Ex Post Coincidence Factor |
|---|---|---|---|
| Micro Nozzle and Drip Irrigation | 19[a] | 0.00[b] | 0.36 |

[a] Excludes sites without interval meter data. However, ineligible projects have been included, as their interval data provides valuable information on coincident peak operation; the project's ineligibility would generally not affect the interval operation of the pump in the post-project configuration.

[b] While the tracking database indicates positive nonzero peak demand savings reported by the programs, program workpapers recommend the assumption of a 0.00 peak coincidence factor.

Evaluators determined that affected irrigation pumps have a 36% probability of operating during the summer peak coincident period. While nearly all of the interviewed farmers indicated a preference to irrigate during nights or on weekends to avoid peak demand surcharges and to mitigate the evaporation of irrigation water, 9 of the 19 interval meter datasets indicated regular peak-period operation. As irrigation runtimes often exceed 12-18 hours per set, particularly for more water-intensive deciduous crops, it is inevitable for irrigation pumps to operate into the coincident period.

that the primary driver of savings differences between ex ante and ex post is the different-than-expected pre-project irrigation method.

[12] Per workpapers and associated savings calculation spreadsheets, a profile of "Nighttime Operation" and CF of 0.00 were assumed within IOU savings estimates.

# 5 NET-TO-GROSS ANALYSIS

The in-depth engineering interviews conducted for this evaluation served not only to verify the installation of rebated sprinkler measures and to collect site-specific information useful for the gross analysis, but also to acquire information about the influence of the program on the purchase of the sprinkler measures. The questions asked of interviewees were designed to gather information that allowed the evaluation team to estimate participant free-ridership to support the development of net-to-gross ratios (NTGRs) and net savings values. A standard battery of NTG questions were asked of the 25 interviewees who purchased and installed micro conversion sprinklers through PGE's program. However, the four ineligible customers were not used in the NTGR calculation. Furthermore, over the course of the study, one additional customer was mistaken by PG&E as a calculated project rather than a deemed project. While this change was reflected in the tracking data, the associated ex ante savings for this project were still zero. For this reason, the customer was removed from the NTG and GRR analyses. The data collected onsite for this customer is included in the parameter level analyses above because the customer is representative of typical practices.

The approach for estimating NTGRs for these customers was based on the large non-residential free-ridership approach developed by the NTGR Working Group and documented in the *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Non-residential Customers*.

The resulting NTGRs were calculated as the average of three program attribution indices (PAI) known as PAI-1, PAI-2, and PAI-3. Each index represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure. Each index takes on a value between zero and one. The larger the value, the more attribution the program is given to having influenced the customer to install the sprinkler measures, and therefore a higher NTG value.

- **Program Attribution Index 1 (PAI–1)** reflects the influence of the most important of various program-related elements in the customer's decision to select a given program measure. PAI-1 is calculated as the highest program influence factor divided by the sum of the highest program influence factor and the highest non-program influence factor. Some example non-program factors are: previous experience with the measure, recommendation from an engineer, standard practice, corporate policy, compliance with rules or regulations, organizational maintenance or equipment replacement policies and "other – specify." Payback is treated as a program influence factor if the rebate/incentives played a major role in meeting payback criteria, but is treated as a non-program influence factor if it did not play a major role in meeting payback criteria.

- **Program Attribution Index 2 (PAI–2)** captures the perceived importance of program factors (including rebate/incentives, recommendation, and training) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This index is determined by asking respondents to assign importance scores to the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents had made the decision to install the measure before learning about the program. The final score is divided by 10 to be put into decimal form, thus making it comparable with PAI-1.
- **Program attribution index 3 (PAI–3)** captures the likelihood of various actions the customer might have taken at the given time and in the future if the program had not been available (the counterfactual). This score is calculated as 10 minus the stated likelihood, between 0 and 10, that the respondent would have installed the same measure in the absence of the program. The final score is divided by 10 to put into decimal form, thus making it comparable with PAI-1 and PAI-2.

The NTGR was estimated as an average of these three indices. If one of the indices was not available (generally due to respondents giving a "don't know" or "refusal" response), then the NTGR was estimated as the average of the two available indices. If two or more indices were missing, results were discarded from the calculation.

Table 5-1 presents the ex post NTGR scores that were developed – using the above methodology – weighted by lifecycle kW and kWh savings for each site-measure. Also presented are the ex ante NTG ratios. Overall, the ex post NTGRs are approximately 21% less than the ex ante value (weighted by ex post kWh). The relative precision of the ex post estimate is 7% weighted by kWh at the 90% confidence interval. These results are drawn from a sample of 2015 program participants, and are representative of the 2015 program design, implementation and customer decision making.

**TABLE 5-1: EX ANTE AND EX POST NET-TO-GROSS RATIOS FOR SPRINKLER MEASURES WEIGHTED BY KW AND KWH**

| Measure | Weighting Factor | n | Ex Ante NTG | Mean Ex Post NTG | Ex Post NTG Relative Precision |
|---|---|---|---|---|---|
| Sprinklers | Lifecycle kWh | 20 | 0.60 | 0.47 | 7% |
| Sprinklers | Lifecycle kW | 20 | 0.60 | 0.46 | 6% |

Table 5-2 below also presents the ex post NTGR along with the average program attribution scores for the 20 customers. Each of these scores are presented at the measure level and are weighted by lifecycle ex post kwh savings.

**TABLE 5-2: INFLUENCE SCORES FOR SPRINKLER MEASURES**

| Measure | n | Ex Post NTG | Mean PAI1 | Mean PAI2 | Mean PAI3 |
|---|---|---|---|---|---|
| Sprinklers | 20 | 0.47 | 0.48 | 0.02 | 0.79 |

The weighted PAI1 scores across the sample of participants is 0.48 which suggests that, on average, program participants valued program factors equally to non-program factors. The 0.02 PAI2 score suggests, on average, that program participants perceived the importance of non-program related factors much more significantly than program factors. In other words, given 10 points to allocated between program and non-program factors, participants allocated more points to non-program factors. Out of the 20 participants, 7 allocated all 10 points to non-program factors and the highest allocation to program factors was 5. The PAI3 score, however, is higher. The 0.79 score suggests, on average, that customers were not likely to have installed the same equipment had the program not been available.

# 6 EVALUATION RESULTS

This section of the report presents the gross and net realization rates that the evaluation team developed for the 2015 deemed sprinkler measures. These results are presented for both first year and lifecycle kW and kWh savings. As discussed, savings are a function of crop type, crop age and pre-project irrigation method. Each of these variables can affect irrigation requirements and subsequent savings from micro-nozzle and drip irrigation installations. Because of the variability that can occur among the participant population from year to year with respect to these parameters, these realization rates are representative of the conditions observed in this evaluation, and are indicative of program performance of substantially similar program designs and operating conditions. Recommendations are provided in this study that would help improve the accuracy reliability of future ex ante estimates.

## 6.1 GROSS FIRST YEAR REALIZATION RATES

The evaluation team estimated gross realization rates (GRR) by examining the ratio of the aggregate evaluated gross savings to the aggregated ex ante gross savings. The evaluation team utilized the following algorithm to develop customer specific GRRs:

$$Gross\_Realization\_Rate = \frac{\sum_{i=1}^{n} Gross\_Ex\_Post\_Impact_i}{\sum_{i=1}^{n} Gross\_Ex\_Ante\_Impact_i}$$

Where:

$Gross\_Ex\_Post\_Impact_i$ = the site-specific gross ex post impact estimate for customer i in the population.

$Gross\_Ex\_Ante\_Impact_i$ = the site-specific gross ex ante impact estimate for customer i in the population.

Table 6-1 below presents the population level first year gross kWh and kW realization rates for the micro conversion and drip irrigation sprinkler measures along with the aggregate ex ante and ex post first year kWh and kW savings. The corresponding relative precisions are also presented. The first year kWh GRR is 13% with a corresponding relative precision of 42% at the 90% confidence interval and the kW GRR is 10% with a corresponding relative precision of 72%. It is important to note that the relative precision calculation is inversely proportional to the GRR. Because of the low GRRs, the relative precision appears to be large. However, the margin of error measured at the 90% confidence level is only 5% for kWh and 7% for kW.

**TABLE 6-1: PGE FIRST YEAR GROSS KWH AND KW REALIZATION RATES FOR EVALUATED SPRINKLERS**

| PA | First Year Gross kWh Savings | | | | First Year Gross kW Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | Ex Ante Savings | Ex Post Savings | GRR | RP | Ex Ante Savings | Ex Post Savings | GRR | RP |
| PGE | 2,427,498 | 315,896 | 13% | 42% | 1,540 | 151 | 10% | 72% |

As discussed throughout Section 4, the ex post impacts and ex ante claims are products of several unique parameters that are generated in the impact algorithm. The underlying ex ante assumptions regarding each parameter vary by measure as do the ex post impacts. Below is a brief discussion of some of those underlying differences and how they affected the overall realization rates.

- Per Section 4.2, evaluators determined a weighted average annual operating hours value 25% lower than that reflected within ex ante kWh savings. This difference reduced the kWh GRR by 17%.
- Evaluators determined that, before the project installation, 8 sites were irrigated using a method different from the IOU-assumed high-pressure sprinkler method, including 3 flood or furrow-irrigated sites. As compared with sprinkler nozzle irrigation, flood/furrow irrigation generally requires a significantly lower discharge pressure at the irrigation pump; previously flood-irrigated sites therefore resulted in negative impacts in some cases. As the ex ante savings calculations reflect a conversion from high-pressure to low-pressure nozzles, this difference resulted in lower ex post savings. Overall, differences in pre-project irrigation method resulted in a 34% reduction in GRR.
- Per Section 4.2, evaluators determined a weighted average pump discharge pressure reduction 100% lower than reflected within ex ante kWh savings. The evaluators found that sites that irrigated in the pre-project case as the IOU assumed, via high-pressure sprinkler nozzles, resulted in a weighted average pump discharge pressure reduction value 43% lower than assumed in ex ante savings. This difference reduced the kWh GRR by 10%.
- Four projects were determined to be ineligible[13] for program participation and therefore resulted in zero savings, driving the GRR down by 12%.

[13] As the program is currently inactive, eligibility requirements cannot be cited via web link of the program application. However, per program workpapers and the program measure offering catalog cited in Table 4-4 of this report, evaluators determined that the following eligibility requirements were not met for these four projects: eligible projects must involve previous electrically-irrigated farmland, and only replacements of high-pressure sprinkler or flood irrigation systems are eligible to participate.

— Two projects involved the installation of micro-nozzles on a field which featured no electrically-powered irrigation previously.

— Two projects involved a field that was not irrigated previously.

- Evaluators determined that the post-project irrigation method was mischaracterized for three sites. These sites were listed as micro-nozzle installations but were determined by evaluators to be drip irrigation projects. This difference resulted in a 6% reduction to the kWh GRR.
- Evaluators determined that seven sites contained crops with ages different than the program's deemed value. This difference further reduced the kWh GRR by 5%.

The key discrepancies categories and their relative contribution to the overall program-level GRR are illustrated in Figure 6-1.

**FIGURE 6-1: KEY DISCREPANCY CATEGORIES AND CONTRIBUTIONS TO OVERALL GRR**

| Discrepancy Category | # Instances | Impact on GRR |
|---|---|---|
| Difference in affected field acreage | 1 | -0.3% |
| Difference in crop age | 7 | -5.0% |
| Difference in irrigation hours of operation | 13 | -16.5% |
| Difference in pump discharge pressure reduction | 12 | -10.0% |
| Incorrect post-project irrigation method | 3 | -6.4% |
| Incorrect pre-project irrigation method | 8 | -34.2% |
| No electric use (diesel-fueled pumps) | 4 | -12.5% |
| Switch in crop type | 3 | -1.9% |
| Reported savings greater than annual billed usage | 1 | -0.2% |
| **Total** | **52** | **-87.0%** |

## 6.2 GROSS LIFECYCLE REALIZATION RATES

Table 6-2 presents the population level gross lifecycle kWh and kW realization rates for the evaluated sprinkler measures along with the aggregate ex ante and ex post lifecycle kWh and kW savings. The corresponding relative precisions are also presented. The evaluation team did not conduct an effective useful life (EUL) analysis for the sprinkler measure (ex ante EUL was used), so the first year and lifecycle GRRs are identical.

