Agricultural Sector Adoption of PEI Pumps Market Study

Final Report

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Executive Summary

This market study, conducted under the CalNEXT program, investigates the adoption of Pump Energy Index (PEI) rated pumps in California's agricultural sector. The United States Department of Energy introduced the PEI rating standard in 2016, which effectively phased out the bottom 25 percent of the least efficient pumps and introduced a simplified metric that helps users easily understand the energy-saving potential of higher-efficiency models. Despite federal mandates requiring PEI compliance for clean water pumps since 2020, adoption in agriculture remains limited due to technical, economic, and information barriers.

The study employed a three-phase methodology involving literature review, stakeholder surveys, and data analysis. Surveys were conducted across five key stakeholder groups: manufacturers, energy efficiency programmers, engineers, contractors, and end-use customers. A total of 24 verified responses were analyzed to assess market readiness, awareness, and barriers to adoption.

Key findings from the study include:

- **Low awareness and understanding:** Across all stakeholder groups, familiarity with PEI ratings and their benefits is limited. Most end-users and contractors default to conventional pump replacements due to ease and familiarity. Most engineers still use pump curves and best efficiency point to select pumps.
- **Economic barriers:** PEI-rated pumps are perceived to cost 15 to 50 percent more than conventional pumps. Existing rebates often cover only one to five percent of project costs, making them financially unattractive.
- **Technical limitations:** Many commonly used agricultural pump types, such as large vertical turbine pumps, fall outside the scope of the Department of Energy PEI standards.
- **Programmatic challenges:** Complex rebate application processes and narrow eligibility criteria hinder participation in energy efficiency programs.

Key opportunities include:

- **Technological availability:** Over 7,800 PEI-rated pump models are now listed by the Hydraulic Institute, indicating growing product availability. The Hydraulic Institute, founded in 1917, is the largest association of pump manufacturers in North America. It develops standards and technical resources for pump systems.
- **Policy alignment:** PEI adoption supports California's decarbonization and water-energy nexus goals. California's Technical Resource Manual has already included deemed measures with PEI-rated pumps.
- **Targeted applications:** Groundwater, surface water, and booster pump applications, which fall within the Department of Energy's PEI scope, offer high potential for energy savings.

The team recommends the following to facilitate broader market adoption:

- **Expand incentives:** Increase utility program rebate levels to cover at least 25 percent of project costs and include system-level components like variable frequency drives with variable load PEI-rated pumps. Include as a custom measure in utility incentive programs for site-specific actual savings.

- **Simplify program design:** Streamline utility incentive application processes and relax eligibility criteria to include more pump types.
- **Enhance education and outreach:** Provide targeted training for contractors and engineers. Develop customer-facing educational materials.
- **Strengthen supply chain engagement:** Encourage manufacturers and distributors to promote PEI-rated products and ensure availability.
- **Leverage data for optimization:** Establish a centralized database to track installations and savings, while refining program strategies accordingly.

By addressing these barriers and leveraging identified opportunities, California can accelerate the adoption of energy-efficient PEI-rated pumps in agriculture, contributing to statewide energy savings and greenhouse gas reduction goals.

Abbreviations and Acronyms

Acronym	Meaning
AESAP	Agriculture Energy Savings Action Plan
BEP	Best efficiency point
CL	Constant load
CPUC	California Public Utilities Commission
DOE	Department of Energy
DWR	Department of Water Resources
eTRM	California Electronic Technical Reference Manual
EE	Energy efficiency
ESCC	End-suction close-coupled
ESFM	End-suction frame-mounted
EUL	Effective useful life
GPM	Gallons per minute
GWh	Gigawatt-hour
HI	Hydraulic Institute
hp	Horsepower
IL	In-line
IOU	Investor-owned utility
kWh	Kilowatt-hour
LCC	Lifecycle cost
NC	New construction

Acronym	Meaning
NR	Normal replacement
NEEA	Northwest Energy Efficiency Alliance
PEI	Pump Energy Index
PEI_{CL}	Constant Load Pump Energy Index
PEI_{VL}	Variable Load Pump Energy Index
PER	Pump Efficiency Rating
PG&E	Pacific Gas and Electric
RPM	Revolutions per minute
RSV	Radially split, multi-stage, vertical, in-line diffuser casing
SCE	Southern California Edison
SWP	State Water Project
SWRCB	State Water Resources Control Board
TWh	Terawatt-hour
US	United States
VL	Variable load
VSD	Variable speed drive
VTS	Submersible turbine

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Introduction

This project is a market study on the adoption of Pump Energy Index (PEI)-rated pumps in the agricultural sector of California. National standards implemented in 2020 require all clean water pumps sold to have a PEI rating of less than or equal to one (≤1.0). However, market knowledge of how these standards correlate to lifecycle costs (LCC) is less understood. Educating facility operators on these savings may help motivate those still hesitant to adopt more efficient pumps. The study will include the following:

- Identify causes of the hesitancy for adopting new, efficient pumps.
- Assess market knowledge of the PEI and the savings potential of PEI pumps.
- Quantify the LCC savings of PEI pumps.
- Recommend utility interventions to support market adoption.

