Work Paper SCE13WP009

**Revision 2**

**Southern California Edison**

**Residential Variable Speed Spa and Wading Pool Pump**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | PM-99453 |
| **Measure Description** | A Variable Speed Pool Pump used for a multifamily spa or wading pool |
| **Base Case Description** | A Two-speed or Single-speed Pool Pump used for a multifamily spa or wading pool |
| **Units** | Pump |
| **Energy Savings** | RET 1st Baseline: 7,220.27 kWh, 0.76 kW  RET 2nd Baseline, ROB: 4,300.47 kWh, 0.76 kW |
| **Full Measure Cost ($/unit)** | $1,650 |
| **Incremental Measure Cost ($/unit)** | $650 |
| **Effective Useful Life** | 10 years (EUL ID: OutD-PoolPump) |
| **Measure Installation Type** | Retrofit (RET), Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | 0.55 (NTGR ID: Res-Default>2) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 11/10/14 | Jason Wang (SCE) | * New WP for the 2013-15 cycle * WP effective 1/1/2015-12/31/2015 |
| 1 | 5/6/15 | Jason Wang (SCE) | Revised work paper in response to CPUC Preliminary Review. Clarified that New Construction is not eligible. |
| 2 | 11/12/15 | Jason Wang (SCE) | Revised work paper in response to CPUC Preliminary Review. Added code baseline cost and other cost parameters. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
| 0 | CS | 4/20/15 | 5/5/15 | * Clarify eligibility of NC. * Clarify code costs. * Add detailed measure descriptions. * Various comments on Ex Ante Data format | * NC is not eligible. * Cost section was revised to include a description of code costs. * Detailed measure descriptions were added. |
| 1 | CS | 7/2/15 | 7/17/15 | * Correct cost calculations. * Revise cost description. | * Cost calculations were corrected. * Cost IDs and descriptions were added. |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

The measure is a Variable Speed (VS) Pool Pump used for a multifamily spa or wading pool, and the base case is an existing Single-speed Pool Pump. The VS Pool Pump enables pool operators to modulate pumping speed based on a programmed schedule, which can lead to energy savings and demand reduction.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Variable Speed Pool Pump |
| Existing Condition | Single-speed Pool Pump |
| Code/Standard | Two-speed Pool Pump |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | PM-99453 |  | Variable Speed Drive on Pool Pump Control replacing Single Speed Pool Pump for Spa or Wading Pool |

**Eligibility Requirements**

* The VS pool pump does not need to have the same horsepower rating as the base case single-speed pump. For example, replacing a 1 HP single-speed pump with a 3 HP VS pump is acceptable. Some counties offer guidance on what size or model of pump to install, based on specific site conditions.
* For this work paper, horsepower rating refers to the nameplate horsepower before service factor is applied.
* Only 1-for-1 pump replacements are eligible. Motor-only replacements are not eligible.
* Only the multifamily building type is eligible.
* All climate zones are eligible.

**Implementation Requirements**

* Health code requirements and inspections must be passed successfully.
* Installation must be performed by a contractor approved by the SCE Multifamily Program or one who has the appropriate licenses and training.
* Contractor must follow all manufacturer installation requirements.
* Equipment and materials must meet or exceed all applicable local, state and federal standards.
* VS pool pump must be a new, qualifying product installed in a pre-existing in-ground spa or wading pool.
* Only one rebate is allowed per spa or wading pool.

**Documentation Requirements**

* The required documentation must indicate that the pre-existing pump was single speed and that the measure case pump has been properly programmed to meet health code requirements.
* For RET measures, proof of age and functionality and preponderance of evidence must be provided.

## 1.2 Technical Description

Pool pumps are used to circulate swimming pool water through a filtration system in order to keep it clear and remove debris and disease-causing agents. Pumps are also used for pool cleaning sweeps, heating, and water features such as fountains and waterfalls. A pool pump motor in California is typically 0.5 to 3 horsepower (HP), single phase, alternating current (AC), and either a permanent split capacitor (PSC) or capacitor-start capacitor-run (CSCR) design [467]. Most run at a fixed single-speed of 3450 revolutions per minute (rpm). There is no difference between a pool pump used for a swimming pool and one used for a spa or wading pool.