**TABLE 6-2: PGE LIFECYCLE GROSS KWH AND KW REALIZATION RATES FOR EVALUATED SPRINKLERS**

| PA | Lifecycle Gross kWh Savings | | | | Lifecycle Gross kW Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | Ex Ante | Ex Post | GRR | RP | Ex Ante | Ex Post | GRR | RP |
| PGE | 48,549,953 | 6,317,918 | 13% | 42% | 30,805 | 3,019 | 10% | 72% |

## 6.3 NET FIRST YEAR REALIZATION RATES

The evaluation team estimated the net ex post impacts in a similar manner as the gross impacts, however, the NTG ratios were multiplied by the gross impacts. The resulting net realization rates (NRR) represent the ratio of aggregated evaluated net savings to the aggregated ex ante net savings. The evaluation team utilized the following algorithm to develop customer specific NRRs:

$$Net\_Realization\_Rate = \frac{\sum_{i=1}^{n} Net\_Ex\_Post\_Impact_i}{\sum_{i=1}^{n} Net\_Ex\_Ante\_Impact_i}$$

Where:

$Net\_Ex\_Post\_Impact_i$ = the site-specific net ex post impact estimate for customer i in the population

$Net\_Ex\_Ante\_Impact_i$ = the site-specific net ex ante impact estimate for customer i in the population.

Table 6-3 below presents the population level first year kWh and kW net realization rates for the evaluated sprinkler measures along with the aggregate ex ante and ex post first year net kWh and kW savings. The net realization rate is impacted by the difference in ex ante and ex post gross savings along with the differences between the ex ante and ex post NTG ratios. As presented in Table 5-1, the ex post NTG ratio for sprinkler measures was 21% less than the ex ante value, so the NRR differs from the GRR by the same order of magnitude. The overall first year kWh NRR is 10% with a corresponding relative precision of 42% at the 90% confidence interval. The kW NRR is 7% with a corresponding relative precision of 72%.

**TABLE 6-3: PGE FIRST YEAR NET KWH AND KW REALIZATION RATES FOR EVALUATED SPRINKLERS**

| PA | First Year Net kWh Savings | | | | First Year Net kW Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | Ex Ante | Ex Post | NRR | RP | Ex Ante | Ex Post | NRR | RP |
| PGE | 1,456,499 | 150,037 | 10% | 42% | 924 | 69 | 7% | 72% |

## 6.4 NET LIFECYCLE REALIZATION RATES

Table 6-4 presents the population lifecycle kWh and kW net realization rates for the evaluated sprinkler measures along with the aggregate ex ante and ex post lifecycle net kWh and kW savings. The corresponding relative precisions are also presented. Again, the evaluation team did not conduct an effective useful life (EUL) analysis for the sprinkler measure (ex ante EUL was used), so the first year and lifecycle NRRs are identical.

**TABLE 6-4: PGE LIFECYCLE NET KWH AND KW REALIZATION RATES FOR EVALUATED SPRINKLERS**

| PA | Lifecycle Net kWh Savings | | | | Lifecycle Net kW Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | Ex Ante | Ex Post | NRR | RP | Ex Ante | Ex Post | NRR | RP |
| PGE | 29,129,972 | 3,000,735 | 10% | 42% | 18,483 | 1,386 | 7% | 72% |

# 7 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions and subsequent recommendations for improved program delivery based on the findings of this research study.

**Conclusion 1 [Section 3]: Agricultural irrigation projects are difficult to accurately characterize with deemed savings values.** Due to its prescriptive delivery mechanism, the program was unaware of several key variables that affect savings at the irrigation pump. Nearly each of the 25 sampled projects was a unique permutation of the following variables not previously considered in the program deemed savings calculation: pre-project crop type, pre-project crop age and pre-project irrigation method. Each of these variables can significantly affect irrigation requirements and subsequent savings from micro-nozzle and drip irrigation installations. Many of the conclusions and recommendations below provide more insight into how the IOUs might better characterize these variables and avoid savings overestimates in the future.

**Recommendation 1 [All PAs]: The program should incorporate a site-specific savings calculator that customizes claimed savings based on key variables determined from project applications.** The savings calculator should be sufficiently customizable to incorporate site-specific data on operating conditions as it becomes available. Evaluators found that key parameters that affect project savings are: crop type, crop age, and pre-project irrigation method. Any information on these parameters, even self-reported via the program application, would be helpful in developing accurate savings claims.

**Conclusion 2 [Section 3]: 4 of the 25 sampled projects were determined to be ineligible for program participation.** 2 of the 4 projects involved farms that had previously used diesel-powered irrigation pumps, while the other 2 involved project installations on farms that used a gravity fed system to irrigate prior to the project.

**Recommendation 2 [All PAs]: The program must perform more careful data collection and screening of applicants to avoid ineligible projects.** The initial application process should include documented proof of the following: existing crop type and age, planned crop type, existing irrigation method, as well as relevant photographs and a prior year's worth of electric billing data for the affected irrigation pump.

**Conclusion 3 [Section 3]: 6 of the 25 sampled projects involved a switch in crop type at the time of the project installation.** 3 of the 6 projects featured conversions to either almonds or walnuts, which are notably more water-intensive crops. As the previous growth is typically razed as a part of the crop switch, participating farmers saw the crop switch as an opportunity to install a new irrigation system. Higher water requirements lead to higher irrigation pumping requirements and possible increases in electric consumption. However, since farmers were very likely to convert their crops regardless of program intervention, the ex post savings are normalized for the higher water requirement of the post-project crop in the pre-project annual kWh consumption calculation.

**Recommendation 3 [All PAs]: The program should utilize an interactive project conversion savings calculator that can account for the different water requirements of various crop types and ages.** The evaluation team developed such a calculator, which incorporates crop-specific water requirement data, allowing fair comparison between pre- and post-project conditions.

**Conclusion 4 [Section 3]: 8 of the 25 sampled projects involved a pre-project irrigation method different from that reflected in ex ante savings assumptions.** The ex ante savings reflected high-pressure sprinkler irrigation in the preexisting configuration. 3 of the 8 projects featured flood or furrow irrigation before the project, while the remaining 5 sites utilized drip irrigation in the pre-project case. While flood irrigation is generally less water-efficient than sprinkler irrigation, the pumping discharge pressure requirement is generally lower for flood irrigation as compared with micro-nozzle or drip irrigation. Pumps supporting flood irrigation must overcome only the static pressure requirement of drawing the water from a well or reservoir. Lower discharge pressure requirements result in lower electric demand for the flood irrigation pump(s) and, depending on flooding frequency and duration, lower electric consumption as compared with micro-nozzle or drip irrigation installations. Farms with drip irrigation in the pre-project case often resulted in a negligible pumping pressure reduction, as the installed drip emitters led to similar discharge pressure requirements.

**Recommendation 4 [All PAs]: The program's savings calculator (recommended in #3) should account for pre-project irrigation method to accurately predict the resulting change in discharge pressure by converting to micro-nozzles or drip irrigation installations.** Recommendation #5 below provides guidance on how the program might acquire the necessary up-to-date pumping information for participation in the program.

**Conclusion 5: None of the sampled participants could produce operating pumping efficiency (OPE) paperwork required for participation in the prescriptive program.** OPE greatly affects savings from the discharge pressure reduction, per the formula in Section 2.3. Per program workpapers, eligible irrigation pumps must feature an OPE of 0.45 or above.

**Recommendation 5 [All PAs]: OPE testing paperwork should be included with the application paperwork to confirm program eligibility and more accurately characterize the affected pump.** PG&E, for example, provides subsidies for such tests.

**Conclusion 6 [Section 3]: Though not anticipated by the program to result in peak demand savings, the sampled irrigation pumps were 36% likely to operate during the summer coincident peak period.** Evaluators assessed 19 sets of utility interval meter data among the 25 sampled projects to determine this average value weighted by project acreage. Though many participating farmers try to irrigate during nights or weekends to avoid peak demand charges, certain crops (particularly full-grown trees) are irrigated for periods exceeding 18 hours, inevitably leading to some irrigation occurring during the peak period. Though program tracking databases indicate positive, non-zero peak demand savings for each sampled project, program workpapers recommend that ex ante demand savings should reflect a coincidence factor assumption of 0.00 due to a "night operation" classification.

**Recommendation 6 [All PAs]: The program should continue to claim peak demand savings from micro-nozzle and drip measures.** PG&E has done extensive research on the interval meter profiles of agricultural pumping systems; this data should be leveraged to determine an accurate coincidence factor for these customers.

# APPENDIX A PHONE AND ON-SITE INSTRUMENT

PG&E and the State of California are conducting a research study to assess the energy savings performance of the irrigation conversion like the one that occurred at your farm. My company, ERS, has been contracted to analyze the energy savings associated with irrigation conversion projects in order to improve PG&E's energy efficiency programs. As part of the program assessment, we are reaching out to past participants to collect some information that will be helpful in determining actual energy savings.

1. Introduction:
    - 1.1. According to our records, the project involved the conversion of [X] acres to a micro-nozzle irrigation system. Is this correct?
        - 1.1.1. [If no] Can you estimate the number of acres that underwent the irrigation conversion and were rebated by PG&E?
    - 1.2. Our records also indicate that the farm is located at [ADDRESS], [CITY]. Is this correct?
        - 1.2.1. [If no] Where is the farm located?
    - 1.3. When did the irrigation project occur?
    - 1.4. PG&E classified the project as a [MICRO or DRIP] conversion. Can you elaborate on what was actually installed through this project?
2. Crop Details
    - 2.1. What types of crops are currently grown on this acreage?
        - 2.1.1. [If tree crops] About how old are the trees that are irrigated using the new system?
3. Irrigation Details
    - 3.1. At what month of the year does the crop growing season begin?
    - 3.2. What month of the year does the crop growing season end?
    - 3.3. Does irrigation occur outside the growing season?
        - 3.3.1. [If yes] At what month of the year does irrigation begin?
        - 3.3.2. [If yes] At what month does irrigation end?
    - 3.4. Is the acreage divided into multiple sets for irrigation?
        - 3.4.1. [If yes] How many sets?
    - 3.5. About how many times per month, on average, is each set irrigated over the course of the growing season?
        - 3.5.1. [Alternative] During the hottest/driest month, how many times is each set irrigated?

3.6. For how many hours is each set typically irrigated at a time?

3.7. What is the source of the irrigation water? (e.g. district water main, well, other (please elaborate), unknown)

3.8. How many pumps supply the water for the new irrigation system?

3.9. What is the total pumping horsepower for the new irrigation system?

3.10. How are the irrigation pumps controlled? (e.g. constant speed, two-speed, soft start, VFD, other (please elaborate))

3.11. About what discharge pressure (in psi) do the irrigation pumps currently operate at?

4. Micro System Details

4.1. Can you provide the make and model of the nozzles installed?

4.2. Do you recall the rated gallons-per-minute or gallons-per-hour of the nozzles?

4.2.1. [For tree crops] Can you estimate the number of trees per acre?

4.2.2. [For tree crops] How many nozzles are used per tree?

4.2.3. [Non-tree crops] Can you estimate the number of nozzles per acre?

5. Pre-project details

5.1. Was the farm's acreage divided into similar sets before the project?

5.1.1. [If no] How was the acreage divided before the project?

5.2. Were similar crops grown at the farm before the new irrigation system was installed?

5.2.1. [If no] What crops were grown before the project?

5.3. [If either pre or post is a tree crop] How old were the trees at the time of the project?

5.4. What type of irrigation system was in place before the project? (e.g. flood, furrow, sprinkler, drip)

5.4.1. [If sprinkler] Do you recall the make, model, or nozzle color of the old sprinkler nozzles?

5.4.2. [If flood/furrow] About how many inches deep did you flood the field during each irrigation?

5.5. [If different crop] At what month of the year did the old crop's growing season begin?

5.6. [If different crop] At what month of the year did the old crop's growing season end?

5.7. [If different crop] Did irrigation occur outside of the growing season?

5.7.1. [If yes] In which month did the old crop's irrigation begin?

5.7.2. [If yes] In which month did the old crop's irrigation end?

5.8. About how many times per month, on average, was each set irrigated over the course of the old crop's growing season?

5.8.1. [Alternative] During the hottest/driest month, how many times was each set irrigated?

5.9. For how many hours was each set typically irrigated at a time?

5.10. Did the irrigation water come from a different source before the project?

5.10.1. [If yes] What was the source of the irrigation water?

5.11. Was the irrigation pumping plant any different before the project?

5.11.1. [If yes] How many irrigation pumps supplied the water before the project?

5.11.2. [If yes] What was the total horsepower of the irrigation pumps?

5.11.3. [If yes] How were the irrigation pumps controlled? (e.g. constant speed, two-speed, soft start, VFD, other (please elaborate))

5.11.4. [If yes] Was the old pump powered by a PG&E electric meter?

5.12. About what pressure (in psi) did the irrigation pumps operate at before the project?

6. Program Questions

6.1. Why did you decide to participate in this program (In your own words)?

6.2. Did you decide to install these sprinklers BEFORE or AFTER you became aware of the program?

6.3. Could you please rate the importance of the following factors that might have influenced your decision to install these sprinklers through the program. Using a scale of 0 to 10, where 0 means not at all important and 10 means extremely important.

6.3.1. Age or condition of the old sprinklers

6.3.2. Availability of the incentive

6.3.3. Information provided from an audit of the facility

6.3.4. Recommendation from a vendor

6.3.5. Previous experience with an EE project

6.3.6. Previous experience with a utility program

6.3.7. Program training course

6.3.8. Program marketing materials

6.3.9. Standard practice

6.3.10. Suggestion by your account rep

6.3.11. Payback

6.3.12. Regular maintenance/replacement

6.3.13. Other factors?

6.4. What financial calculations does your organization make before proceeding with a project such as this one? Payback? Return on investment?