This draft report provides a comprehensive overview of the market study, beginning with a technology background that includes pump efficiency, an introduction to the PEI, associated savings and benefits of the PEI, the California agricultural water-energy nexus, historical trends, and a literature review. It outlines the study's objectives, methodology, and approach, followed by key findings such as current market barriers, gaps, opportunities, and stakeholder feedback. The report concludes with targeted recommendations and a summary of conclusions to guide future actions and policy development. The project team conducted 24 surveys across five different categories of responders. Findings are presented for each category of responders, and a summary of the responses is presented.

Background

The term "pump" refers to equipment designed to move liquids, which may include entrained gases, free solids, and totally dissolved solids, by physical or mechanical action, and includes a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, a driver, and controls (DOE 2016). This project is related to clean water pumps' efficiency ratings, the use of efficient pumps in the agricultural sector, and the adoption of efficient pumps in this market sector.

Pumps can be classified depending on many criteria. The California agricultural sector uses pumps for many different applications and purposes. Agricultural sectors that use clean water pumps are mostly for:

- Groundwater pumping for irrigation.
- Surface water pumping for irrigation.
- Conveyance and pressurization of irrigation water using booster pumps.

Pump Efficiency

Pump efficiency is often defined as wire-to-water or overall plant efficiency, which is a measure of how much water horsepower is produced by the pumping plant from the input horsepower. It is a combination of three efficiencies: bowl efficiency (the efficiency of the pump itself), driver efficiency (the efficiency of the electric motor or engine), and transmission efficiency (a measure of losses that occur in transmission shafts, chains, pulleys, and v-belts). Figure 1 shows the difference between an inefficient and an efficient pump, highlighting the bowl or pump loss, transmission loss, and electrical loss. These losses are presented in Appendix B: Formulas.

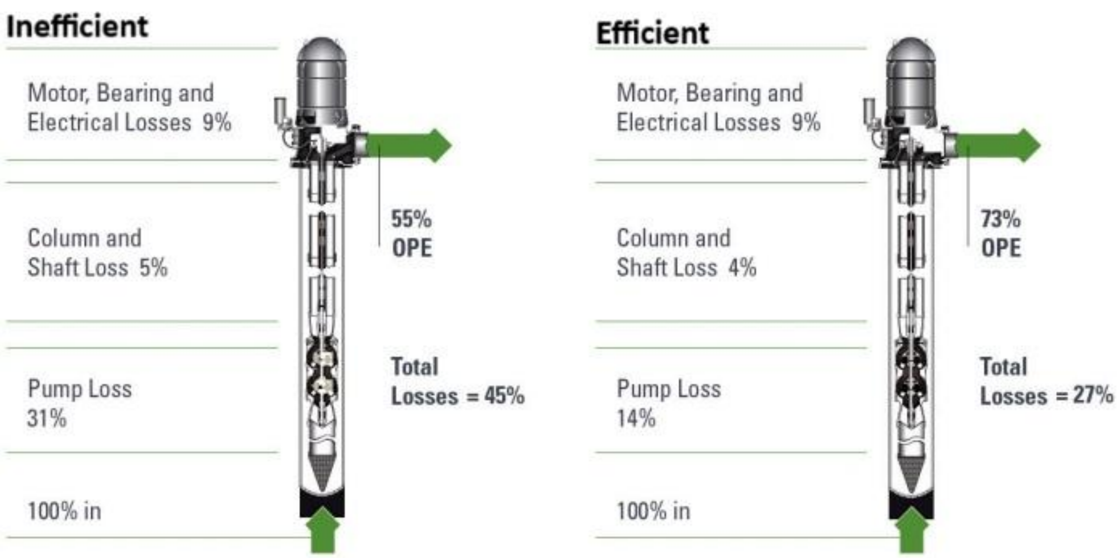


Figure 1: Losses in a pump.

Source: (SCE 2023).

Conventional Rating

Pump manufacturers generally provide a flow capacity, head, speed, and impeller diameter as the specifications of a pump on the nameplate. This indicates another term often used in the pumping industry called the best efficiency point (BEP) or duty point. The BEP is the specific operating condition where the pump performs most efficiently, delivering the desired flow rate and pressure. It represents the intersection of the pump's performance curve and the system's resistance curve. Figure 2 shows some pumps' conventional nameplates with speed, flow capacity, and head for the corresponding pumps' BEP.

Figure 2: Nameplates of different pumps without PEI rating.

Source: Project team.