A VS pool pump uses a motor controller that can be programmed to modulate motor speed and flow rate. For VS pool pumps ≤ 3 HP, the controller and pump are integrated into a single unit as shown in Figure 1. Larger pumps typically use a VS control unit housed in a separate enclosure; these are not included in the scope of this work paper. VS pool pumps typically use electronically-commutated motors (ECMs), which offer higher efficiencies than PSC motors.



Figure 1: Variable Speed Pool Pump

Significant energy savings can be achieved by reducing flow rate when it is not necessary to operate at full flow. This is indicated by the Pump Affinity Law, which expresses the relationship between power (P), speed (n), and flow (Q):

Running the pump at half speed will theoretically reduce power draw to 1/8 of full power, but actual power draw will likely be higher due to lower motor efficiencies at part load. For this work paper, savings are derived from measured data and not the Affinity Law.

Benefits of VS pool pumps are not limited to energy savings. They are quieter and need less maintenance than single-speed pumps. Lower flow rates allow the filter to more effectively remove debris, which improves water clarity. Reduced strain on the pump, filters, and plumbing prolong the useful life of the equipment [466]. Bundling VS pumps with other pool energy efficiency measures such as LED lighting should be considered.

## 1.3 Installation Types and Delivery Mechanisms

The Delivery Mechanisms and Installation Types are:

1. **Financial Support / Direct Install**

The SCE Multifamily Energy-Efficiency Program will use authorized contractors to install VS pool pumps at no cost to the customer. Authorized contractors are knowledgeable about the energy efficiency benefits and proper programming strategies for VS pool pumps. They must have the appropriate licenses from the California Contractors State License Board, such as C-53 Swimming Pool Contractor or C61-D35 Pool and Spa Maintenance Contractor. The Multifamily program will typically partner with pool pump manufacturers to offer contractors field training on best practices.

Customers typically only replace pool pumps upon failure, and they often choose the quickest, most familiar, and lowest-cost solution—a single speed pump. The Direct Install program aims to avoid this scenario by promoting early retirement, using a no-cost installation as an incentive. The program also encourages contractors to educate customers on the features of VS pool pumps.

The default Direct Install approach will use the **Retrofit (RET)** installation type because the baseline is the customer’s existing single speed pump. To qualify as an RET measure, the existing pump must have more than one year of remaining useful life (RUL), and there must be a preponderance of evidence that the customer would not have installed a VS pump otherwise. To satisfy the RUL requirement, customers can provide:

* Documentation of the pump’s age (install dates, invoices, or other records)
* Photos of the existing equipment
* Documentation or measurements indicating the functionality of the existing equipment.

For the preponderance of evidence requirement, a mixture of the following can be provided:

* Dialogue from meetings showing how SCE accelerated the early retirement of the existing measure and how SCE made customer aware of program features.
* Documentation of any additional drivers for the project not related to energy efficiency.
* Information on the customer’s normal replacement, remodeling and equipment replacement practices.
* Documentation of the known standard efficiency equipment alternatives available in the market or those considered by the customer.
* Customer statements regarding the viability of and continued intent to use the existing equipment through the proposed RUL period.

If the contractor discovers that the existing pump is past its useful life or no longer functional, then the install type will be **Replace-on-Burnout (ROB)**, which uses a two speed pump as the baseline (as required by code). This does not mean that a two-speed pump is installed first; it only means that the allowable energy savings will be the difference between a two-speed pump and a variable speed pump.

1. **Financial Support / Down-Stream Incentive – Deemed**

The Down-stream measure will be offered through the Multifamily Energy Efficiency Rebate Program (MFEER), where participating customers will receive rebates for purchasing and installing qualifying VS pool pumps. Training on VS pool pumps will be offered to contractors using channels such as pool & spa shows, partnerships with equipment manufacturers, and relationships with contractors and businesses. Contractors will play a large role in marketing and communicating with customers.

The Down-stream approach will use the **Replace-on-Burnout (ROB)** installation type, which uses a two speed pump as the baseline.