6.4.1. What is the required threshold in terms of payback or return on investment?

6.5. Was the rebate critical in moving the project within this range?

6.6. How important was it that payback be within this acceptable range on a scale of 0-10?

6.7. When deciding on this project, how important were program-related factors (e.g. rebate, audit, payback) in comparison to non-program factors (e.g. age/condition of equipment, previous program experience, corporate policy)? Please indicate a percentage of importance for either type of factor (i.e. 60% program-related, 40% non-program related).

6.8. If the program had not been available, what is the likelihood that you would have installed the same equipment as you did?

6.9. If the program had not been available, what is the likelihood that you would have installed the equipment at the same time as you did?

6.10. If the program had not been available what is the probability in percentage likelihood that you would have installed the equipment within one year?

6.11. If the program had not been available what is the probability in percentage likelihood that you would have installed the equipment within three years?

6.12. If the program had not been available what is the probability in percentage likelihood that you would have installed the equipment within five years?

6.13. What would you have done had the program not been available?

# APPENDIX B SITE REPORTS

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_TRK_999_0000030077 | Pre-project | 1 | 125 | 125 | Tomatoes and Peppers | 1 | District main | March | August | Furrow | 0 | 0 | Constant speed | 59,375 | 0 |
| Claim ID | 1 | Post-project | 2 | 62.5 | 125 | Tomatoes and Peppers | 1 | District main | March | August | Drip | 1 | 60 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing a gravity-driven furrow setup with a drip irrigation system used to irrigate tomatoes. Since the site contact confirmed that there were no electric pumps used for irrigation in the pre-project configuration, the project was deemed as ineligible per program rules.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | No electric use |
| 2 | |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_953_0000100362 | Pre-project | 3 | 24.8 | 74.3 | Misc. Field crops | 1 | Well | March | August | HP Sprinkler | 1 | 40 | Constant speed | 35,293 | 6,220 |
| Claim ID | 1 | Post-project | 3 | 24.8 | 74.3 | Almonds | 1 | Well | March | October | Micro-nozzle | 1 | 40 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles at the same time as a crop switch from miscellaneous field crops to almonds. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time after project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. The switch in crop type led to a significant increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program as well as lower pump hours of operation than anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in irrigation hours of operation |
| 2 | Difference in crop age |
| 3 | Difference in pump discharge pressure reduction |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_953_0000153588 | Pre-project | 5.5 | 14.5 | 80 | Tomatoes and Peppers | 1 | Well | March | August | HP Sprinkler | 1 | 60 | Constant speed | 38,000 | -9,905 |
| Claim ID | 1 | Post-project | 2 | 40 | 80 | Tomatoes and Peppers | 1 | Well | March | August | Drip | 1 | 60 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with a drip irrigation system used to irrigate tomatoes. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficien period of time before or after the project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. As there was no change in crop type, the baseline was determined to be the pre-project conditions described by the participant. However, evaluators determined a reduced number of irrigation sets in the post case, which resulted in higher-than-expected post-project electric demand on the drip irrigation system. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program as well as lower pump hours of operation than anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in pump discharge pressure reduction |
| 2 | Difference in irrigation hours of operation |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_959_0000254013 | Pre-project | 12 | 12.3 | 147 | Tomatoes and Peppers | 1 | Well | April | September | Furrow | 1 | 60 | Constant speed | 69,825 | -7,330 |
| Claim ID | 1 | Post-project | 4 | 36.8 | 147 | Tomatoes and Peppers | 1 | Well | April | September | Drip | 1 | 60 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing a furrow setup with a drip irrigation system used to irrigate tomatoes. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time after project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. As there was no change in crop type, the baseline was determined to be the pre-project conditions described by the participant. However, evaluators determined a reduced number of irrigation sets in the post case, which resulted in higher-than-expected post-project electric demand on the drip irrigation system. The reduced number of sets and lower-pressure irrigation method used in the pre-project case resulted in an overall energy penalty. Other discrepancies contributing to lower-than-expected savings include: a different pre-project irrigation method than anticipated by the program as well as lower pump hours of operation than anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Incorrect pre-project irrigation method |
| 2 | Difference in irrigation hours of operation |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_960_0000299552 | Pre-project | 2 | 46 | 92 | Walnuts | 3 | Well | March | November | HP Sprinkler | 2 | 250 | VFD | 67,252 | 12,450 |
| Claim ID | 1 | Post-project | 2 | 46 | 92 | Walnuts | 4 | Well | March | November | Micro-nozzle | 2 | 250 | VFD | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time prior to project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The age of the trees led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Overall, the primary discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in pump discharge pressure reduction |
| 2 | Difference in crop age |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_960_0000299580 | Pre-project | 1 | 25 | 25 | Walnuts | 3 | Well | March | November | HP Sprinkler | 1 | 30 | Constant speed | 18,619 | 6,893 |
| Claim ID | 1 | Post-project | 1 | 25 | 25 | Walnuts | 4 | Well | March | November | Micro-nozzle | 1 | 30 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time prior to project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The age of the trees led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Overall, the primary discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in crop age |
| 2 | Difference in pump discharge pressure reduction |
| 3 | 0 |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0000553055 | **Pre-project** | 1 | 100.5 | 100.5 | Rice | 1 | Well | April | September | Flood | 2 | 65.5 | Constant speed | 47,738 | 0 |
| **Claim ID** | 1 | **Post-project** | 4 | 25.1 | 100.5 | Tomatoes and Peppers | 1 | Well | May | September | Drip | 1 | 75 | VFD | | |

**Site Project Summary**

This project consisted of replacing a flood system with a drip irrigation system at the same time as a crop switch from rice to tomatoes. The site contact indicated that the pre-project pumps serving the flood system were diesel pumps. Since the site contact confirmed that there were no electric pumps used for irrigation in the pre-project configuration, the project was deemed as ineligible, per program eligibility requirements.

| Top Contributing Discrepancy Categories | |
|---|---|
| **1** | No electric use |
| **2** | |
| **3** | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0000604227 | **Pre-project** | 4 | 31 | 124 | Walnuts | 1 | Unknown | May | October | HP Sprinkler | 3 | 225 | Constant speed | 90,644 | 12,179 |
| **Claim ID** | 1 | **Post-project** | 4 | 31 | 124 | Walnuts | 2 | Unknown | May | October | Micro-nozzle | 3 | 225 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low-pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time after project installation. The evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. As there was no change in crop type, the baseline was determined to be the pre-project conditions described by the participant. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program as well as lower pump hours of operation than anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| **1** | Difference in crop age |
| **2** | Difference in pump discharge pressure reduction |
| **3** | Difference in irrigation hours of operation |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0000827247 | **Pre-project** | 1 | 51 | 51 | Almonds | 1 | Well | April | October | LP Sprinkler | 1 | 75 | VFD | 37,281 | 26,081 |
| **Claim ID** | 1 | **Post-project** | 1 | 51 | 51 | Almonds | 2 | Well | April | October | Drip | 1 | 75 | VFD | | |

**Site Project Summary**

This project consisted of replacing low-pressure sprinklers with a drip irrigation system used to irrigate almond trees. While evaluators confirmed that drip emitters were installed, program tracking data indicated that micro-nozzles were to be installed. Billing data provided was insufficient for analyzing the impacts of the project. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. As there was no change in the crop type, the baseline was determined to be the pre-project conditions described by the participant. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program, lower pump hours of operation than anticipated by the program, and an incorrect classification of the post-project irrigation method.

| Top Contributing Discrepancy Categories | |
|---|---|
| **1** | Incorrect post-project irrigation method |
| **2** | Difference in pump discharge pressure reduction |
| **3** | Difference in irrigation hours of operation |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_959_0000847533 | Pre-project | 2 | 96 | 192 | Walnuts | 1 | Well | May | October | Drip | 2 | 20 | Constant speed | 91,200 | -7,157 |
| Claim ID | 1 | Post-project | 1 | 192 | 192 | Walnuts | 1 | Well | March | August | Micro-nozzle | 1 | 100 | VFD | | |

**Site Project Summary**

This project consisted of replacing a drip irrigation system with low-pressure micro-nozzles used to irrigate walnut trees. The provided billing data included over a year's worth of both pre- and post-project electric usage. Billing data was used to analyze the impacts of the project after being normalized to account for differences in the pre- and post-project crop age and subsequent water requirement. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. The reduced number of sets and an increase in the discharge pressure from converting from drip to micro-nozzle resulted in a higher post-project electric usage. Additional discrepancies contributing to lower-than-expected savings include: an incorrect classification of the pre-project irrigation method (drip instead of high-pressure sprinklers) as well as lower pump hours of operation than anticipated by the program.

**Top Contributing Discrepancy Categories**

1. Difference in irrigation hours of operation
2. Incorrect pre-project irrigation method
3.

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_953_0000951404 | Pre-project | 1 | 120 | 120 | Alfalfa, Hay and Clover | 1 | District main | March | September | Flood | 0 | 0 | Unknown | 57,000 | 0 |
| Claim ID | 1 | Post-project | 1 | 120 | 120 | Tomatoes and Peppers | 1 | District main | May | September | Drip | 1 | 140 | Constant speed | | |

**Site Project Summary**

This project consisted replacing a flood irrigation system with a low-pressure drip irrigation system at the same as a crop switch from alfalfa to tomatoes. This site was deemed ineligible due to use of a diesel pump to irrigate crops both before and after the project took place, per the program's eligibility requirements.

**Top Contributing Discrepancy Categories**

1. No electric use
2.
3.

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_959_0000963625 | Pre-project | 1 | 28 | 28 | Walnuts | 4 | Well | March | November | HP Sprinkler | 2 | 50 | Constant speed | 20,468 | 20,423 |
| Claim ID | 1 | Post-project | 1 | 28 | 28 | Walnuts | 5 | Well | March | November | Micro-nozzle | 2 | 50 | Constant speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low-pressure micro-nozzles used to irrigate walnut trees. The provided billing data included over a year's worth of both pre- and post-project electric usage. Billing data was used to analyze the impacts of the project after being normalized to account for differences in the pre- and post-project crop age and subsequent water requirement. The main discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program.

**Top Contributing Discrepancy Categories**

1. Difference in pump discharge pressure reduction
2.
3.

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_959_0001020853 | Pre-project | 2 | 22.5 | 45 | Walnuts | 4 | Well | May | September | HP Sprinkler | 1 | 65 | Constant speed | 43,129 | 20,551 |
| Claim ID | 1 | Post-project | 1 | 45 | 45 | Walnuts | 5 | Well | May | September | Micro-nozzle | 1 | 65 | VFD | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with a low-pressure micro-nozzle system used to irrigate walnut trees. The provided billing data included over a year's worth of both pre- and post-project electric usage. Billing data was used to analyze the impacts of the project after being normalized to account for differences in the pre- and post-project crop age and subsequent water requirement. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. Several discrepancies contributed to lower-than-expected savings including: a difference in the affected field acreage (the respondent stated the installed project was completed for 45 acres rather than the previously reported 59 acres), the reported savings being equal to or greater than the annual billed usage of the affected pump (possibly due to incorrect account number on application), and pump hours of operation being lower than anticipated by the program.