The pump manufacturers also provide a pump curve showing the pump's specifications and operating limits in terms of impeller diameter, speed, flow capacity, total head, bowl efficiency, brake horsepower, and net positive suction head (NPSH) for a specific pump model. The pump curve helps select a pump for a specific application. The pump curve in Figure 3 shows that the pump with an 11-inch impeller diameter, operating at 1,750 revolutions per minute (RPM), will perform most efficiently, achieving a hydraulic efficiency of 82.5 percent and delivering approximately 970 gallons per minute (GPM) of clean water at 100 feet of total head.

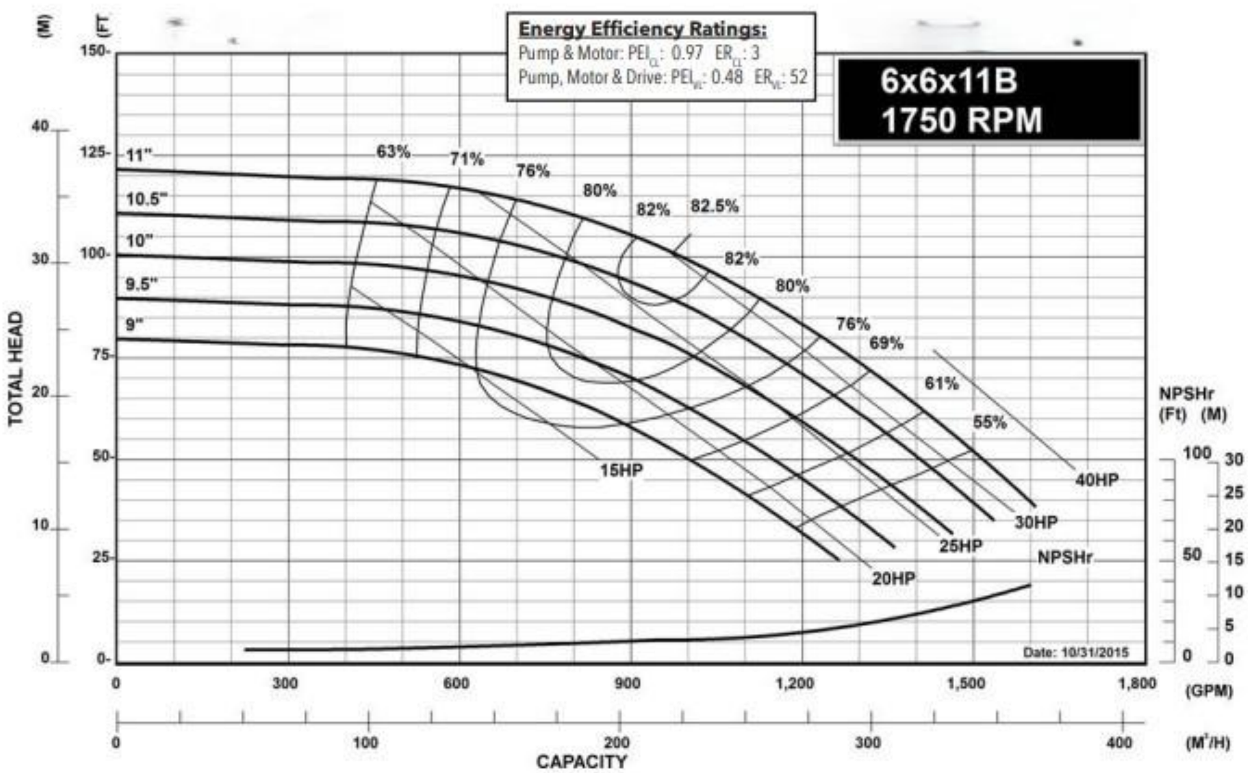


Figure 3: Pump curve for a specific pump model.

Source: Bell & Gossett Series e-80 (Xylem 2019).

Introduction to the PEI

The Energy Policy and Conservation Act of 1975, as amended, sets forth a variety of provisions designed to improve energy efficiency (EE). The Department of Energy (DOE) introduced the PEI as part of its energy conservation standards for pumps. The DOE determined that the new energy conservation standards for pumps are technologically feasible and economically justified, and would result in significant conservation of energy. The effective date of this rule was March 28, 2016. Compliance with the new standards established for pumps is required on and after January 27, 2020. The new standards apply to all equipment classes listed in the Federal Register (DOE 2016) and manufactured in, or imported into, the United States on and after January 27, 2020. The DOE did not have energy conservation standards for pumps before this ruling. Two rules were published into law:

- Energy conservation standards for pumps (DOE 2016).
- Test procedure for pumps (DOE 2016).

A pump model is compliant if its PEI rating is less than or equal to the adopted standard. PEI is defined as the pump efficiency rating (PER) for a given pump model with full impeller diameter, divided by a calculated minimally compliant PER for the given pump model. PER is defined as a weighted average of the electric input power supplied to the pump over a specified load profile, represented in horsepower. A PEI greater than 1.00 would indicate that the pump does not comply with the DOE's energy conservation standard, while a value less than 1.00 would indicate that the pump is more efficient than the standard requires. A pump model is compliant if its PEI rating is less than or equal to the adopted standard.

