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AGRICULTURE

WATER PUMP UPGRADE

SWWP004-01

CONTENTS

MEASURE NAME

Water Pump Upgrade

STATEWIDE MEASURE ID

SWWP004-01

TECHNOLOGY SUMMARY

The U.S. Department of Energy (DOE) defines a "pump" as equipment used to move liquids (which may contain entrained gases, free solids, and totally dissolved solids) by physical or mechanical action.[1] A pump includes a bare pump and mechanical equipment, driver and controls.

Water pumps are the second most common sought equipment after the motor and are found across all sectors. In addition, nearly one- fifth of electricity generated in California supports water-related uses.[2] Until recently, pump efficiency and requirements have not been standardized. The DOE realized this gap and developed the Energy Conservation Standard (ECS) for commercial, industrial, and agricultural clean water pumps. The purpose of the ECS is to quickly move the market to sell minimally compliant efficient clean water pumps by 2020. In 2011, the Hydraulic Institute (HI) worked with the DOE and developed the pump energy efficiency rating system: Pump Energy Index (PEI).[3] Since 2016, pumps have been sold with ECS labels that include PEI. By 2020, all clean water pumps sold will be required to have ECS labels with PEI ≤ 1.0.

MEASURE CASE DESCRIPTION

This measure is defined as the installation of a clean water pump with pump energy index (PEI) as specified below. As shown, measure offerings (and therefore measure impacts) vary by load type (variable or constant) and by pump horsepower range.

Measure Case Specification

Control Strategy	Max. Pump Energy Index (PEI)	Horsepower Range
Constant Load	0.96	1 < hp ≤ 3
		3 < hp ≤ 50
		50 < hp ≤ 200

[1] Code of Federal Regulations 10 CFR Parts 429 and 432. Page 30.

[2] California Energy Commission. 2005. *California's Water – Energy Relationship.* CEC-700-2005-011-SF.

[3] The pump energy index (PEI) is the weighted average performance of the rated pump at specific load points, normalized with respect to the performance of a minimally compliant pump.

Hydraulic Institute. 2016. *Hydraulic Institute Program Guide for HI Energy Rating Program.* HI 40.5-2016.

Control Strategy	Max. Pump Energy Index (PEI)	Horsepower Range
Variable Load	0.46	1 < hp < 3
		3 < hp ≤ 50
		50 < hp ≤ 200

BASE CASE DESCRIPTION

The base case for this measure is a clean water pump with a PEI rating specified below. These baseline values were calculated from a database of performance data collected from major manufacturers and the Hydraulic Institute (HI), as reported by the Northwest Regional Technical Forum (RTF). The base case for this measure is conservative and considers above market average efficient clean water pumps. Note that by 2020 the federal standard will require a clean water pump system to have a PEI rating ≤ 1.0 (see Code Requirements).

Base Case Specification

Control Strategy	Pump Energy Index (PEI)	Source
Constant Load	0.96 – 1.00	Northwest Regional Technical Forum. 2015. "CIP_FR_LCC_2015-09-21_VL_baselinePEI_V2.xlsm."
Variable Load	0.49 – 0.66	

CODE REQUIREMENTS

This measure is not governed by California state codes and standards. Under Title 10 Section 431.462,[4] the U.S. Department of Energy (DOE) developed the Energy Conservation Standard (ECS) for commercial, industrial, and agricultural clean water pumps. As of January 2020, all clean water pumps sold are required to have an ECS label with a pump energy index (PEI) rating ≤ 1.0.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None.	n/a
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards	Title 10 Section 431.462	January 27, 2020

NORMALIZING UNIT

Rated horsepower (hp).

[4] Code of Federal Regulations at 10 CFR 431.462, Subpart Y – Pumps.

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility for Investor-Owned Utilities

Measure Application Type	Delivery Type	Sector
Normal replacement	UpDeemed	Com
Normal replacement	UpDeemed	Ind
Normal replacement	UpDeemed	Ag
New construction	UpDeemed	Com
New construction	UpDeemed	Ind
New construction	UpDeemed	Ag

Eligible Products

Only clean water pumps with a nominal horsepower rating of ≤ 200 and meet the PEI requirements specified in the Measure Case Description.

Any of the following clean water rotodynamic pump classes are eligible:

- End Suction Frame Mount (ESFM)
- End Suction Close Coupled (ESCC)
- In-line (IL)
- Radially Split multi-stage vertical in-line diffuser casing (RSV)
- Vertical Turbine Submersible (ST)
- No wastewater pumps of any kind are allowed

Eligible Building Types and Vintages

This measure is applicable for any agricultural, commercial, and industrial facility of any vintage.

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

None.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Water pumping & irrigation

ELECTRIC SAVINGS (kWh)

This unit energy savings (UES) analysis was adopted from the pump savings analysis approved by the Regional Technical Forum (RTF) for the Northwest Energy Efficiency Alliance (NEEA) Efficient Commercial and Industrial Pumps (ECIP) Project.[5] This analysis, approved in December 2016, was part of the first phase of the ECIP project and included extensive pump modeling, DOE database information, and customer/vendor field data.