**Top Contributing Discrepancy Categories**

1. Difference in affected field acreage
2. Reported savings greater than annual billed usage
3. Difference in irrigation hours of operation

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_936_0001025614 | Pre-project | 1 | 400 | 400 | Misc. Field crops | 1 | Well | November | April | Drip | 3 | 1800 | VFD | 190,000 | 0 |
| Claim ID | 1 | Post-project | 1 | 400 | 400 | Misc. Field crops | 1 | Well | November | April | Drip | 3 | 1800 | VFD | | |

**Site Project Summary**

This project consisted of the replacement of old drip tape with new drip tape. It is the farm's practice to replace their drip tape every 5 years. The farm plants a variety of field crops, including lettuce, melons, garlic, and onions. The evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. Since no changes in crop or irrigation method occurred as a result of the project, the evaluated impact is zero.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Incorrect pre-project irrigation method |
| 2 | Difference in irrigation hours of operation |
| 3 | Incorrect post-project irrigation method |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_959_0001064568 | Pre-project | 3 | 53.3 | 160 | Walnuts | 3 | Well | March | November | HP Sprinkler | 1 | 125 | Constant Speed | 116,938 | 92,173 |
| Claim ID | 1 | Post-project | 3 | 53.3 | 160 | Walnuts | 4 | Well | March | November | Micro-nozzle | 1 | 125 | Constant Speed | | |

**Site Project Summary**

This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. The provided billing data included over a year's worth of both pre- and post-project electric usage. Billing data was used to analyze the impacts of the project after being normalized to account for differences in the pre- and post-project crop age and subsequent water requirement. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program as well as a difference in crop age that was not anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in pump discharge pressure reduction |
| 2 | |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_952_0001235048 | Pre-project | 2.5 | 46.8 | 117 | Melons, Squash, Cucumbers | 1 | Well | April | October | Drip | 1 | 75 | Constant speed | 0 | -9,927 |
| Claim ID | 1 | Post-project | 2.5 | 46.8 | 117 | Corn and Grain Sorghum | 1 | Well | April | October | Drip | 1 | 100 | Two speed | | |

**Site Project Summary**

This project consisted of the replacement of old drip tape with new drip tape at the same time as a crop switch from pumpkins to corn. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time before and after project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. The switch in crop type led to a significant increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project’s impacts. Perhaps as a result of the drip-to-drip replacement, the program claimed 0 savings for this project, although this could not be confirmed. However, the evaluators determined negative impacts from the project, due primarily to the switch in crop type and a different pre-project irrigation method than anticipated by the program.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Switch in crop type |
| 2 | Incorrect pre-project irrigation method |
| 3 | Difference in pump discharge pressure reduction |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| trackSiteID | PGE_NRF_939_0003906706 | Pre-project | 1 | 16.2 | 16.2 | Misc. Field crops | 1 | Well | November | March | Drip | 5 | 800 | VFD | 5,135 | -506 |
| Claim ID | 1 | Post-project | 1 | 16.2 | 16.2 | Misc. Field crops | 1 | Well | November | March | Micro-nozzle | 5 | 800 | VFD | | |

**Site Project Summary**

This project consisted of replacing a drip irrigation system with micro-nozzles used to irrigate field crops on a small portion of a large farm. Since the area affected by the project is such a small portion relative to the total acreage served by the pump (<5%), utility bills could not be used to assess this project's impacts, and evaluators therefore chose to perform a theoretical assessment of the project using information gathered during the interview. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. The major discrepancy contributing to slightly negative energy impact is lower pump hours of operation than anticipated by the program and the fact that a drip irrigation system, not a high-pressure nozzle system, was replaced with micro-nozzles.

| Top Contributing Discrepancy Categories | |
|---|---|
| 1 | Difference in irrigation hours of operation |
| 2 | Incorrect pre-project irrigation method |
| 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_936_0005621999 | **Pre-project** | 1 | 570 | 570 | Misc. Field crops | 1 | Well | November | April | Drip | 3 | 1800 | VFD | 270,750 | 0 |
| **Claim ID** | 1 | **Post-project** | 1 | 570 | 570 | Misc. Field crops | 1 | Well | November | April | Drip | 3 | 1800 | VFD | | |

| Site Project Summary | Top Contributing Discrepancy Categories | |
|---|---|---|
| This project consisted of the replacement of old drip tape with new drip tape. It is the farm's practice to replace their drip tape every 5 years. The farm plants a variety of field crops, including lettuce, melons, garlic, and onions. The evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, irrigation schedule, and pre-project irrigation characteristics. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. Since no changes in crop or irrigation method occurred as a result of the project, the evaluated impact is zero. | 1 | Incorrect pre-project irrigation method |
| | 2 | Difference in irrigation hours of operation |
| | 3 | Incorrect post-project irrigation method |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_956_0005626273 | **Pre-project** | 4 | 18 | 72 | Walnuts | 3 | Well | March | November | HP Sprinkler | 4 | 500 | VFD | 52,632 | 4,872 |
| **Claim ID** | 1 | **Post-project** | 4 | 18 | 72 | Walnuts | 4 | Well | March | November | Micro-nozzle | 4 | 500 | VFD | | |

| Site Project Summary | Top Contributing Discrepancy Categories | |
|---|---|---|
| This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time prior to project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The age of the trees led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Overall, the primary discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program. | 1 | Difference in crop age |
| | 2 | Difference in pump discharge pressure reduction |
| | 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0005626298 | **Pre-project** | 2 | 192.5 | 385 | Walnuts | 3 | Well | March | November | HP Sprinkler | 2 | 250 | VFD | 281,435 | 52,100 |
| **Claim ID** | 1 | **Post-project** | 2 | 192.5 | 385 | Walnuts | 4 | Well | March | November | Micro-nozzle | 2 | 250 | VFD | | |

| Site Project Summary | Top Contributing Discrepancy Categories | |
|---|---|---|
| This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time prior to project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The age of the trees led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Overall, the primary discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program. | 1 | Difference in crop age |
| | 2 | Difference in pump discharge pressure reduction |
| | 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_960_0005681005 | **Pre-project** | 1 | 17.6 | 17.6 | Walnuts | 3 | Well | March | November | HP Sprinkler | 1 | 15 | Constant speed | 12,858 | 4,761 |
| **Claim ID** | 1 | **Post-project** | 1 | 17.6 | 17.6 | Walnuts | 4 | Well | March | November | Micro-nozzle | 1 | 15 | Constant speed | | |

| Site Project Summary | Top Contributing Discrepancy Categories | |
|---|---|---|
| This project consisted of replacing high-pressure sprinklers with low pressure micro-nozzles used to irrigate walnut trees. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient period of time prior to project installation. Therefore, the evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The age of the trees led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Overall, the primary discrepancy contributing to lower-than-expected savings was a lower pump discharge pressure reduction than anticipated by program. | 1 | Difference in crop age |
| | 2 | Difference in pump discharge pressure reduction |
| | 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0005689268 | **Pre-project** | 1 | 125 | 125 | Grain and Grain Hay | 1 | Well | May | September | Flood | 1 | 40 | Unknown | 91,375 | 27,387 |
| **Claim ID** | 1 | **Post-project** | 6 | 20.8 | 125 | Walnuts | 1 | Well | March | October | Micro-nozzle | 2 | 125 | VFD | | |

| Site Project Summary | | Top Contributing Discrepancy Categories |
|---|---|---|
| This project consisted of replacing a flood irrigation system with low-pressure micro-nozzles at the same time as a crop switch from grains to walnuts. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient amount of time prior to project installation. The evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The switch in crop type led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Th evaluators determined an increase in discharge pressure in switching from flood to nozzles and expected the project to result in negative energy savings. However the increase in the number of sets reduced the volume of water required at any one time which resulted in lower pumping work and subsequent positive energy savings. Additional discrepancies contributing to lower-than-expected savings include: an incorrect classification of the pre-project irrigation method, the switch in crop type, and lower pump hours of operation than anticipated by the program. | 1 | Incorrect pre-project irrigation method |
| | 2 | Switch in crop type |
| | 3 | Difference in irrigation hours of operation |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_953_0005706632 | **Pre-project** | 5.5 | 14.5 | 80 | Tomatoes and Peppers | 1 | Well | March | August | HP Sprinkler | 1 | 60 | Constant speed | 38,000 | -9,905 |
| **Claim ID** | 1 | **Post-project** | 2 | 40 | 80 | Tomatoes and Peppers | 1 | Well | March | August | Drip | 1 | 60 | Constant speed | | |

| Site Project Summary | | Top Contributing Discrepancy Categories |
|---|---|---|
| This project consisted of replacing high-pressure sprinklers with a drip irrigation system used to irrigate tomatoes. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficien amount of time prior to project installation. The evaluators chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. As there was no switch in crop type, the baseline was determined to be the pre-project conditions described by the participant. The reduced number of sets in the post case led to more work for the pump and subsequently higher post-project electric usage with the drip irrigation system. Discrepancies contributing to lower-than-expected savings include: a lower pump discharge pressure reduction than anticipated by program as well as lower pump hours of operation than anticipated by the program. | 1 | Difference in pump discharge pressure reduction |
| | 2 | Difference in irrigation hours of operation |
| | 3 | |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_NRF_959_0006204002 | **Pre-project** | 1 | 173 | 173 | Alfalfa, Hay and Clover | 1 | Well | March | November | Flood | 2 | 200 | Constant speed | 126,463 | -4,421 |
| **Claim ID** | 1 | **Post-project** | 2.67 | 64.9 | 173 | Almonds | 2 | Well | February | October | Micro-nozzle | 2 | 250 | VFD | | |

| Site Project Summary | | Top Contributing Discrepancy Categories |
|---|---|---|
| This project consisted of replacing a flood system with low-pressure micro-nozzles at the same time as a crop switch from alfalfa to almonds. Billing data provided was insufficient for analyzing the impacts of the project, as it did not cover a sufficient amount of time prior to project installation. The evaluators therefore chose to perform a normalized analysis using information gathered during the interview: crop type, crop age, and irrigation schedule. The switch in crop type led to an increase in water requirement, and the baseline electric usage was therefore normalized to reflect the post case water requirement to accurately assess the project's impacts. Th increased number of sets in the post case yielded a lower pump power requirement with the micro-nozzle system; however, the increased discharge pressure of the post-project system resulted in negative energy savings overall. Additional discrepancies contributing to lower-than-expected savings include: an incorrect classification of the pre-project irrigation method, the switch in crop type, and lower pump hours of operation than anticipated by the program. | 1 | Incorrect pre-project irrigation method |
| | 2 | Switch in crop type |
| | 3 | Difference in irrigation hours of operation |

| Project Identifiers | | Operating Scenario | # of Sets | Average Acreage/Set | Total Acreage | Crop Type | Crop Age | Water Source | Irrigation Season Start | Irrigation Season End | Irrigation Method | # of Pumps | Total Rated HP | Pump Control Method | Ex Ante First Year kWh Impact | Ex Post First Year kWh Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **trackSiteID** | PGE_TRK_999_0000030077 | **Pre-project** | 1 | 75 | 75 | Tomatoes and Peppers | 1 | District main | March | August | Furrow | 1 | 40 | Constant speed | 35,625 | 0 |
| **Claim ID** | 2 | **Post-project** | 2 | 37.5 | 75 | Tomatoes and Peppers | 1 | District main | March | August | Micro-nozzle | 1 | 40 | Constant speed | | |

| Site Project Summary | | Top Contributing Discrepancy Categories |
|---|---|---|
| This project consisted of replacing a gravity-driven furrow setup with a drip irrigation system used to irrigate tomatoes. Since the site contact confirmed that there were no electric pumps used for irrigation in the pre-project configuration, the project was deemed as ineligible per program rules. | 1 | No electric use |
| | 2 | |
| | 3 | |

|  |  | Overall |  |
| --- | --- | --- | --- |
| **Discrepancy Category** | **Explanation of Discrepancy** | **# Instances** | **Impact on GRR** |
| Difference in affected field acreage | The evaluators found that the impacted field acreage was different than the value obtained from the CATI survey. | 1 | -0.3% |
| Difference in crop age | The evaluators found that the crop's age (i.e. water requirement) was different than the program's deemed value. | 7 | -5.0% |
| Difference in irrigation hours of operation | The evaluators found that the pump hours of operation were different than the program's deemed values. | 13 | -16.5% |
| Difference in pump discharge pressure reduction | The evaluators found the the reduction in pump discharge pressure was different than the program's deemed value. | 12 | -10.0% |
| Incorrect post-project irrigation method | The evaluators found that the post-project irrigation method was mischaracterized by the program. | 3 | -6.4% |
| Incorrect pre-project irrigation method | The evaluators found that the pre-project irrigation method was mischaracterized by the program. | 8 | -34.2% |
| No electric use | The evaluators found that the pre- or post-project irrigation method did not use an electric powered pump. | 4 | -12.5% |
| Switch in crop type | The evaluators found that a crop switch had occurred in conjunction with the project installation. | 3 | -1.9% |
| Reported savings greater than annual billed usage | The evaluators found that the savings claimed by the program exceeded the facility's annual energy usage. | 1 | -0.2% |
|  | **Total** | **52** | **-87.0%** |

# APPENDIX C NTG MATERIALS

# NET-TO-GROSS APPENDIX MATERIALS

This appendix includes the following documents:

The Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers, developed by the Nonresidential Net-to-Gross Working Group in October 2012, which describes the algorithm used to estimate the NTGRs. This method has been used for the 2013-15 ESPI nonresidential impact evaluations.

The net-to-gross ratios and corresponding program attribution index scores for all interview respondents.

An example calculation for a NTGR score. Note that an excel version of this calculator was posted to the Commercial PCG Basecamp project on January 30th, 2017.

# Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers

**Prepared for the Energy Division, California Public Utilities Commission**

**By**

**The Nonresidential Net-To-Gross Ratio Working Group**

**October 16, 2012**

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## Acknowledgments

As part of the evaluation of the 2010-12 energy efficiency programs designed and implemented by the four investor-owned utilities (Pacific Gas & Electric Company, Southern California Edison Company, Southern California Gas Company, and San Diego Gas and Electric Company) and third parties, the Energy Division of the California Public Utilities Commission (CPUC) re-formed the nonresidential net-to-gross ratio working group that was originally formed during the PY2006-2008 evaluation. The main purpose of this group was to furtherrefine and improve the standard net-to-gross methodological framework that was developed during the PY2006-2008 evaluation cycle. This framework includes decision rules, for integrating in a systematic and consistent manner the findings from both quantitative and qualitative information in estimating net-to-gross ratios. The working group, listed alphabetically, is composed of the following evaluation professionals:

- Jennifer Fagan, Itron, Inc.
- Nikhil Gandhi, Strategic Energy Technologies, Inc.
- Kay Hardy, Energy Division, CPUC
- Jeff Hirsch, James J. Hirsch & Associates
- Richard Ridge, Ridge & Associates
- Mike Rufo, Itron, Inc.
- Claire Palmgren, KEMA
- Valerie Richardson, KEMA
- Philippus Willems, PWP, Inc.