The minimally compliant PER is unique to each pump model and is a function of specific speed (a dimensionless quantity describing the geometry of the pump), flow at BEP, and a specified C-value. A C-value is the translational component of a three-dimensional polynomial equation that describes the attainable hydraulic efficiency of pumps as a function of flow at BEP, specific speed, and C-value. Thus, when a C-value is used to define an efficiency level, that efficiency level can be considered equally attainable across the full scope of flow and specific speed encompassed by this final rule (DOE 2016).

The following clean water pumps used in a variety of commercial, industrial, agricultural, and municipal applications with a nominal design speed of 1,800 and 3,600 RPM and an operating mode of constant load (CL) or variable load (VL) are within the scope of the energy conservation standard, with the following exceptions:

- End suction close-coupled (ESCC).
- End suction frame mounted/own bearings (ESFM).
- In-line (IL).
- Radially split, multi-stage, vertical, in-line diffuser casing (RSV).
- Submersible turbine (VTS) pumps.

There is a great variety of pumps and applications that are not included in the PEI rating. Figure 4 shows examples of PEI-rated pump nameplates with pump model number, serial number, and PEI rating.

Pump with PEI CL 0.95　　Pump with PEI CL 0.97

Figure 4: Nameplates of different pumps with PEI rating.

Source: Project team.

The pump in Figure 3 has a PEI rating of Constant Load Pump Energy Index (PEI_{CL}) 0.97 and Variable Load Pump Energy Index (PEI_{VL}) 0.48, which means that the pump is 3 percent more efficient than a pump rated PEI_{CL} 1.00 when operating at constant load and is 52 percent more efficient than a pump rated PEI_{VL} 1.00 when operating at VL.

Savings and Benefits

The DOE evaluated the economic impacts of the adopted standards on consumers of pumps and found the average LCC savings positive and the simple payback period less than the average lifetime of pumps. The DOE's analyses indicate that the adopted energy conservation standards for pumps would save a significant amount of energy. Without new standards, the lifetime energy savings for pumps purchased in the 30-year period that begins in the anticipated year of compliance with the new standards (2020–2049), amount to 0.29 quadrillion British thermal units. This represents savings of one percent relative to the energy use of these products in the case without new standards. In addition, the standards for pumps would have significant environmental benefits. The DOE estimates that the standards would result in 17 million metric tons of cumulative carbon dioxide greenhouse gas emission reductions over the same testing period as energy savings.

California Agriculture Water Energy Nexus

California water use can vary significantly in wet and dry years. On average, communities use 10 percent, agriculture uses 40 percent of water statewide, and the environment uses 50 percent. These proportions vary depending on the region and whether the year is wet or dry (PPIC 2023). Figure 5 and Figure 6 depict California water uses and water supply sources in a representative wet (2019) and dry (2020) year. On average, California agriculture irrigates more than nine million acres using roughly 34 million acre-feet of water, typically diverted from surface waters or pumped from groundwater. Surface waters include rivers, lakes, and reservoirs that deliver water through an extensive network of aqueducts and canals (CDWR 2025).

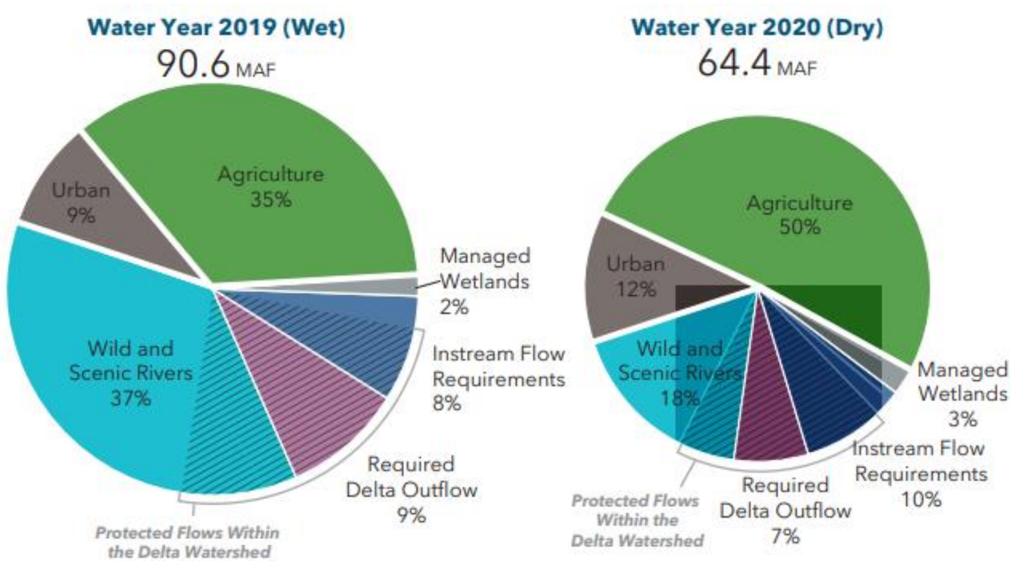


Figure 5: California water uses can vary significantly in wet and dry years.