**Persistence:** As mentioned in the Program & Technology Review of the Home Energy Efficiency Rebate and Business & Consumer Electronics programs [479], customers may not understand the concept and rationale for programming VS pool pumps. Therefore, after the contractor has performed initial setup, customers may try to adjust the settings themselves. This is a behavioral issue that may prevent a VS pool pump installation from achieving its potential savings.

To evaluate the persistence issue for multifamily spas and wading pools, this work paper incorporates power usage data that was taken immediately after installation, as well as during a revisit performed 10 months later. The revisit was for 29% of the sites in the data set, and it showed that the savings changed very slightly (less than 1%). Further explanation is in Section 2.

**Installation Type Descriptions**

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

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

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Appliance Turn-in and Recycling | The program motivates customers, through financial incentives, to recycle appliances that are functional but inefficient. This prevents the continued use of those appliances, by both the current owner and potential future owners. |
| Audit - Information - Testing Services | The program performs a free assessment of a customer’s facility and provides the customer with information and guidance on energy efficiency opportunities. |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |
| Up-Stream Programs | *See Up-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Exchange - Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| Giveaway | The program provides customers with energy efficiency equipment or services for free. |
| Mid-Stream Incentive  Mid-Stream Buy Down | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |
| On-bill Finance – Loan (OBF) | The program offers financing for the cost of an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |
| Up-Stream Incentive  Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor (manufacturer or distributor) to encourage the manufacture, provision, or distribution of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER 2015 does not include a spa and wading pool pump measure.

DEER Difference Summary

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

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below. Since SCE has offered VSD pool pump measures in the residential sector for more than 2 years, the Res-Default>2 NTG was selected.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 |

**Spillage Rate**

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

**Installation Rate**

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

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

**Effective and Remaining Useful Life**

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| OutD-PoolPump | High Efficiency Pool Pump | Res | Recreation | 10 | 3.3 |

### 1.4.2 Codes and Standards Analysis

**California Code of Regulations, Title 20, Public Utilities and Energy (2015) [493]:** Section 1605.3(g)(5) requires two-speed control for residential pool pumps ≥ 1 HP, effective January 1, 2008. This code applies to the measure in this work paper because residential pool pumps are often installed in multifamily settings. Commercial pool pumps, which are not affected by this regulation, can also be installed.

**California Code of Regulations, Title 24, Building Standards Code (2013) [462]:** Chapter 31B “Public Swimming Pools,” Section 3124B provides capacity requirements for several types of pools. The pools eligible for this work paper fall under items 1 and 3. The Title 24 language states that the pump system must have the capability of turning over the pool water in 0.5 hours for spas and 1 hour for wading pools.



**Local Health Codes:** Health departments at the city or county level may provide regulations and guidelines for public swimming pools. Most counties will cite the Title 24 turnover time requirements.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2015) | Section 1605.3(g)(5) | January 1, 2010 |
| Title 24 (2013) | Chapter 31B Section 3124B | January 1, 2014 |

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

### 1.5.1 DOE Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings [466]

This report discusses the function, energy consumption, and energy savings potential for pool pumps. It was prepared for by the DOE by the Building Media and the Building America Retrofit Alliance, in 2012. This work paper uses the report as a general source of information about the benefits, potential, and costs of VS pool pumps when compared to single-speed pumps.

## 1.6 Data Quality and Future Data Needs

The savings in this work paper are based on SCE’s program data. The data can be augmented in the future with additional collected data.

# Section 2. Calculation Methodology

This savings in this work paper were developed using installation data from VSD pump retrofit projects for multifamily spas and wading pools. The data were collected by the SCE multifamily program; Table 1 contains a summary. All sites have passed local health code inspections and requirements.