A public webinar was conducted to obtain feedback from the four investor-owned utilities and other interested stakeholders. The questionnaire was then pre-tested and, based on the pre-test results, finalized in December 2011.

# 1. OVERVIEW OF THE LARGE NONRESIDENTIAL FREE RIDERSHIP APPROACH

The methodology described in this section was developed to address the unique needs of Large Nonresidential customer projects developed through energy efficiency programs offered by the four California investor-owned utilities and third-parties. This method relies exclusively on the Self-Report Approach (SRA) to estimate project and program-level Net-to-Gross Ratios (NTGRs), since other available methods and research designs are generally not feasible for large nonresidential customer programs. This methodology provides a standard framework, including decision rules, for integrating findings from both quantitative and qualitative information in the calculation of the net-to-gross ratio in a systematic and consistent manner. This approach is designed to fully comply with the *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (Protocols) and the *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches* (Guidelines)**.**

This approach preserves the most important elements of the approaches previously used to estimate the NTGRs in large nonresidential customer programs. However, it also incorporates several enhancements that are designed to improve upon that approach, for example:

- The method incorporates a 0 to 10 scoring system for key questions used to estimate the NTGR, rather than using fixed categories that are assigned weights.

- The method asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy efficiency decision making, rather than focusing narrowly on only their rating of the program's importance. This question structure more accurately reflects the complex nature of the real-world decision making and should help to ensure that all non-program influences are reflected in the NTGR assessment in addition to program influences.

*It is important to note that the NTGR approach described in this document is a general framework, designed to address all large nonresidential programs. In order to implement this approach on a program-specific basis, it also needs to be customized to reflect the unique nature of the individual programs.*

# 2. BASIS FOR SRA IN SOCIAL SCIENCE LITERATURE

The social sciences literature provides strong support for use of the methods used in the SRA to assess program influence. As the *Guidelines* notes,

> More specifically, the SRA is a mixed method approach that involves asking one or more key participant decision-makers a series of structured and open-ended questions about whether they would have installed the same EE equipment in the

absence of the program as well as questions that attempt to rule out rival explanations for the installation (Weiss, 1972; Scriven, 1976; Shadish, 1991; Wholey et al., 1994; Yin, 1994; Mohr, 1995). In the simplest case (e.g., residential customers), the SRA is based primarily on quantitative data while in more complex cases the SRA is strengthened by the inclusion of additional quantitative and qualitative data which can include, among others, in-depth, open-ended interviews, direct observation, and review of program records. Many evaluators believe that additional qualitative data regarding the economics of the customer's decision and the decision process itself can be very useful in supporting or modifying quantitatively-based results (Britan, 1978; Weiss and Rein, 1972; Patton, 1987; Tashakkori and Teddlie, 1998).[1]

More details regarding the philosophical and methodological underpinnings of this approach are in Ridge, Willems and Fagan (2009), Ridge, Willems, Fagan and Randazzo (2009) and Megdal, Patil, Gregoire, Meissner, and Parlin (2009). In addition to these two articles, Appendix A provides an extensive listing of references in the social sciences literature regarding the methods employed in the SRA.

# 3. FREE RIDERSHIP ANALYSIS BY PROJECT TYPE

There are three levels of free-ridership analysis. The most detailed level of analysis, the **Standard – Very Large Project** NTGR, is applied to the largest and most complex projects (representing 10 to 20% of the total) with the greatest expected levels of gross savings[2] The **Standard** NTGR, involving a somewhat less detailed level of analysis, is applied to projects with moderately high levels of gross savings. The least detailed analysis, the **Basic** NTGR, is applied to all remaining projects. Evaluators must exercise their own discretion as to what the appropriate thresholds should be for each of these three levels.

# 4. SOURCES OF INFORMATION ON FREE RIDERSHIP

There are five sources of free-ridership information in this study. Each level of analysis relies on information from one or more of these sources. These sources are described below.

1. **Program Files**. As described in previous sections of this report, programs often maintain a paper file for each paid application. These can contain various pieces of information which are relevant to the analysis of free-ridership, such as letters written by the utility's customer representatives that document what the customer had planned to do in the absence of the rebate and explain the customer's motivation for implementing the efficiency measure. Information on the measure payback with and without the rebate may also be available.

[1] *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches*, October 15, 2007, pg. 3.

[2] Note that we do not refer to an Enhanced level of analysis, since this is defined by the Protocols to involve the application of two separate analysis approaches, such as billing analysis or discrete choice modeling.

2. **Decision-Maker Surveys**. When a site is recruited, one must also determine who was involved in the decision-making process which led to the implementation of measures under the program. They are asked to complete a Decision Maker survey. This survey obtains highly structured responses concerning the probability that the customer would have implemented the same measure in the absence of the program. First, participants are asked about the timing of their program awareness relative to their decision to purchase or implement the energy efficiency measure. Next, they are asked to rate the importance of the program versus non-program influences in their decision making. Third, they are asked to rate the significance of various factors and events that may have led to their decision to implement the energy efficiency measure at the time that they did. These include:

   - the age or condition of the equipment,
   - information from a feasibility study or facility audit
   - the availability of an incentive or endorsement through the program
   - a recommendation from an equipment supplier, auditor or consulting engineer
   - their previous experience with the program or measure,
   - information from a program-sponsored training course or marketing materials provided by the program
   - the measure being included as part of a major remodeling project
   - a suggestion from program staff, a program vendor, or a utility representative
   - a standard business practice
   - an internal business procedure or policy
   - stated concerns about global warming or the environment
   - a stated desire to achieve energy independence.

   In addition, the survey obtains a description of what the customer would have done in the absence of the program, beginning with whether the implementation was an early replacement action. If it was not, the decision maker is asked to provide a description of what equipment would have been implemented in the absence of the program, including both the efficiency level and quantities of these alternative measures. This is used to adjust the gross engineering savings estimate for partial free ridership, as discussed in Section 5.2.

   This survey contains a core set of questions for **Basic** NTGR sites, and several supplemental questions for both **Standard and Standard – Very Large** NTGR sites For example, if a Standard or Standard-Very Large respondent indicates that a financial calculation entered highly into their decision, they are asked additional questions about their *financial criteria* for investments and their rationale for the current project in light of them. Similarly, if they respond that a *corporate policy* was a primary consideration in their decision, they are asked a series of questions about the specific policy that led to their adoption of the installed measure. If they indicate the installation was a *standard practice*, there are supplemental questions to understand the origin and evolution of that standard practice within their organization. These questions are intended to provide a deeper understanding of the decision making process and the likely level of program influence versus these internal policies and procedures. Responses to these questions also serve as a basis for consistency checks to investigate conflicting answers regarding the relative importance of the program and other elements in influencing the decision. In addition, **Standard – Very Large** sites may receive additional detailed probing on various aspects of their installation decision based on industry- or technology-specific issues, as determined by review of other information sources. For Standard-Very Large sites all these data are used to construct an internally consistent "story" that supports the NTGR calculated based on the overall information given.

3. **Vendor Surveys**. A Vendor Survey is completed for all **Standard** and **Standard-Very Large** NTGR sites that utilized vendors, and for **Basic** NTGR sites that indicate a high level of vendor influence in the decision to implement the energy efficient measure. For those sites that indicate the vendor was very influential in decision making, the vendor survey results enter directly into the NTGR scoring. The vendor survey findings are also be used to corroborate Decision Maker findings, particularly with respect to the vendor's specific role and degree of influence on the decision to implement the energy efficient measure. Vendors are queried on the program's significance in their decision to recommend the energy efficient measures, and on their likelihood to have recommended the same measure in the absence of the program. Generally, the vendors contacted as part of this study are contractors, design engineers, distributors, and installers.

4. **Utility and Program Staff Interviews**. For the Standard and Standard-Very Large NTGR analyses, interviews with utility staff and program staff are also conducted. These interviews are designed to gather information on the historical background of the customer's decision to install the efficient equipment, the role of the utility and program staff in this decision, and the name and contact information of vendors who were involved in the specification and installation of the equipment.

5. **Other information**. For **Standard – Very Large Project** NTGR sites, secondary research of other pertinent data sources is performed. For example, this could include a review of standard and best practices through industry associations, industry experts, and information from secondary sources (such as the U.S. Department of Energy's Industrial Technologies Program, Best Practices website URL, http://www1.eere.energy.gov/industry/bestpractices/). In addition, the Standard- Very Large NTGR analysis calls for interviews with other employees at the participant's firm, sometimes in other states, and equipment vendor experts from other states where the rebated equipment is being installed (some without rebates), to provide further input on standard practice within each company.

Table 1 below shows the data sources used in each of the three levels of free-ridership analysis. Although more than one level of analysis may share the same source, the amount of information that is utilized in the analysis may vary. For example, all three levels of analysis obtain core question data from the Decision Maker survey.

**Table 1: Information Sources for Three Levels of NTGR Analysis**

| | Program File | Decision Maker Survey Core Question | Vendor Surveys | Decision Maker Survey Supplemental Questions | Utility & Program Staff Interviews | Other Research Findings |
|---|---|---|---|---|---|---|
| Basic NTGR | √ | √ | √[1] | | √[2] | |
| Standard NTGR | √ | √ | √[1] | √ | √ | |
| Standard NTGR - Very Large Projects | √ | √ | √[3] | √ | √ | √ |

[1]Only performed for sites that indicate a vendor influence score (N3d) greater than maximum of the other program element scores (N3b, N3c, N3g, N3h, N3l).

[2]Only performed for sites that have a utility account representative

[3]Only performed if significant vendor influence reported or if secondary research indicates the installed measure may be becoming standard practice.

A copy of the complete survey forms (with lead-in text and skip patterns) are available upon request.

# 5. NTGR FRAMEWORK

The Self-Report-based Net-to-Gross analysis relies on responses to a series of survey questions that are designed to measure the influence of the program on the participant's decision to implement program-eligible energy efficiency measure(s). Based on these responses, a NTGR is derived based on responses to a set of "core" NTGR questions.

## 5.1. NTGR Questions and Scoring Algorithm

A self-report NTGR is computed for all NTGR levels using the following approach. Adjustments may be made for **Standard – Very Large** NTGR sites, if the additional information that is collected is inconsistent with information provided through the Decision Maker survey.

The NTGR is calculated as an average of three scores. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure.

- **Program attribution index 1 (PAI–1) score** that reflects the influence of the **most important** of various program and program-related elements in the customer's decision to select the specific program measure at this time. Program influence through vendor recommendations is also incorporated in this score.

- **Program attribution index 2 (PAI–2) score** that captures the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program.

- **Program attribution index 2 (PAI–3) score** that captures the likelihood of various actions the customer might have taken at this time and in the future if the program had not been available (the counterfactual).

When there are multiple questions that feed into the scoring algorithm, as is the case for both the **PAI-1** and **PAI-3** scores, the maximum score is always used. The rationale for using the maximum value is to capture the most important element in the participant's decision making. Thus, each score is always based on the strongest influence indicated by the respondent. However, high scores that are inconsistent with other previous responses trigger consistency checks and can lead to follow-up questions to clarify and resolve the discrepancy.

The calculation of each of the above scores is discussed below. For each score, the associated questions are presented and the computation of each score is described.

#### 5.1.1. PAI–1 score

**For the Decision Maker, the questions asked are:**
*I'm going to ask you to rate the importance of the program as well as other factors that might influence your decision to implement [MEASURE.] Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.*

Now, using this 0 to 10 rating scale, where 0 means "Not at all important" and 10 means "Very important," please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.

- Availability of the PROGRAM rebate

- Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through PROGRAM

- Information from PROGRAM training course

- Information from other PROGRAM marketing materials
- Suggestion from program staff
- Suggestion from your account rep
- Recommendation from a vendor/supplier (If a score of greater than 5 is given, a vendor interview is triggered)

**For the Vendor, the questions asked (if the interview is triggered) are:**
*I'm going to ask you to rate the importance of the [PROGRAM] in influencing your decision to recommend [MEASURE] to [CUSTOMER] and other customers. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.*

1. Using this 0 to 10 scale where 0 is 'Not at all important" and 10 is "Very Important," how important was the PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?
2. And using a 0 to 10 likelihood scale, where 0 denotes "not at all likely" and 10 denotes "very likely," if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?
3. Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend MEASURE before you learned about the [PROGRAM]?
4. And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend MEASURE now that you have worked with the [PROGRAM]?
5. And, using the same 0 to 10 scale where 0 is "Not at all important" and 10 is "Very important", how important in your recommendation were:
   a. Training seminars provided by UTILITY?
   b. Information provided by the UTILITY website?
   c. Your firm's past participation in a rebate or audit program sponsored by UTILITY?