Source: (California Water Plan 2023).

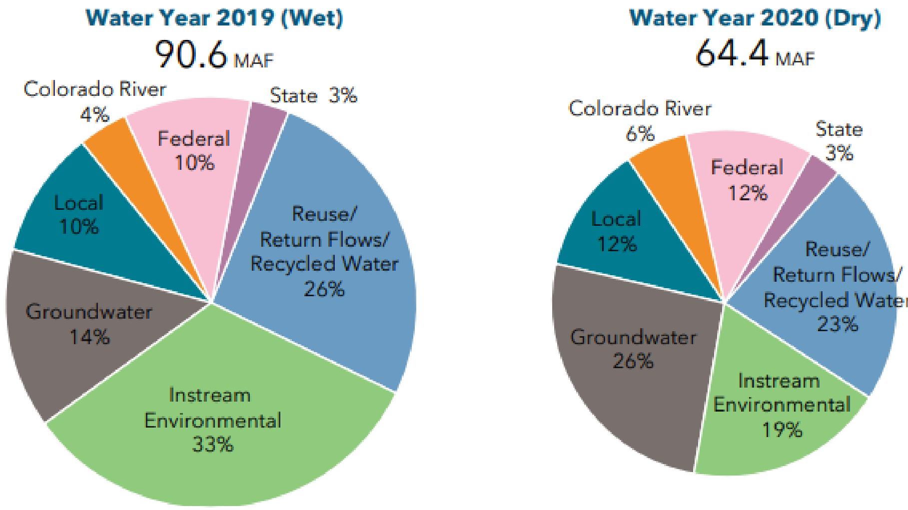


Figure 6: Developed or dedicated water supplies vary during wet and dry years.

Source: (California Water Plan 2023).

On average, about 12.68 to 16.74 million acre-feet of groundwater is pumped. Furthermore, statewide groundwater pumping for municipal and agricultural usage needs grid electricity of 8.8 terawatt-hours (TWh) in a normal year and 11.9 TWh in a dry year (CEC 2023). Energy is used for:

- Water extraction and conveyance.
- Water treatment.
- Water distribution.
- Wastewater collection and treatment.

The California agricultural sector consumes 10,560 gigawatt hours (GWh) of electricity, 18 million therms of natural gas, and 88 million gallons of diesel to pump, convey, and pressurize water in a typical weather year (CEC 2005). Table 1 shows the different types of energy used in different categories of pumping applications in the California agricultural sector.

Table 1: Energy source type and energy share per pumping application.

Pump by Energy Source	Quantity	Application	Energy in GWh
Electric pump	68,681	Groundwater pumping	4,745
Electric pump	N/A	Surface water pumping	822
Electric pump	N/A	Conveyance	2,120
Electric pump	N/A	Pressurized irrigation	2,873
Diesel engine-driven pump	12,535	Water pumping	1,113

Pump by Energy Source	Quantity	Application	Energy in GWh
Natural gas engine-driven pump	1,332	Water pumping	118

Source: (CEC 2005); (USDA 2003).

Note: N/A: Not available. The electric pump total quantity is 68,681. A breakdown per application is not available.

The project team researched agricultural irrigation pump data using United States Department of Agriculture (USDA) surveys. Figure 7 shows a comparison of irrigation water pumps between California and the U.S. California has approximately 16 percent of the total agricultural irrigation pumps in the U.S.