The UES from retrofitting a base case pump to a more efficient measure case pump is based on the NEEA modification of the Hydraulic Institute (HI) pump energy savings calculation.[6] The HI energy savings calculation assumes a conservative base case efficiency scenario and does not include adjustment factors to account for pump nominal power and actual pump performance variances. The NEEA modifications of the HI calculation considered baseline market average pump efficiencies and adjustment factors that consider nominal versus actual power draw and actual pump system curves.

The energy savings analysis the NEEA analysis was streamlined for this measure to meet the needs of midstream and distributor operations. The electric unit energy saving (UES) of installing high efficiency pump was calculated by the following equation:

$$UES = HP \times H \times Load\ Factor \times (PEI_{Baseline} - PEI_{Measure}) \times C$$

HP =	*Nominal pump horsepower (hp)*
H =	*Annual operating hours (hours/year)*
LoadFactor =	*Load factor*
PEI =	*Pump efficiency index, baseline or measure (no units)*
C =	*Conversion factor, constant, 0.746 kW/hp*

[5] Northwest Regional Technical Forum (RTF). 2016. "Research Strategy for Efficient Pumps." December 6.

Northwest Regional Technical Forum (RTF). 2017. "RFT ComIndAgPumps_1_1.xlsm."

[6] Northwest Regional Technical Forum (RTF). 2017. "RFT ComIndAgPumps_1_1.xlsm."

The inputs for the UES calculation are specified below. *Annual hours of operation* for differing pumping applications were derived from different sources and presented in the RTF analysis. The load factors were derived as the average of average load factors for non-VT (non-vertical turbine submersible) pumps, across all product classes presented in the RTF analysis.

Annual Operating Hours[7]

Pumping Application	Annual Operation Hours	
	Baseline	Measure Case
Commercial	4,000	4,000
Industrial and Municipal	5,000	5,000
Agricultural Irrigation	2,400	2,400

Load Factor – Constant Speed [8]

Product Class	Load Factor	Average Load Factor
ESCC,1800	0.84591	0.82506
ESCC,3600	0.84591	0.86275
ESFM,1800	0.84591	0.82586
ESFM,3600	0.84591	0.84470
IL,1800	0.84591	0.85415
IL,3600	0.84591	0.86294
RSV,1800	0.84591	
RSV,3600	0.84591	
VT-S,1800	1.15238	
VT-S,3600	1.15238	1.15238

Load Factor – Variable Speed [9]

Product Class	Industrial & Municipal (20% Static head)	Commercial HVAC & DHW (40% Static head)	Agricultural Irrigation (20% Static head)
ESCC,1800	1.127	1.216	1.127
ESCC,3600	1.127	1.216	1.127
ESFM,1800	1.127	1.216	1.127
ESFM,3600	1.127	1.216	1.127
IL,1800	1.127	1.216	1.127
IL,3600	1.127	1.216	1.127

[7] Tingleff, B. (SBW Consulting) and A. Hadley. 2016. "Efficient Commercial & Industrial Pumps." Northwest Regional Technical Forum (RTF). December 6. Page 31.

Green Motors Practices Group (GMPG). 2012. "A-09 Ag operating hours 11_2_2012 ETH.xlsx" Submitted to the Regional Technical Forum.

[8] Northwest Regional Technical Forum. 2015. "CIP_FR_LCC_2015-09-21_CL_CL_LoadFactor.xlsm".See "Pivot chart" tab.

[9] Northwest Regional Technical Forum. 2015. "CIP_FR_LCC_2015-09-21_CL_CL_LoadFactor.xlsm". See "Pivot chart" tab.

VT-S,3600	1.500	1.604	1.500
RSV,1800	1.127	1.216	1.127
RSV,3600	1.127	1.216	1.127
VT-S,1800	1.500	1.604	1.500

Pump Energy Index

Control Strategy	Pump Horsepower Range (hp)	PEI Range	PEI - Baseline[10]	PEI - Measure
Constant	1 ≤ HP < 3	PEI < 0.96	0.90	0.98
Constant	3 ≤ HP ≤ 50	PEI < 0.96	0.90	0.98
Constant	50 < HP ≤ 200	PEI < 0.96	0.90	0.98
Variable	1 ≤ HP < 3	PEI < 0.49	0.48	0.54
Variable	3 ≤ HP ≤ 50	PEI < 0.49	0.46	0.51
Variable	50 < HP ≤ 200	PEI < 0.49	0.45	0.50

PEAK ELECTRIC DEMAND REDUCTION (kW)

There is no peak demand reduction associated with pump efficiency improvements.

GAS SAVINGS (Therms)

Not applicable.