If the Vendor interview is triggered, a score is calculated that captures the highest degree of program influence on the vendor's recommendation. This score (VMAX) is calculated as the MAXIMUM value of the following:

1. The response to question 1
2. 10 minus the response to question 2
3. The response to question 4 minus the response to question 3, divided by 10
4. The response to question 5a.
5. The response to question 5b.
6. The response to question 5c.

Note that vendors are asked an additional question regarding other ways that their recommendations regarding the measure might have been influenced. Their responses are not used in the direct calculation of the NTGR but are potentially useful in making adjustments to the core NTGR.

**The PAI–1 score is calculated as:**
The highest program influence score divided by the sum of the highest program influences (i.e., the responses to the first six decision maker questions) plus the highest non-program influence score, multiplied by 10. and, if the vendor interview has been triggered, the VMAX score multiplied by the score the decision makers assigned to the vendor recommendation.

#### 5.1.2. PAI–2 score

**The questions asked are**:

1. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

2. Now I'd like to ask you a last question about the importance of the program to your decision as opposed to other factors that may have influenced your decision. Again using the 0 to 10 rating scale we used earlier, where 0 means “Not at all important” and 10 means “Very important,” please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

**The PAI–2 score is calculated as:**
The importance of the program, on the 0 to 10 scale, to question 2. This score is reduced by half if the respondent learned about the program after the decision had been made.

#### 5.1.3. PAI–3 Score

**The questions asked are:**

1. Now I would like you to think about the action you would have taken with regard to the installation of this equipment if the &PROGRAM had not been available.

Using a likelihood scale from 0 to 10, where 0 is “Not at all likely” and 10 is “Extremely likely”, if PROGRAM had not been available, what is the likelihood that you would have installed exactly the same program-qualifying efficiency equipment that you did in this project?

**The PAI-3 score is calculated as:**

10 minus the likelihood of installing the same equipment

#### 5.1.4. The Core NTGR

The self-reported core NTGR in most cases is simply the average of the PAI-1, PAI-2, and PAI-3 scores, divided by 10. The one exception to this is when the respondent indicates a 10 in 10 probability of installing the same equipment at the same time in the absence of the program, in which case the NTGR is based on the average of the PAI-2 and PAI-3 scores only.

## 5.2. Data Analysis and Integration

The calculation of the Core NTGR is fairly mechanical and is based on the answers to the closed-ended questions. However, the reliance of the Standard NTGR – Very Large on more information from so many different sources requires more of a case study level of effort. The SRA Guidelines point out that a case study is one method of assessing both quantitative and qualitative data in estimating a NTGR. A case study is an organized presentation of all these data available about a particular customer site with respect to all relevant aspects of the decision to install the efficient equipment. In such cases where multiple interviews are conducted eliciting both quantitative and qualitative data and a variety of program documentation has been collected, one will need to integrate all of this information into an internally consistent and coherent story that supports a specific NTGR.

The following data sources should be investigated and reviewed as appropriate to supplement the information collected through the decision maker interviews.

- Account Representative Interview
- Utility Program Manager/Staff Interview
- Utility Technical Contractor Interview
- Third party Program Manager Interview
- Evaluation Engineer Interview
- Gross Impact Site Plan/Analysis Review
- Corporate Green/Environmental Policy Review (if mentioned as important)
- Corporate Standard Practice Review (if mentioned as important)
- Industry Standard Practice Review (if mentioned as important)
- Corporate payback review (if mentioned as important)
- Review relevant codes and standards, including regulatory requirements
- Review industry publications, websites, reports such as the Commercial Energy Use Survey, historical purchase data of specific measures etc.

As detailed in the Self-Report NTGR Guidelines, when complementing the quantitative analysis of free-ridership with additional quantitative and qualitative data from multiple respondents and other sources, there are some basic concerns that one must keep in mind. Some of the other data – including interviews with third parties who were involved in the decision to install the energy efficient equipment – may reveal important influences on the customer's decision to install the qualifying program measure. When one chooses to incorporate other data, one should keep the following principles in mind: 1) the method chosen should be balanced. That is, the method should allow for the possibility that the other influence can either increase or decrease the NTGR calculated from the decision maker survey responses, 2) the rules for deciding which customers will be examined for potential other influences should be balanced. In the case of Standard –Very Large interviews, all customers are subject to such a review, so that the pool of customers selected for such examination will not be biased towards ones for whom the evaluator believes the external influence will have the effect of influencing the NTGR in only one direction, 3) the plan for capturing other influences should be based on a well-conceived causal framework. The onus is on the evaluator to build a compelling case using a variety of quantitative and/or qualitative data for estimating a customer's NTGR.

**Establishing Rules for Data Integration**

Before the analysis begins, the evaluation team should establish, to the extent feasible, rules for the integration of the quantitative and qualitative data. These rules should be as specific as possible and be strictly adhered to throughout the analysis. Such rules might include instructions regarding when the NTGR based on the quantitative data should be overridden based on qualitative data, how much qualitative data are needed to override the NTGR based on quantitative data, how to handle contradictory information provided by more than one person at a given site, how to handle situations when there is no decision-maker interview, when there is no appropriate decision-maker interview, or when there is critical missing data on the questionnaire, and how to incorporate qualitative information on deferred free-ridership.

One must recognize that it is difficult to anticipate all the situations that one may encounter during the analysis. As a result, one may refine existing rules or even develop new ones during the initial phase of the analysis. One must also recognize that it is difficult to develop algorithms that effectively integrate the quantitative and qualitative data. It is therefore necessary to use judgment in deciding how much weight to give to the quantitative versus qualitative data and how to integrate the two. The methodology and estimates, however, must contain methods to support the validity of the integration methods through preponderance of evidence or other rules/procedures as discussed above.

For the **Standard-Very Large** cases in the large Nonresidential programs, the quantitative data used in the NTGR Calculator (which calculates the "core" NTGR), together with other information collected from the decision maker regarding the installation decision, form the initial basis for the NTG "story" for each site. Note that in most cases, supplemental data such as tracking data, program application files and results of interviews with program/IOU staff and vendors, will have been completed before the decision maker is contacted and will help guide the non-quantitative questioning in the interview. In practice, this means that most potential inconsistencies between decision maker responses and other sources of information should have been resolved before the interview is complete and data are entered into the NTGR Calculator. For example, if a company has an aggressive "green" policy widely promoted on its website that is not mentioned by the decision makers, the interviewer will ask the respondent to clarify the role of that policy in the decision. Conversely, if the decision maker attributes the decision to install the equipment to a new company wide initiative rather than the program, yet there is no evidence of such an initiative reported by program staff, vendors, or the company's website, the decision maker will be asked to explain the discrepancy so that his or her responses can be changed if needed.

In some cases, however, it may be necessary to modify or override one of the scores contributing to the overall NTGR or the NTGR itself. Before this is done all quantitative and qualitative data will be systematically (and independently) analyzed by two experienced researchers who are familiar with the program, the individual site and the social science theory that underlies the decision maker survey instrument. Each will determine whether the additional information justifies modifying the previously calculated NTGR score, and will present any recommended modifications and their rationale in a well-organized manner, along with specific references to the supporting data. Again, it is important to note that the other influences can have the effect of either increasing or decreasing the NTGR calculated from the decision maker survey responses, and one should be skeptical about a consistent pattern of "corrections" in one direction or another.

Sometimes, *all* the quantitative and qualitative data will clearly point in the same direction while, in others, the *preponderance* of the data will point in the same direction. Other cases will be more ambiguous. In all cases, in order to maximize reliability, it is essential that more than one person be involved in analyzing the data. Each person must analyze the data separately and then compare and discuss the results. Important insights can emerge from the different ways in which two analysts look at the same set of data. Ultimately, differences must be resolved and a case made for a particular NTGR. Careful training of analysts in the systematic use of rules is essential to insure inter-rater reliability[3].

Once the individual analysts have completed their review, they meet to discuss their respective findings and present to the other the rationale for their recommended changes to the Calculator-derived NTGR. Key points of these arguments will be written down in summary form (e.g., Analyst 1 reviewed recent AQMD ruling and concluded that customer would have had to install the same measure within 2 years, not 3, thereby reducing NP score from 7.8 to 5.5) and also presented in greater detail in a workpaper so that an independent reviewer can understand and judge the data and the logic underlying each NTGR estimate. Equally important, the CPUC will have all the essential data to enable them to replicate the results, and if necessary, to derive their own estimates.

The outcome of the reconciliation by two analysts determines the final NTGR for a specific project. Again, the reasoning behind the "negotiated" final value must be thoroughly documented in a workpaper, while a more concise summary description of the rationale can be included in the NTGR Calculator workbook (e.g., Analyst 1 and Analyst 2 agreed that the NTGR score should have been higher than the calculated value of 0.45

[3] Inter-rater reliability is the extent to which two or more individuals (coders or raters) agree. Inter-rater reliability addresses the consistency of the implementation of a rating system.

because of extensive interaction between program technical staff and the customer, but they disagreed on whether this meant the NTGR should be .6 or .7. After discussion, they agreed on a NTGR of .65 as reflecting the extent of program influence on the decision).

In summary, it has been decided that supplemental data from non-core NTG questions collected through these surveys should be used in the following ways in the California Large Nonresidential evaluations:

- Vendor interview data will be used at times in the direct calculation of the NTGR. It will also be used to provide context and confirming/contradictory information for Standard-Very Large decision maker interviews.

- Qualitative and quantitative information from other sources (e.g., industry data, vendor estimates of sales in no-program areas, and other data as described above) may be used to alter core inputs only if contradictions are found with the core survey responses. Since judgments will have to be made in deciding which information is more compelling when there are contradictions, supplemental data are reviewed independently by two senior analysts, who then summarize their findings and recommendations and together reach a final NTGR value.

- Responses will also be used to construct a NTGR "story" around the project; that is they will help to provide the context and rationale for the project. This is particularly valuable in helping to provide guidance to program design for future years. It may be, for example, that responses to the core questions yield a high NTGR for a project, but additional information sources strongly suggest that the program qualifying technology has since become standard practice for the firm or industry, so that free ridership rates in future years are likely to be higher if program rules are not changed.

- Findings from other non-core NTGR questions (e.g., Payback Battery, Corporate Policy Battery) are also be used to **cross-check the consistency** of responses to core NTGR questions. When an inconsistency is found, it is presented to the Decision Maker respondent who is then be asked to explain and resolve it if they can. If they are not able to do so, their responses to the core NTGR question with the inconsistency may be overridden by the findings from these supplemental probes. These situations are handled on a case-by-case basis; however consistency checks are programmed into the CATI survey instrument used for the Basic and Standard cases.

Finally, some analysis of additional information beyond the close-ended questions that are used to calculate the Core NTGR could be done for the **Standard NTGR**. For example information regarding the financial criteria used to make capital investments, corporate policy regarding the purchase of energy efficiency equipment or the influence of standard practice in the same industry as the participant could be taken into account and used to make adjustments to the Core NTGR in a manner similar what is done for the Standard – Very Large NTGR.

## 5.3. Accounting for Partial Free Ridership

Partial free-ridership can occur when, in the absence of the program, the participant would have installed something more efficient than the program-assumed baseline efficiency but not as efficient as the item actually installed as a result of the program.

In situations where there is partial free ridership, the assumed baseline condition is affected. Absent partial free ridership, the assumed baseline would normally be based on existing equipment (in early replacement cases), on code requirements (in normal replace on burnout cases), or on a level above current code (e.g., this could be a market average or value purposefully set above code minimum but below market average; in this case, the definition and requirement would typically be defined by a specific program's baseline rules). In some cases, there may be a "dual" baseline (more specifically, a baseline that changes over the measure's EUL) if the project involves early replacement plus partial free ridership. In such cases, the baseline basis for estimating savings is the existing equipment over the remaining useful life (RUL) of the equipment, and then a baseline of likely intermediate efficiency equipment (e.g., code or above) for the remainder of the analysis period (i.e., the period equal to the EUL-RUL). When there is partial free ridership, the baseline equipment that would have been installed absent the program is of an intermediate efficiency level (resulting in lower energy savings than that assumed by the program if the program took in situ equipment efficiency as the basis for savings over the entire EUL). A related issue with respect to determination of the appropriate baseline is whether the adjustment made, if any, from the in situ or otherwise claimed baseline in the ex ante calculation, is whether the adjustment applies to the gross or net savings calculation.