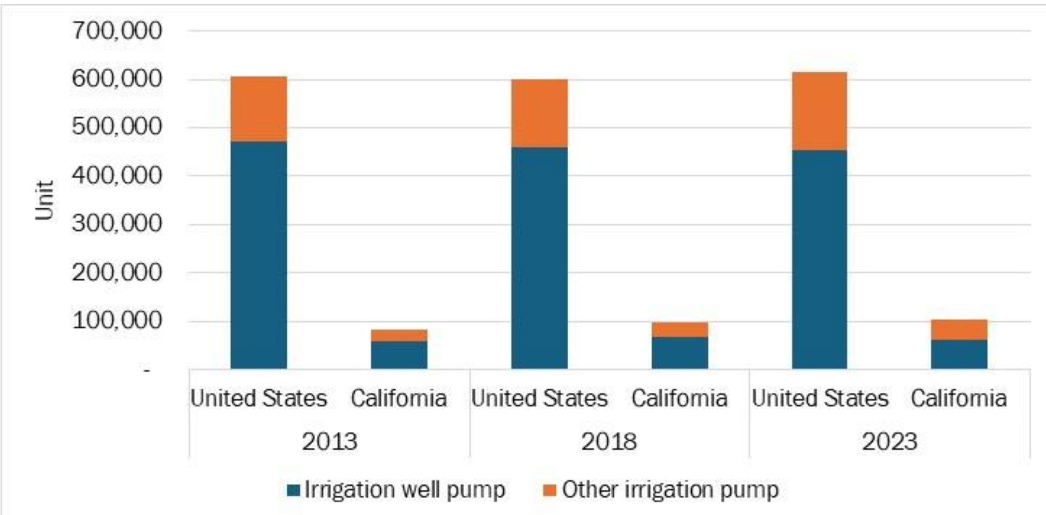
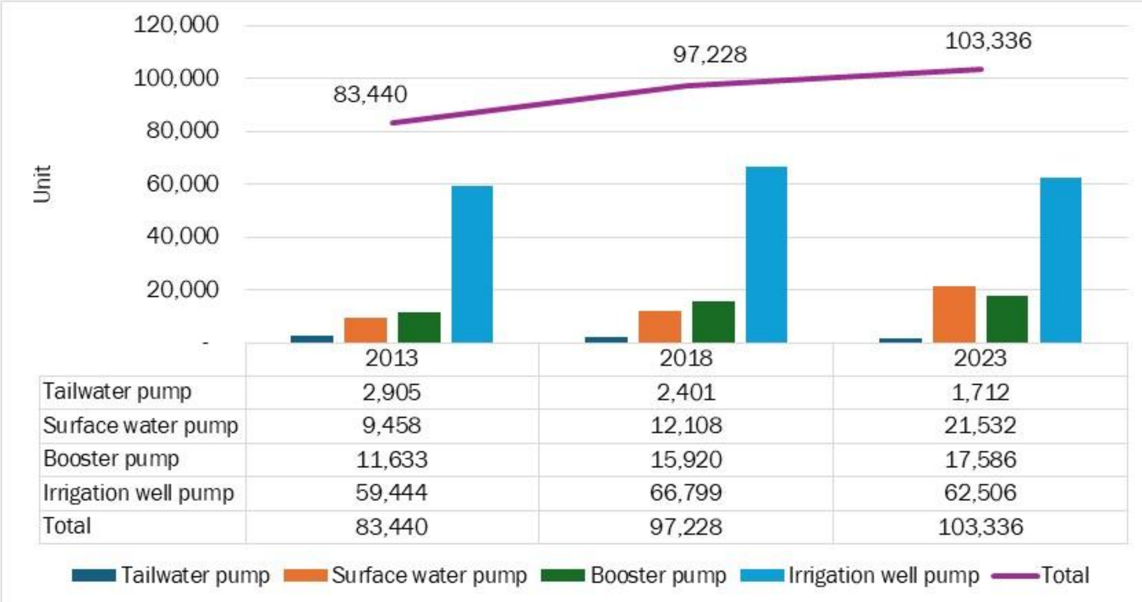


Figure 7: Historical irrigation pump data California versus the US.

Source: (USDA n.d.)

In the United States, irrigation well pumps make up 76 percent, and the remaining 24 percent are for other irrigation pumps, which include tailwater pumps, surface water pumps, and booster pumps. In California, irrigation well pumps make up 66 percent, and the other 34 percent are for other pumps. Figure 8 **Error! Reference source not found.Error! Reference source not found.**shows the distribution of irrigation pumps by application and an increasing trend of irrigation pump numbers in California over the last 12 years.



	2013	2018	2023
Tailwater pump	2,905	2,401	1,712
Surface water pump	9,458	12,108	21,532
Booster pump	11,633	15,920	17,586
Irrigation well pump	59,444	66,799	62,506
Total	83,440	97,228	103,336

Figure 8: Irrigation pump types and historical trends in California.

Source: (USDA n.d.)

The average well depth in California is 387 feet, and the average pumping capacity is 677 GPM for irrigation well pumps. Well water pumping uses deep well turbine pumps or submersible pumps. Most of the surface water, tailwater, and booster pumps fall under PEI-rated centrifugal pumps of ESCC, ESFC, IL, and RSV types.

The California agricultural sector mostly uses the following pumps for different applications:

- **Centrifugal pumps:** These are the most common type of rotodynamic pump, with radial, mixed, or axial flow. They are mainly used to increase the pressure head. Centrifugal pumps are ideal for pumping surface water or shallow groundwater and as a booster pump for irrigation. Energy conservation standards apply the PEI rating system to specific types of centrifugal pumps, including ESCC, ESFM, IL, and RSV models.
- **Deep-well turbine pumps:** These are vertical pumps designed for deep well applications. They consist of multiple stages of impellers and diffusers and are suitable for deep groundwater sources where the water table is significantly below the surface. Energy conservation standards do not apply the PEI rating system to this type of pump.
- **Submersible pumps:** These pumps are designed to be submerged in water. They have a sealed motor close-coupled to the pump body and are used for deep wells and boreholes, effective for lifting water from deep underground sources. Energy conservation standards apply the PEI rating system to VTS pumps.
- **Propeller pumps:** These pumps use a propeller to move water axially through the pump. They are suitable for low-head, high-flow applications such as flood irrigation. Energy conservation standards do not apply the PEI rating system to this type of pump.

