Work Paper PGECOPUM106
Water Pump Upgrade
Revision #1

Pacific Gas & Electric Company

Customer Energy Solutions

Water Pump Upgrade

Measure Codes: PM002, PM003, PM004, PM005, PM006, PM007

January 25, 2018

AT-A-GLANCE SUMMARY

Measure Codes	PM002, PM003, PM004, PM005, PM006, PM007
Measure Description	Installation of high efficiency clean water pumps
Base Case Description	Above market average efficient clean water pumps
Units	Per horsepower (HP)
Energy Savings	Refer to Table 9 Electric Energy Savings Summary
Full Measure Cost ($/unit)	Refer to Table 12 Measure Cost Data
Incremental Measure Cost ($/unit)	Refer to Table 12 Measure Cost Data
Effective Useful Life	15 years (DEER EUL ID: Motors-pump)
Measure Installation Type	Replace on Burnout or New Construction (ROBNC)
Net-to-Gross Ratio	0.7 (DEER NTGR ID: All-Default<=2yrs)
Important Comments	

REVISION HISTORY

Rev	Date	Author (Company)	Summary of Changes
1	1/25/18	Linda Wan (PG&E)	Measure code consolidation: Removed measure codes PM008 – PM019. Added Com and IndOth building types to PM002-PM007. Effective 2/1/2018.
0	9/18/17	Danielle Dragon, PE, CEM, CDSM	This is a new workpaper

COMMISSION STAFF AND CAL TF COMMENTS

Rev	Party	Submittal Date	Comment Date	Comments	WP Developer Response

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

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SECTION 1. GENERAL MEASURE & BASELINE DATA

1.1 BACKGROUND AND MEASURE DESCRIPTION

Pumps are the second most common sought equipment after the motor and are found across all sectors. In addition, nearly a fifth of electricity generated in California supports water-related uses.[1] Until recently, pump efficiency and requirements have not been standardized. The Department of Energy (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).[2] 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 less than or equal to 1.0. The purpose of this workpaper is to move the market further and influence customers with rebates to install clean water pumps with aggressive PEIs less than 0.96. Current conditions and proposed measure details are shown in Table 1 and Table 2.

Table 1 Base, Standard, and Measure Cases

Case	Description of Typical Scenario
Measure	Clean water pumps with DOE PEI rating less than: 0.96 (constant load) and 0.49 (variable load)
Base	Clean water pumps with DOE PEI rating of: 0.96 – 1.00 (constant load) and 0.49 – 0.66 (variable load)
Existing Condition	All clean water pumps with PEIs above and below 1.0
Code/Standard	N/A
Industry Standard Practice (ISP)	N/A

N/A = not applicable, however 2020 federal standard will require clean water pump system to have PEI ≤ 1.00

Table 2 Measures and Codes

Measure Codes				Measure Name
SCG	SDG&E	SCE	PG&E	
			PM002	CL TO CL, LT 0.96 PEI, GTE 1HP, LT 3HP
			PM003	CL TO CL, LT 0.96 PEI, GTE 3HP, LTE 50HP
			PM004	CL TO CL, LT 0.96 PEI, GT 50HP, LTE 200HP
			PM005	VL TO VL, LT 0.46 PEI, GTE 1HP, LT 3HP
			PM006	VL TO VL, LT 0.46 PEI, GTE 3HP, LTE 50HP
			PM007	VL TO VL, LT 0.46 PEI, GT 50HP, LTE 200HP

CL = constant load, VL = variable load, LT = less than, GT = greater than, LTE = less than or equal to, GTE = greater than or equal to

1.2 REQUIREMENTS

The measure type is Replace on Burnout or New Construction (ROBNC) and will go through the mid-stream channel. A qualifying pump includes the following:

- Clean water rotodynamic pumps class:
  - 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)

- Nominal horsepower rating: 1 – 200 HP
- DOE PEI < 0.96 for constant load pumps
- DOE PEI < 0.49 for variable load pumps
- Sectors: Agricultural, Commercial, Industrial

1.3 Technical Description

DOE defines a "pump" as equipment used to move liquids (entrained gases, free solids, and totally dissolved solids) by physical or mechanical action.[3] A pump includes a bare pump and mechanical equipment, driver and controls. This workpaper focuses on bare pump efficiency improvements and uses the Regional Technical Forum (RTF) approved Northwest Energy Efficiency Alliance (NEEA)'s pump ECS savings analysis from the Efficient Commercial and Industrial Pumps (ECIP) Project.[4]

1.3.1 Base Case

In 2020 the federal standard will require clean water pump systems to have PEIs ≤ 1.0. The base case for this workpaper is conservative and considers above market average efficient clean water pumps.[4] The average PEIs per pump class vary between 0.96 – 1.00 and 0.49 – 0.66 for constant and variable load pumps, respectively.