**Assignment of Partial Free Ridership Effects to Gross versus Net.** In past evaluations, partial free ridership impacts have principally been incorporated into the net-to-gross ratio. This is because most partial free ridership is induced by market conditions, rather than by non-market factors. Market conditions refer primarily to standard adoption of a technology by a particular market segment or end user as a result of competitive market forces or other end user-specific factors. The key determining principle with respect to application of the adjustment to the net-to-gross ratio is whether there is a level of efficiency, below the efficiency of the measure for which savings are paid and claimed, but above what is required by code or minimum program baseline requirements that the end user would have implemented anyway without the program. Conditions that cause this adjustment to be made to gross savings rather than the net-to-gross ratio may include factors such as

- changing baseline equipment to meet changed business circumstances (such as increased production/throughput, changes in occupancy, etc.);
- compliance with environmental regulations, indoor air quality requirements, safety requirements; or
- the need to address an operational problem.

Each project should be examined separately for partial free ridership and a determination should be made based on the unique circumstances of each installation of whether an adjustment to gross savings or the net-to-gross ratio is warranted.

**Data Collection Procedures.** Information is gathered on partial free ridership using the following questions asked as part of the decision maker NTGR survey.

1. Now I would like you to think one last time about what action you would have taken if the program had not been available. Supposing that you had not installed the program qualifying equipment, which of the following alternatives would you have been MOST likely to do?
   a. Install fewer units
   b. Install standard efficiency equipment or whatever required by code
   c. Install equipment more efficient than code but less efficient than what you installed through the program
   d. repair/rewind or overhaul the existing equipment
   e. do nothing (keep the existing equipment as is)
   f. something else (specify what ______________)

2. (IF FEWER UNITS) How many fewer units would you have installed? (It is okay to take an answer such as ...HALF...or 10 percent fewer ... etc.)

3. (IF MORE EFFICIENT THAN CODE) Can you tell me what model or efficiency level you were considering as an alternative? (It is okay to take an answer such as … 10 percent more efficient than code or 10 percent less efficient than the program equipment)

4. (IF REPAIR/REWIND/OVERHAUL) How long do you think the repaired/rewound/refurbished equipment would have lasted before requiring replacement?

In addition, these same partial free ridership questions should be asked during the on-site audit for a given project. This latter interview will be conducted by the project engineers. The collected information helps the gross impact and NTG analysis teams gain a more complete understanding of the true project baseline and equipment selection decision. These decision maker questions are included in the Excel version of the CATI-based Standard and Basic decision maker survey instrument as well as in the Standard-Very Large instrument.

**Data Analysis and Integration Procedures.** In cases where partial free ridership is found and it is determined that the adjustment should be made to the net-to-gross ratio, the following procedure should be used:

On the net side, the adjustment is based on the intermediate baseline indicated by the decision maker for the time period in which the intermediate equipment would have been installed. The calculation of energy saved under this intermediate baseline is done, and then divided by the savings calculated under the in situ baseline. The resulting ratio is then multiplied by the initial NTGR which was previously calculated using only the ‘core’ scoring inputs. The effect of this adjustment is to reduce the NTGR further to reflect the effects of the revealed partial free ridership.

In all cases, the Gross Impacts and NTG analysis teams will need to carefully coordinate their calculations to ensure that they are not inadvertently adjusting the savings twice for the same partial free ridership, i.e., through adjustments both to the gross savings calculation and to the NTG ratio.

# 6. NTGR Interview Process

The NTGR surveys are conducted via telephone interviews. Highly-trained professionals with experience levels that are commensurate with the interview requirements should perform these interviews. Basic and Standard level interviews should be conducted by senior interviewers, who are highly experienced conducting telephone interviews of this type. Standard - Very Large interviews should be completed by professional consulting staff due to the complex nature of these projects and related decision making processes. More than likely, these will involve interviews of several entities involved in the project including the primary decision maker, vendor representatives, utility account executives, program staff and other decision influencers, as well as a review of market data to help establish an appropriate baseline.

All but the Standard -Very Large interviews should be conducted using computer-aided telephone interview (CATI) software. Use of a CATI approach has several advantages: (1) the surveys can be customized to reflect the unique characteristics of each program, and associated program descriptions, response categories, and skip patterns; (2) it drastically reduces inaccuracies associated with the more traditional paper and pencil method; and (3) the process of checking for inconsistent answers can be automated, with follow up prompts triggered when inconsistencies are found.

# 7. Compliance with Self-Report Guidelines

The proposed NTGR framework fully complies with all of the CPUC/ED and the MECT’s Guidelines for Estimating Net-to-Gross Ratios Using the Self-Report Approach.

## Appendix A

## References

Blalock, H. (1970). Estimating measurement error using multiple indicators and several points in time," *American Sociological Review*, 35, pp. 101-111.

Bogdan, Robert and Steven J. Taylor. (1975). *Introduction to qualitative research methods*. New York: John Wiley & Sons.

Britan, G. M. (1978). Experimental and contextual models of program evaluation. *Evaluation and Program Planning*, 1: 229-234.

Cochran, William G. (1977). *Sampling techniques*. New York: John Wiley & Sons.

Crocker, L. and J. Algina. (1986). *Introduction to classical and modern test theory*. New York: Holt, Rinehart & Winston.

Cronbach L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.

DeVellis, R.F. (1991). *Scale development: Theory and applications*. Newbury Park, CA: Sage Publications, Inc.

Duncan, O.D. (1984). *Notes on social measurement: Historical and critical*. New York: Russell Sage.

Guba, E. G. (1978). Toward a methodology of naturalistic inquiry in educational evaluation. *CSE Monographic Series in Evaluation No. 8*. Los Angeles: Center for the Study of Evaluation.

Hall, Nick, Johna Roth, Carmen Best, Sharyn Barata, Pete Jacobs, Ken Keating, Ph.D., Steve Kromer, Lori Megdal, Ph.D., Jane Peters, Ph.D., Richard Ridge, Ph.D., Francis Trottier, and Ed Vine, Ph.D. (2007). *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals*. Prepared for the California Public Utilities Commission.

Lyberg, Lars, Paul Biemer, Martin Collins, Edith De Leeuw, Cathryn Dippo, Norbert Schwarz, and Dennis Trewin. (1997). *Survey measurement and process quality*. New York, NY: John Wiley & Sons.

Madow, William G., Harold Nisselson, Ingram Olkin. (1983). *Incomplete data in sample surveys*. New York: Academic Press.

Maxwell, Joseph A. (2004). Using Qualitative Methods for Causal Explanations. *Field Methods*, *Vol. 16, No. 3*, 243-264.

Megdal, Lori, Yogesh Patil, Cherie Gregoire, Jennifer Meissner, and Kathryn Parlin (2009). Feasting at the Ultimate Enhanced Free-Ridership Salad Bar. *Proceedings of the International Energy Program Evaluation Conference*.

Mohr, Lawrence B. (1995). *Impact analysis for program evaluation*. Thousand Oaks, CA: Sage Publications, Inc.

Netemeyer, Richard G., William O. Bearden, and Subhash Sharma. (2003). *Scaling procedures: Issues and applications*. Thousand Oaks, CA: SAGE Publications.

Patton, Michael Quinn. (1987). *How to use qualitative methods in evaluation*. Newbury Park, California: SAGE Publications.

Ridge, Richard, Philippus Willems, and Jennifer Fagan. (2009). Self-Report Methods for Estimating Net-to-Gross Ratios in California: Honest! *Proceedings from the 19th National Energy Services Conference*.

Ridge, Richard, Philippus Willems, Jennifer Fagan and Katherine Randazzo. (2009). The Origins of the Misunderstood and Occasionally Maligned Self-Report Approach to Estimating the Net-To-Gross Ratio. *Proceedings of the International Energy Program Evaluation Conference*.

Rogers, Patricia J., Timothy A. Hacsi, Anthony Petrosino, and Tracy A. Huebner (Eds.) (2000). *Program theory in evaluation: Challenges and opportunities*. San Francisco, CA: Jossey-Bass Publishers.

Rossi, Peter and Howard E. Freeman. (1989). *Evaluation: A systematic approach.* Newbury Park, California: SAGE Publications.

Sayer, Andrew. (1992). *Method in social science: A Realist Approach*. New York: Routledge.

Sax, Gilbert. (1974). *Principles of educational measurement and evaluation*. Belomont, CA: Wadsworth Publishing Company, Inc.

Schumacker, Randall E. and Richard G. Lomax. (1996). *A beginner's guide to structural equation modeling*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Scriven, Michael. (1976). Maximizing the power of causal explanations: The modus operandi method. In G.V. Glass (Ed.), *Evaluation Studies Review Annual, Vol. 1*, pp.101-118). Bevery Hills, CA: Sage Publications.

Shadish, Jr., William R. and Thomas D. Cook, and Laura C. Leviton. (1991). *Foundations of program evaluation*. Newbury Park, CA: Sage Publications, Inc.

Stone, Arthur A., Jaylan S. Turkkan, Christine A. Bachrach, Jared B. Jobe, Howard S. Kurtzman, and Virginia S. Cain. (2000). *The science of the self-report: Implications for research and practice*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Tashakkori, Abbas and Charles Teddlie. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: SAGE Publications.

TecMarket Works, Megdal & Associates, Architectural Energy Corporation, RLW Analytics, Resource Insight, B & B Resources, Ken Keating and Associates, Ed Vine and Associates, American Council for an Energy Efficient Economy, Ralph Prahl and Associates, and Innovologie. (2004). *The California evaluation framework.* Prepared for the California Public Utilities Commission and the Project Advisory Group.

Velleman, P. F., and Wilkinson, L. (1993), Nominal, ordinal, interval and ratio typologies are misleading. *American Statistician, 47(1)*, 65-72.

Weiss, Carol H. (1998). *Evaluation*. Upper Saddle River, New Jersey: Prentice Hall.

Weiss, R. S. and M.Rein. (1972). The Evaluation of broad-aim programs: Difficulties in experimental design and an alternative. In C. H. Weiss (ed.) *Evaluating action programs: Readings in social action and education*. Boston: Allyn and Bacon.

Wholey, Joseph S., Harry P. Hatry and Kathryn E. Newcomer. (1994). *Handbook of practical program evaluation*. San Francisco, CA: Jossey-Bass, Inc.

Yin, Robert K. (1994). *Case study research: Design and methods*. Newbury Park, California: SAGE Publications.

**Sprinklers Net-to-Gross Ratios and Program Attribution Indices**

| TracksiteID | NTGR | PAI1 | PAI2 | PAI3 |
|---|---|---|---|---|
| PGE_NRF_936_0001025614 | 0.35 | 4.44 | 4.00 | 2.00 |
| PGE_NRF_936_0005621999 | 0.35 | 4.44 | 4.00 | 2.00 |
| PGE_NRF_939_0003906706 | 0.60 | 10.00 | | 2.00 |
| PGE_NRF_953_0000100362 | 0.37 | 5.00 | 5.00 | 1.00 |
| PGE_NRF_953_0000153588 | 0.37 | 5.00 | 5.00 | 1.00 |
| PGE_NRF_953_0005706632 | 0.37 | 5.00 | 5.00 | 1.00 |
| PGE_NRF_956_0005626273 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_959_0000254013 | 0.48 | 5.26 | 2.00 | 7.00 |
| PGE_NRF_959_0000604227 | 0.00 | 0.00 | | 0.00 |
| PGE_NRF_959_0000827247 | 0.75 | 5.00 | | 10.00 |
| PGE_NRF_959_0000847533 | 0.39 | 5.56 | 3.00 | 3.00 |
| PGE_NRF_959_0000963625 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_959_0001020853 | 0.57 | 6.36 | | 5.00 |
| PGE_NRF_959_0001064568 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_959_0005626298 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_959_0005689268 | 0.44 | 3.75 | | 5.00 |
| PGE_NRF_959_0006204002 | 0.40 | 5.00 | | 3.00 |
| PGE_NRF_960_0000299552 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_960_0000299580 | 0.47 | 5.00 | 0.00 | 9.00 |
| PGE_NRF_960_0005681005 | 0.47 | 5.00 | 0.00 | 9.00 |