- **Positive displacement pumps:** Both rotary and reciprocating positive displacement pumps move water by trapping a fixed amount of fluid and forcing it through the pump. They are used for precise irrigation applications where consistent flow rates are required. Energy conservation standards do not apply the PEI rating system to this type of pump.
- **Solar-powered pumps**: These pumps are powered by solar energy and can be either centrifugal or positive displacement types. They are ideal for remote areas with limited access to electricity. They are used for both surface and groundwater sources. Energy conservation standards do not apply the PEI rating system to this type of pump.

Historical Trends

The State Water Resources Control Board (SWRCB) has jurisdiction throughout California. Nine regional water quality control boards exercise rulemaking and regulatory activities by basins (SWRCB 2013). The California Department of Water Resources (DWR) manages the state's water resources, systems, and infrastructure, including the State Water Project (SWP). The SWP delivers water to 29 water contractors in the state. These water contractors, in turn, sell water to their customers. The SWP supplies water to almost 27 million Californians and about one million acres of farmland. The DWR also regulates the use of groundwater, which accounts for at least one third of all water use in California. California had 28,635 farms with 103,336 pumps in 2023, excluding institutional, research, and experimental farms (USDA 2023). According to the Secretary of State's business database, there are around 102 active business entities in California that provide drilling, supply, installation, repair, and maintenance services related to water pumps (California Secretary of State 2025). The number of engineering firms that provide engineering services to the contractors and end-customers is unknown. The initial findings in this report present a historical market trend of irrigation water pumps in California using USDA data.

Before the 1990s, standard-efficient electric motor- or engine-driven constant speed centrifugal pumps, with a typical bowl efficiency of 60 percent to 80 percent, were used for irrigation water pumping. Later, variable speed drives (VSDs) were introduced to operate pumps more efficiently under varying load conditions. As a result of the evolution of computational fluid dynamics, computer-based modeling, and energy-efficiency needs, high-efficiency pumps with variable speed applications, premium efficient motors, and VSDs became familiar in the 2000s. There were no federal or state energy conservation standards for pumps before 2016. The DOE introduced the PEI as part of its energy conservation standards for pumps in 2016 and required compliance on and after January 27, 2020.

Literature Review

The Hydraulic Institute (HI) standardizes rotodynamic and positive displacement pump types, definitions, and nomenclature. The description for each pump type and acronym, and the related industry standard, are included in this literature review. Rotodynamic pumps impart energy to the pumped fluid by means of a rotating impeller, propeller, or rotor. They include centrifugal pumps and mixed and axial flow pumps. Positive displacement pumps trap and move fluid with each shaft rotation. They are divided into reciprocating and rotary types. Reciprocating types use pistons, plungers, and diaphragms while rotary types use meshing components, such as screws, gears, lobes, and vanes.

Centrifugal pump types are:

- Rotodynamic overhung.
- Rotodynamic between bearing.
- Rotodynamic vertically suspended.

Positive displacement pump types are:

- Rotary positive displacement.
- Reciprocating positive displacement.

Figure 9 and Figure 10 show the classification of rotodynamic pumps of interest for this project. Only the green-marked ones are standardized by the DOE ruling.