1.3.2 Measure Case

The measure case PEIs for constant and variable load pumps is less than 0.96 and 0.49, respectively.

1.4 Installation Types and Delivery Mechanisms

As shown in Table 3, this work paper addresses the installation type of Replace on Burnout or New Construction (ROB/NC). The delivery mechanism is mid-stream rebate, where the distributor sells the qualifying energy efficient equipment to a contractor or end-user and submits an incentive application to the utility program. Upon application approval, the utility program pays a rebate to the distributor.

Table 3 Installation Type Description

Installation Type	Savings		Life	
	1st Baseline (BL)	2nd BL	1st BL	2nd BL
Replace on Burnout or New Construction (ROBNC)	Above Code or ISP	N/A	EUL	N/A

1.5 Measure Parameters

1.5.1 DEER Data

As shown in Table 4, the measures in this workpaper are not from the Database of Energy Efficient Resources (DEER) since no DOE PEI measure has previously been developed by DEER.

Table 4 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	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

1.5.2 Net-to-Gross Ratio

The NTG values were obtained using the DEER READI tool. Table 5 includes the relevant All-Default<=2yrs value of 0.70 for the measures in this workpaper.

Table 5 Net-to-Gross Ratio

NTGR ID	DEER Description	Sector	BldgType	Measure Delivery	NTGR
All-Default<=2yrs	All other Energy Efficiency Measure (EEM) with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years.	Any	Any	All	0.70

1.5.3 Installation Rate

The installation rate (IR) value was obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in Table 6.

Table 6 Installation Rate

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

1.5.4 Effective and Remaining Useful Life

The effective useful life (EUL) and remaining useful life (RUL) values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The relevant EUL and RUL values for the measures in this work paper are in Table 7.

Table 7 Effective and Remaining Useful Life

EUL ID	Description	Sector	UseCategory	EUL (Years)	RUL (Years)
Motors-pump	Water Loop Pumps	Com	Any	15	5

1.6 Codes and Standards Analysis

The measures in this work paper are impacted by DOE standards and not impacted by Title 24 or Title 20 code standards. Discussion on the standards as they relate to the measures is summarized in Table 8 and presented here for information purposes only.

1.6.1 Federal Standards

Under Title 10 Section 431.462[5], the Department of Energy (DOE) developed the Energy Conservation Standard (ECS) for commercial, industrial, and agricultural clean water pumps. By 2020, all clean water pumps sold will be required to have ECS labels with PEI less than or equal to 1.0. Although since 2016, pumps have been sold with ECS labels that include PEI, there is currently no PEI requirement for clean water pumps.

Table 8 Code Summary

Code	Reference	Effective Dates
Title 24 (2016)	These measures do not fall under Title 24	N/A

Title 20 (2013)	These measures do not fall under Title 20	N/A
Federal Codes (DOE / EPA)	These measures do fall under Federal DOE and do not fall under EPA Energy Regulations.	01/27/2020

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

After identifying a gap and potential for energy savings for clean water pumps, the DOE 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).[2] 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 less than or equal to 1.0.

In December 2016, the Regional Technical Forum (RTF) approved the Northwest Energy Efficiency Alliance (NEEA)'s pump ECS savings analysis. This analysis is part of the first phase of the Efficient Commercial and Industrial Pumps (ECIP) project and includes extensive pump modeling, DOE database information, and customer/vendor field data. The second phase of the ECIP project will conclude in December 2019 and include an Evaluation, Measurement and Verification (EM&V) strategy to further analyze parameters that impact energy saving calculations (e.g. pump load, hours of operation, etc.).