LIFE CYCLE

Effective Useful Life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. EUL is often, but not always, derived from measure persistence or retention studies. Remaining Useful Life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL and RUL specified for this measure are specified below. This EUL was adopted for the 2008 Database for Energy Efficient Resources (DEER) and is based upon estimates reported in several California-based retention studies. Note that RUL is only applicable for add-on equipment and accelerated replacement measures and is not applicable for this measure.

[10] Northwest Regional Technical Forum (RTF). 2015. "CIP_FR_LCC_2015-09-21_CL_CL_LoadFactor.xlsm". See "Baseline" tab.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	15.0	San Diego Gas & Electric (SDG&E). 2003. *1996 & 1997 Agricultural Energy Efficiency Incentives Sixth Year Retention Evaluation.* Study ID Nos. 1000 & 1024. ADM Associates, Inc. 2003. *Southern California Edison Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Retention Study.* Prepared for Southern California Edison Company. San Diego Gas & Electric (SDG&E), Marketing Programs & Planning. 2004. *1994 & 1995 Commercial Energy Efficiency Incentives Ninth Year Retention Evaluation*. Study ID Nos. 925 & 961. California Public Utilities Commission (CPUC). 2008. "EUL_Summary_10-1-08.xls."
RUL (yrs)	n/a	n/a

BASE CASE MATERIAL COST ($/UNIT)

Base case material costs were adopted from the analysis approved by the Regional Technical Forum (RTF) in 2016.[11] The costs include data from the U.S. Department of Energy (DOE) Life Cycle Cost analyses and Grainger[12] cost data.

MEASURE CASE MATERIAL COST ($/UNIT)

Measure case material costs were adopted from the analysis approved by the Regional Technical Forum (RTF) in 2016.[13] The costs include data from the U.S. Department of Energy (DOE) Life Cycle Cost analyses and Grainger[14] cost data.

BASE CASE LABOR COST ($/UNIT)

Base case labor costs are assumed to equal the Measure Case Labor cost.

[11] Regional Technical Forum (RTF). 2017. "RTF ComIndAgPumps_1_1.xlsm." See "VFD Costs Pivot".

Regional Technical Forum (RTF). 2015. "CIP_FR_LCC_2015-09-21_Costs.xlsm." See "LCC Sample" tab.

[12] Tingleff, B. (SBW Consulting) and A. Hadley. 2016. "Efficient Commercial & Industrial Pumps." Northwest Regional Technical Forum (RTF). December 6.

[13] Regional Technical Forum (RTF). 2017. "RFT ComIndAgPumps_1_1.xlsm." See "VFD Costs Pivot".

Regional Technical Forum (RTF). 2015. "CIP_FR_LCC_2015-09-21_Costs.xlsm." See "LCC Sample" tab.

[14] Tingleff, B. (SBW Consulting) and A. Hadley. 2016. "Efficient Commercial & Industrial Pumps." Northwest Regional Technical Forum (RTF). December 6.

MEASURE CASE LABOR COST ($/UNIT)

As reported in the Measure case labor costs were calculated as the average cost to install a pump, from the 2017 RSMeans Mechanical Cost Data, as reported in the cost analysis approved by the Regional Technical Forum (RTF) in 2016.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. This value is the "default" NTG value approved for a measure designated as an emerging technology.[15]

This NTG is assigned to this measure because the market still needs to ramp-up with respect to education and supply to meet the newly created Energy Conservation Standard (ECS) for clean water pumps. This new standard, the pump energy index (PEI) was created by the U.S. Department of Energy (DOE) and is effective as of January 2020. (See Code Requirements.) The measure offerings are designed to encourage purchases of equipment that exceeds the 2020 Standards.

Net-to-Gross Ratios

Parameter	Value	Source
ET-Default	0.85	California Public Utilities Commission (CPUC). 2012. Decision 12-05-015 in the Order Instituting Rulemaking to Examine the Commission's Post-2008 Energy Efficiency Policies, Programs, Evaluation, Measurement, and Verification, and Related Issues (R.09-11-014). Issued May 18, 2012. O.P. 14.

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current "default" rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rates

Parameter	GSIA	Source
GSIA - Default	1.00	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31.

NON-ENERGY BENEFITS

Non-energy impacts for this measure have not been quantified.

[15] California Public Utilities Commission (CPUC). 2012. Decision 12-05-015 in the Order Instituting Rulemaking to Examine the Commission's Post-2008 Energy Efficiency Policies, Programs, Evaluation, Measurement, and Verification, and Related Issues (R.09-11-014). Issued May 18, 2012. Ordering paragraph 14.

DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	n/a
Reason for Deviation from DEER	DEER does not contain this type of measure.
DEER Measure IDs Used	n/a
NTG	The NTG of 0.85 is associated with NTG ID: *ET-Default*
GSIA	The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	The value of 15 years is associated with EUL ID: *Motors-pump*.

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	03/312018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGECOPUM106, Revision 1 (January 25, 2018) Consensus reached among Cal TF members.
	03/29/2019	Jennifer Holmes Cal TF Staff	Revisions for submittal of version 01.