Table 1: Summary of VSD Pump Projects Data Set

|  |  |  |
| --- | --- | --- |
| **Description** | **Baseline** | **Measure** |
| Pumps in data set | 69 | |
| Pool size | Average: 1,357 gal  Range: 471 to 2,596 gal | |
| Pump control | Single speed | Variable speed |
| Pump power | 0.5, 0.75, 1, 1.5, 2, or 3 HP | 1 or 3 HP |
| Pump speed | 3450 rpm | Setting 1 (high speed): 2,507 rpm (average)  Setting 2 (low speed): 1,903 rpm (average) |
| Pump demand (assumed to be DEER peak demand) | 1.617 kW | Setting 1: 0.859 kW  Setting 2: 0.410 kW |
| Hours of operation | 17 to 24 hours/day  (68% are 24 hours/day) | Setting 1: 6 AM–10 PM (includes 2 hours before and after the pool is open)  Setting 2: 10 PM–6 AM |
| Average electricity consumption (assuming 365 days/year operation) | 13,390 kWh/year | 6,231 kWh/year |

**RET Savings**

The RET savings calculation methodology is:

The demand reduction calculations assume a coincident diversity factor (CDF) of 1.0 because all sites opened their pools from 2–5 PM:

Energy savings and demand reduction were calculated individually for each site and then straight-averaged across all 69 sites. The results are:

**Persistency Revisit**

Twenty of the 69 installations were revisited approximately 10 months after the initial commissioning, in order to assess the persistency of pump control settings and energy use. The high speed settings for nine of the 20 sites had been increased by an average of 117 rpm because the pool cleaners wanted higher flow to perform their duties. Most of the low speed settings were untouched, but at one site the low speed was set to the same as high speed; this was corrected during the visit. The results are:

Table 2: Results from the Revisit

|  |  |  |
| --- | --- | --- |
|  | **kWh savings** | **kW reduction** |
| Twenty selected sites | 7,171.92 | 0.80720 |
| The twenty sites after 10 months | 7,180.24 | 0.81335 |
| Percent change | Increased by 0.12% | Increased by 0.76% |

Despite the increases in pump speed, the savings increased slightly. Therefore no adjustments were made to the savings.

**ROB Savings**

Title 20 requires that residential pool pumps be able to operate at two or more speeds. Since the pump projects data set only had single speed pumps in the baseline, a theoretical two speed baseline was created for each project. The assumptions for the two-speed pump are:

* Operates at high speed (3450 rpm) from 6 AM–10 PM. The power is the same as for a single speed pump.
* Operates at half speed (1725 rpm) from 10 PM–6 AM. The power is calculated using CEC data. For all two-speed pumps in the CEC Pool Products database, the average ratio of half speed power to full speed power is 0.22488. Therefore the high speed power is multiplied by this value.

Energy savings and demand reduction were calculated individually for each site and then straight-averaged across all 69 sites. The demand reduction is the same as for RET because the theoretical two speed pump is assumed to operate at high speed from 2–5 PM. The results are:

The ROB savings are also the second baseline savings for the RET measure. See Attachment 2 for the data set and calculations.

# Section 3. Load Shapes

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

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Multi-family | Residential Pool Pumps | Residential |

# Section 4. Costs

## 4.1 Base Case Cost

The SCE evaluation team solicited bids (material and labor) for single-speed and VS residential pool pumps to ascertain costs. The bid to replace a single-speed pump with a single-speed pump is $687.24. A DOE Measure Guideline document on VS pool pumps estimated single-speed pool pump costs as $400 to $700 [466].

Based on these sources, the single-speed base case cost used for this work paper is $700. From contractor quotes, about $200 of this is for labor, and $500 is for equipment.

The DOE Measure Guideline document estimated two-speed pump costs as $700 to $1000. The two-speed case cost is approximated to be $1000. Based on contractor quotes, about $300 of this is for labor, and $700 is for equipment.

## 4.2 Measure Case Cost

The bid to replace an existing single-speed pump, remove the mechanical timer, and install and program a VS pump is $1,705.77. A DOE Measure Guideline document on VS pool pumps estimated measure costs as $1,400 to $1,800 [466].

Based on these sources, the measure case cost used for this work paper is $1,650. From contractor quotes, about $500 of this is for labor, and $1,150 is for equipment.

In some cases, auxiliary equipment such as flow meters and valves need to be replaced. These are not included in the measure cost. Permit fees are also not included in the measure cost.

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

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

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| PM-99453 | ROB | $650 | $650 | N/A |
| RET | $650 | $1,650 | $650 |

# Attachments

1. 

1. 

# References



[462]

[466]

[467]

[479]

[493]