1.8 Data Quality and Future Data Needs

The RTF approved ECIP first phase savings analysis is comprehensive and includes conservative modifications to HI energy saving assumptions and calculations. Further details are provided in Section 2. PG&E will continue to be informed about any findings or changes with the second phase of the ECIP project.

SECTION 2. CALCULATION METHODOLOGY

The energy savings for this workpaper are based on the approved RTF values from NEEA's ECIP savings analysis.[4]

2.1 ENERGY SAVINGS AND PEAK DEMAND REDUCTION

The energy savings from retrofitting a base case pump to a more efficient measure case pump is based on NEEA's conservative modification of the HI pump energy savings calculation. The HI energy savings calculation assumes worst base case efficiency scenario and does not include adjustment factors to consider pump nominal power and actual pump performance variances. NEEA's conservative modifications do consider baseline market average pump efficiencies and adjustment factors that consider nominal versus actual power draw and actual pump system curves. There is no peak demand reduction associated with pump efficiency improvements in this workpaper.

The electrical energy saving (EES) of installing high efficiency pump is calculated by the follow equation:

$$EES = HP \times H \times [(PEI_{BASE} \times Adj_{BASE}) - (PEI_{EFF} \times Adj_{EFF})] \times C$$

Where,

HP = nominal pump horsepower, (hp)

H	=	annual operating hours, (hr/yr)
PEI_{BASE}	=	base case pump efficiency index, no units
Adj_{BASE}	=	base case adjustment factor correction for nominal/actual power consumption and actual system load profile, no units
PEI_{EFF}	=	measure case efficient pump efficiency index, no units
Adj_{EFF}	=	measure case adjustment factor correction for nominal/actual power consumption and actual system load profile, no units
C	=	constant, 0.746 kW/hp

Energy savings from NEEA's analysis was streamlined to meet the needs of mid-stream and distributor operations. This workpaper considers the average savings of five clean water rotodynamic pump classes (ESFM, ESCC, IL, RSV, and ST) per horsepower bin and pump load control. Table 9 Electric Energy Savings Summaryincludes the electric energy savings for this workpaper.

Table 9 Electric Energy Savings Summary

Pump HP Range	PEI Range	Control Strategy	Sector	Energy Savings (kWh/hp-yr)
1 ≤ HP < 3	PEI < 0.96	Constant	Agricultural	118.88
3 ≤ HP ≤ 50	PEI < 0.96	Constant	Agricultural	118.88
50 < HP ≤ 200	PEI < 0.96	Constant	Agricultural	118.97
1 ≤ HP < 3	PEI < 0.49	Variable	Agricultural	130.87
3 ≤ HP ≤ 50	PEI < 0.49	Variable	Agricultural	100.66
50 < HP ≤ 200	PEI < 0.49	Variable	Agricultural	94.89
1 ≤ HP < 3	PEI < 0.96	Constant	Commercial	198.14
3 ≤ HP ≤ 50	PEI < 0.96	Constant	Commercial	198.14
50 < HP ≤ 200	PEI < 0.96	Constant	Commercial	198.14
1 ≤ HP < 3	PEI < 0.49	Variable	Commercial	235.38
3 ≤ HP ≤ 50	PEI < 0.49	Variable	Commercial	181.04
50 < HP ≤ 200	PEI < 0.49	Variable	Commercial	170.65
1 ≤ HP < 3	PEI < 0.96	Constant	Industrial	247.68
3 ≤ HP ≤ 50	PEI < 0.96	Constant	Industrial	247.85
50 < HP ≤ 200	PEI < 0.96	Constant	Industrial	247.68
1 ≤ HP < 3	PEI < 0.49	Variable	Industrial	272.65
3 ≤ HP ≤ 50	PEI < 0.49	Variable	Industrial	209.71
50 < HP ≤ 200	PEI < 0.49	Variable	Industrial	197.68

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 Table 10.