## NTGR Algorithm Calculator

| Survey Question | | Example Score | Notes: |
|---|---|---|---|
| | **Score 1:** | **PAI-1** | |
| | **Highest Program Influence Score** | **10.00** | |
| | **Highest Non-program Influence Score** | **8.00** | |
| | **PAI - 1 Score = Highest Program Factor / (Highest Program Factor + Highest Nonprogram Factor)** | **5.56** | |
| Survey Question | Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time. | | Notes: |
| 6.3.2 | Availability of the program rebate | 9 | Program Factor |
| 6.3.3 | Information provided through study, audit or other technical assistance provided through the program | 7 | Program Factor |
| 6.3.7 | Information from your utility or program training course | 8 | Program Factor |
| 6.3.8 | Information from your utility or program marketing materials | 6 | Program Factor |
| 6.3.10 | Suggestion by your utility account rep | 10 | Program Factor |
| 6.3.11 (if 6.6 > =6) | Payback on the investment P (score if rebate moved into range, 0 else) | 8 | Program Factor |
| 6.3.11 (if 6.6 < 6) | Payback on the investment NP (score if rebate did not affect PB, 0 else) | | Non-program factor |
| 6.3.5 | Previous experience with an EE project | 8 | Non-program factor |
| 6.3.6 | Previous experience with this program | 3 | Non-program factor |
| 6.3.9 | Standard practice in your industry | 5 | Non-program factor |
| 6.3.12 | Reduced maintenance or equipment replacement policies | 3 | Non-program factor |
| 6.3.13 if open end is program related | Other Program factor from open end | 5 | Program Factor |
| 6.3.13 if open end is non-program related | Other Non-Program factor from open end | 5 | Non-program factor |
| | **PAI - 2 Score -- Score reduced by half if learned after decision = 6.7 or 6.7 if 6.2 = AFTER** | **8** | |
| 6.2 | Did you make the decision to install MEASURE before or after you began discussions with UTILITY regarding the availability of rebates for this measure? | AFTER | |
| 6.7 | How significant was PROGRAM versus other factors in your decision to implement this MEASURE?<br>Please rate the overall importance of the PROGRAM in your decision to implement this MEASURE? | 8 | |
| | **Score 3 -- No-Program Score = 10 minus 6.9 Score** | **7.00** | |
| 6.9 | If the PROGRAM had not been available, what is the likelihood that you would have installed exactly the same program qualifying efficient equipment | 3 | |
| | **OVERALL NTGR SCORE** | **0.69** | |

# APPENDIX AA STANDARDIZED HIGH LEVEL SAVINGS

## Gross Lifecycle Savings (MWh)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 48,887 | 6,655 | 0.14 | 0.7% | 0.13 |
| **PGE** | **Total** | **48,887** | **6,655** | **0.14** | **0.7%** | **0.13** |
| SDGE | Sprinklers | 101 | 101 | 1.00 | 100.0% | |
| **SDGE** | **Total** | **101** | **101** | **1.00** | **100.0%** | |
| | ***Statewide*** | ***48,988*** | ***6,756*** | ***0.14*** | ***0.9%*** | ***0.13*** |

## Net Lifecycle Savings (MWh)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 29,345 | 3,216 | 0.11 | 0.7% | 0.60 | 0.48 | 0.60 | 0.47 |
| **PGE** | **Total** | **29,345** | **3,216** | **0.11** | **0.7%** | **0.60** | **0.48** | **0.60** | **0.47** |
| SDGE | Sprinklers | 60 | 60 | 1.00 | 100.0% | 0.60 | 0.60 | | |
| **SDGE** | **Total** | **60** | **60** | **1.00** | **100.0%** | **0.60** | **0.60** | | |
| | ***Statewide*** | ***29,406*** | ***3,277*** | ***0.11*** | ***0.9%*** | ***0.60*** | ***0.48*** | ***0.60*** | ***0.47*** |

## Gross Lifecycle Savings (MW)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 30.9 | 3.2 | 0.10 | 0.4% | 0.10 |
| **PGE** | **Total** | **30.9** | **3.2** | **0.10** | **0.4%** | **0.10** |
| SDGE | Sprinklers | 0.1 | 0.1 | 1.00 | 100.0% | |
| **SDGE** | **Total** | **0.1** | **0.1** | **1.00** | **100.0%** | |
| | ***Statewide*** | ***31.0*** | ***3.2*** | ***0.10*** | ***0.6%*** | ***0.10*** |

## Net Lifecycle Savings (MW)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 18.6 | 1.5 | 0.08 | 0.5% | 0.60 | 0.47 | 0.60 | 0.46 |
| **PGE** | **Total** | **18.6** | **1.5** | **0.08** | **0.5%** | **0.60** | **0.47** | **0.60** | **0.46** |
| SDGE | Sprinklers | 0.0 | 0.0 | 1.00 | 100.0% | 0.60 | 0.60 | | |
| **SDGE** | **Total** | **0.0** | **0.0** | **1.00** | **100.0%** | **0.60** | **0.60** | | |
| | ***Statewide*** | ***18.6*** | ***1.5*** | ***0.08*** | ***0.6%*** | ***0.60*** | ***0.47*** | ***0.60*** | ***0.46*** |

## Gross Lifecycle Savings (MTherms)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0 | | | |
| **PGE** | **Total** | **0** | **0** | | | |
| SDGE | Sprinklers | 0 | 0 | | | |
| **SDGE** | **Total** | **0** | **0** | | | |
| | ***Statewide*** | ***0*** | ***0*** | | | |

## Net Lifecycle Savings (MTherms)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0 | | | | | | |
| **PGE** | **Total** | **0** | **0** | | | | | | |
| SDGE | Sprinklers | 0 | 0 | | | | | | |
| **SDGE** | **Total** | **0** | **0** | | | | | | |
| | ***Statewide*** | ***0*** | ***0*** | | | | | | |

## Gross First Year Savings (MWh)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 2,495 | 383 | 0.15 | 2.7% | 0.13 |
| **PGE** | **Total** | **2,495** | **383** | **0.15** | **2.7%** | **0.13** |
| SDGE | Sprinklers | 5 | 5 | 1.00 | 100.0% | |
| **SDGE** | **Total** | **5** | **5** | **1.00** | **100.0%** | |
| | ***Statewide*** | ***2,500*** | ***388*** | ***0.16*** | ***2.9%*** | ***0.13*** |

## Net First Year Savings (MWh)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 1,500 | 193 | 0.13 | 2.9% | 0.60 | 0.50 | 0.60 | 0.47 |
| **PGE** | **Total** | **1,500** | **193** | **0.13** | **2.9%** | **0.60** | **0.50** | **0.60** | **0.47** |
| SDGE | Sprinklers | 3 | 3 | 1.00 | 100.0% | 0.60 | 0.60 | | |
| **SDGE** | **Total** | **3** | **3** | **1.00** | **100.0%** | **0.60** | **0.60** | | |
| | ***Statewide*** | ***1,503*** | ***196*** | ***0.13*** | ***3.1%*** | ***0.60*** | ***0.51*** | ***0.60*** | ***0.47*** |

## Gross First Year Savings (MW)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 1.6 | 0.2 | 0.11 | 1.7% | 0.10 |
| **PGE** | **Total** | **1.6** | **0.2** | **0.11** | **1.7%** | **0.10** |
| SDGE | Sprinklers | 0.0 | 0.0 | 1.00 | 100.0% | |
| **SDGE** | **Total** | **0.0** | **0.0** | **1.00** | **100.0%** | |
| | ***Statewide*** | ***1.6*** | ***0.2*** | ***0.12*** | ***1.9%*** | ***0.10*** |

## Net First Year Savings (MW)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0.9 | 0.1 | 0.09 | 1.8% | 0.60 | 0.49 | 0.60 | 0.46 |
| **PGE** | **Total** | **0.9** | **0.1** | **0.09** | **1.8%** | **0.60** | **0.49** | **0.60** | **0.46** |
| SDGE | Sprinklers | 0.0 | 0.0 | 1.00 | 100.0% | 0.60 | 0.60 | | |
| **SDGE** | **Total** | **0.0** | **0.0** | **1.00** | **100.0%** | **0.60** | **0.60** | | |
| | ***Statewide*** | ***0.9*** | ***0.1*** | ***0.09*** | ***2.0%*** | ***0.60*** | ***0.49*** | ***0.60*** | ***0.46*** |

## Gross First Year Savings (MTherms)

| PA | Standard Report Group | Ex-Ante Gross | Ex-Post Gross | GRR | % Ex-Ante Gross Pass Through | Eval GRR |
|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0 | | | |
| **PGE** | **Total** | **0** | **0** | | | |
| SDGE | Sprinklers | 0 | 0 | | | |
| **SDGE** | **Total** | **0** | **0** | | | |
| | ***Statewide*** | ***0*** | ***0*** | | | |

## Net First Year Savings (MTherms)

| PA | Standard Report Group | Ex-Ante Net | Ex-Post Net | NRR | % Ex-Ante Net Pass Through | Ex-Ante NTG | Ex-Post NTG | Eval Ex-Ante NTG | Eval Ex-Post NTG |
|---|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0 | | | | | | |
| **PGE** | **Total** | **0** | **0** | | | | | | |
| SDGE | Sprinklers | 0 | 0 | | | | | | |
| **SDGE** | **Total** | **0** | **0** | | | | | | |
| | ***Statewide*** | ***0*** | ***0*** | | | | | | |

# APPENDIX AB STANDARDIZED PER UNIT SAVINGS

## Per Unit (Quantity) Gross Energy Savings (kWh)

| PA | Standard Report Group | Pass Through | % ER Ex-Ante | % ER Ex-Post | Average EUL (yr) | Ex-Post Lifecycle | Ex-Post First Year | Ex-Post Annualized |
|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0.0% | 0.0% | 20.0 | 1,435.0 | 71.8 | 71.8 |
| PGE | Sprinklers | 1 | 0.0% | | 5.0 | 50.0 | 10.0 | 10.0 |
| SDGE | Sprinklers | 1 | 0.0% | | 20.0 | 1,652.1 | 82.6 | 82.6 |

## Per Unit (Quantity) Gross Energy Savings  (Therms)

| PA | Standard Report Group | Pass Through | % ER Ex-Ante | % ER Ex-Post | Average EUL (yr) | Ex-Post Lifecycle | Ex-Post First Year | Ex-Post Annualized |
|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0.0% | 0.0% | 20.0 | 0.0 | 0.0 | 0.0 |
| PGE | Sprinklers | 1 | 0.0% | | 5.0 | 0.0 | 0.0 | 0.0 |
| SDGE | Sprinklers | 1 | 0.0% | | 20.0 | 0.0 | 0.0 | 0.0 |

## Per Unit (Quantity) Net Energy Savings (kWh)

| PA | Standard Report Group | Pass Through | % ER Ex-Ante | % ER Ex-Post | Average EUL (yr) | Ex-Post Lifecycle | Ex-Post First Year | Ex-Post Annualized |
|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0.0% | 0.0% | 20.0 | 681.6 | 34.1 | 34.1 |
| PGE | Sprinklers | 1 | 0.0% | | 5.0 | 31.9 | 6.4 | 6.4 |
| SDGE | Sprinklers | 1 | 0.0% | | 20.0 | 991.3 | 49.6 | 49.6 |

## Per Unit (Quantity) Net Energy Savings (Therms)

| PA | Standard Report Group | Pass Through | % ER Ex-Ante | % ER Ex-Post | Average EUL (yr) | Ex-Post Lifecycle | Ex-Post First Year | Ex-Post Annualized |
|---|---|---|---|---|---|---|---|---|
| PGE | Sprinklers | 0 | 0.0% | 0.0% | 20.0 | 0.0 | 0.0 | 0.0 |
| PGE | Sprinklers | 1 | 0.0% | | 5.0 | 0.0 | 0.0 | 0.0 |
| SDGE | Sprinklers | 1 | 0.0% | | 20.0 | 0.0 | 0.0 | 0.0 |

# APPENDIX AC RESPONSE TO RECOMMENDATIONS

EM&V Impact Study Recommendations
Study Title: 2015 Nonresidential Downstream Deemed Sprinkler Impact Evaluation
Study Manager: CPUC

| ID | | Section | Conclusion | Recommendation | Disposition (Accepted, Rejected, or Other) | Disposition Notes (e.g. Description of specific program change or Reason for rejection or Under further review) |
|---|---|---|---|---|---|---|
| 1 | PG&E, SCE, SDG&E | 4 | Agricultural irrigation projects are difficult to accurately characterize with deemed savings values. | The program should incorporate a site-specific savings calculator that customizes claimed savings based on key variables determined from project applications. | | |
| 2 | PG&E, SCE, SDG&E | 4 | Four of the 25 sampled projects were determined to be ineligible for program participation. | The program must perform more careful data collection and screening of applicants to avoid ineligible projects. | | |
| 3 | PG&E, SCE, SDG&E | 4 | Six of the 25 sampled projects involved a switch in crop type at the time of the project installation. | The program should utilize an interactive project conversion savings calculator that can account for the different water requirements of various crop types and ages. | | |
| 4 | PG&E, SCE, SDG&E | 4 | Eight of the 25 sampled projects involved a pre-project irrigation method different from that reflected in ex ante savings assumptions. | The program's savings calculator (recommended in #3) should account for pre-project irrigation method to accurately predict the resulting change in discharge pressure by converting to micro-nozzles or drip irrigation installations. | | |
| 5 | PG&E, SCE, SDG&E | 4 | None of the sampled participants could produce operating pumping efficiency (OPE) paperwork required for participation in the prescriptive program. | OPE testing paperwork should be included with the application paperwork to confirm program eligibility and more accurately characterize the affected pump. | | |
| 6 | PG&E, SCE, SDG&E | 4 | Though not anticipated by the program to result in peak demand savings, the sampled irrigation pumps were 36% likely to operate during the summer coincident peak period. | The program should continue to claim peak demand savings from micro-nozzle and drip measures. | | |