Table 10 Building Types and Load Shapes

Building Type	Load Shape	E3 Alternate Building Type
Commercial	PGE:COMMERCIAL:6 = Commercial Motors	6 = Commercial Motors
Other Agricultural	PGE:AGRICULTURAL:14 = Agricultural	14 = Agricultural
Other Industrial	PGE:INDUSTRIAL:12 = Industrial Motors	12 = Industrial Motors

SECTION 4. COSTS

Material costs are from the ECIP project and include data from DOE Life Cycle Cost (LCC) analyses and Grainger cost data.[6] Labor costs are from RSMeans Mechanical 2017.[7]

4.1 Base Case Cost

The average base case costs per horsepower (HP) are listed in Table 19. For more details, refer to "PGE Pump Upgrade Savings Calcs" spreadsheet.[8]

Table 11 Base Case Cost Data

Pump Horsepower (HP) Range	PEI Range	Control Strategy	Average Cost ($/HP)
1 ≤ HP < 3	0.96 ≤ PEI ≤ 1.00	Constant	$860.72
1 ≤ HP < 3	0.49 ≤ PEI ≤ 0.66	Variable	$1,693.01
3 ≤ HP ≤ 50	0.96 ≤ PEI ≤ 1.00	Constant	$199.73
3 ≤ HP ≤ 50	0.49 ≤ PEI ≤ 0.66	Variable	$476.66
50 < HP ≤ 200	0.96 ≤ PEI ≤ 1.00	Constant	$33.73
50 < HP ≤ 200	0.49 ≤ PEI ≤ 0.66	Variable	$134.12

4.2 Measure Case Cost

The average measure case costs per horsepower (HP) are listed in Table 20. For more details, refer to "PGE Pump Upgrade Savings Calcs" spreadsheet.[8]

Table 12 Measure Cost Data

Motor Size Range	PEI Range	Control Strategy	Average Cost ($/HP)
1 ≤ HP < 3	PEI < 0.96	Constant	$980.60
1 ≤ HP < 3	PEI < 0.49	Variable	$1,820.10
3 ≤ HP ≤ 50	PEI < 0.96	Constant	$299.23
3 ≤ HP ≤ 50	PEI < 0.49	Variable	$507.99
50 < HP ≤ 200	PEI < 0.96	Constant	$41.85
50 < HP ≤ 200	PEI < 0.49	Variable	$142.16

4.3 FULL AND INCREMENTAL MEASURE COST

Table 13 includes a summary of the pump cost difference data. Table 14 includes the Full and Incremental Measure Cost Equations. Table 15 includes the Full and Incremental Costs.

Table 13 Cost Difference Data

Pump Size, Control Strategy	Case	Average Cost ($/HP)	Cost Difference ($/HP)
1 ≤ HP < 3, Constant	Base	$860.72	-
	Measure	$980.60	$119.89
1 ≤ HP < 3, Variable	Base	$1,693.01	-
	Measure	$1,820.10	$127.09
3 ≤ HP ≤ 50, Constant	Base	$199.73	-
	Measure	$229.23	$29.50
3 ≤ HP ≤ 50, Variable	Base	$476.66	-
	Measure	$507.99	$31.33
50 < HP ≤ 200, Constant	Base	$33.73	-
	Measure	$41.85	$8.12
50 < HP ≤ 200, Variable	Base	$134.12	-
	Measure	$142.16	$8.04

Table 14 Full and Incremental Measure Cost Equations

Installation Type	Incremental Measure Cost	Full Measure Cost	
		1st Baseline	2nd Baseline
ROBNC	(MEC + MLC) – (BEC + BLC)	(MEC + MLC) – (BEC + BLC)	N/A

MEC = Measure Equipment Cost; MLC = Measure Labor Cost
BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

Table 15 Full and Incremental Costs

Installation Type	Pump Size, Control Strategy	Incremental Measure Cost	Full Measure Cost	
			1st Baseline	2nd Baseline
ROBNC	1 ≤ HP < 3, Constant	$119.89	$980.60	N/A
	1 ≤ HP < 3, Variable	$127.09	$1,820.10	N/A
	3 ≤ HP ≤ 50, Constant	$29.50	$229.23	N/A
	3 ≤ HP ≤ 50, Variable	$31.33	$507.99	N/A
	50 < HP ≤ 200, Constant	$8.12	$41.85	N/A
	50 < HP ≤ 200, Variable	$8.04	$142.16	N/A

REFERENCES/ATTACHMENTS

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[7] Dale Morris, "RSMeans Mechanical 2017"

[8] PGE Pump Upgrade Savings Calcs.xlsx