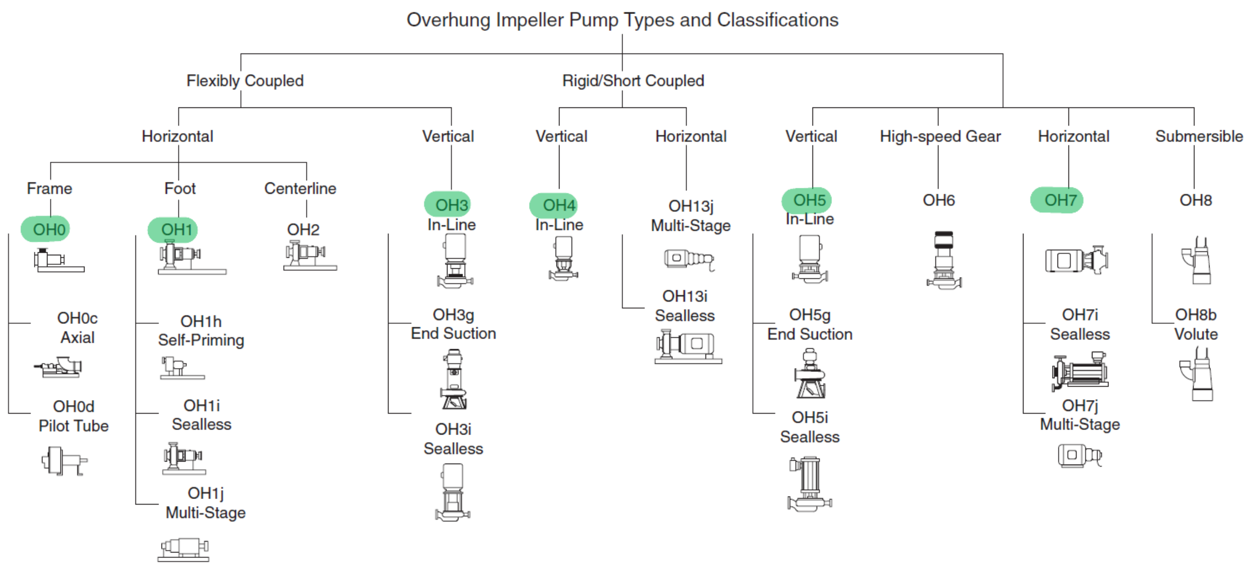


Figure 9: Rotodynamic overhung impeller pump types and classifications.

Source: (Hydraulic Institute n.d.).

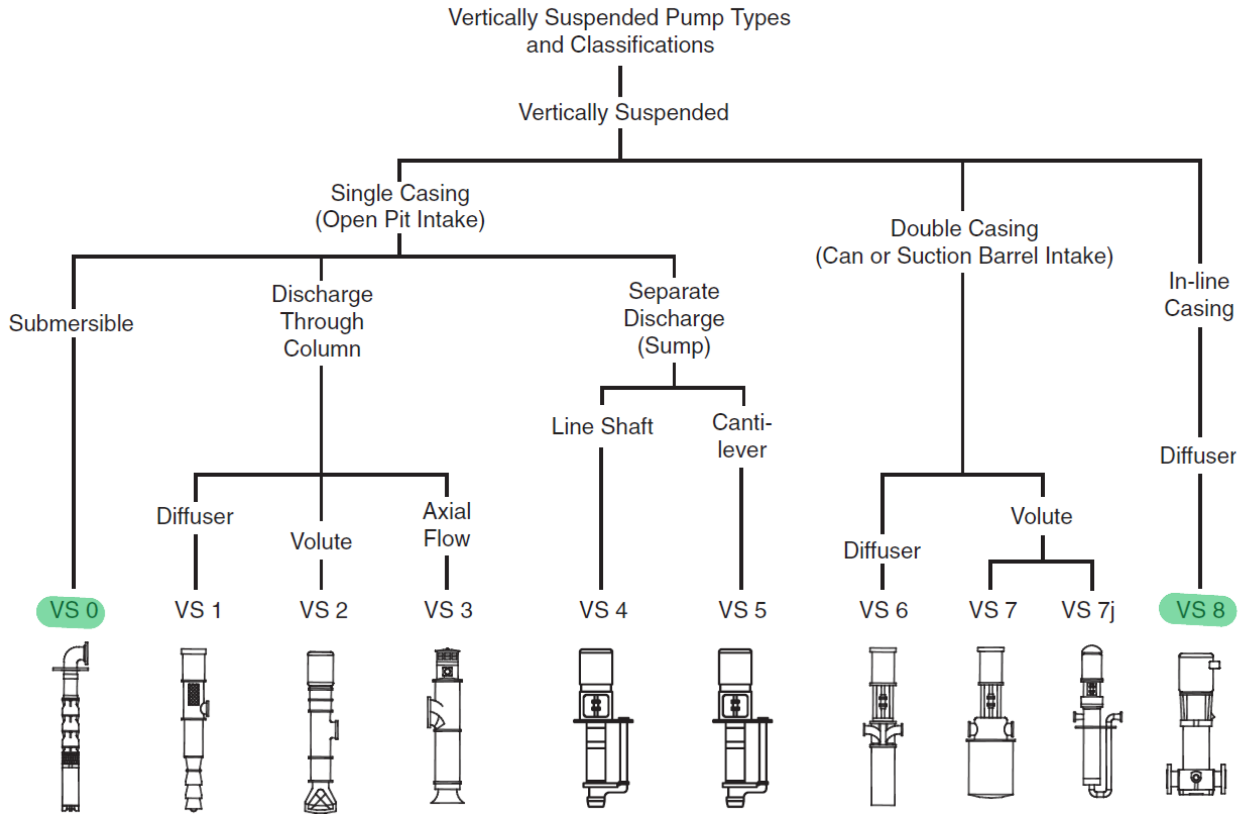


Figure 10: Rotodynamic vertically suspended pump types and classifications.

Source: (Hydraulic Institute n.d.).

Nomenclature, definitions, and scope of the standardized pumps are summarized in Appendix C.

Industry Context and Developments

The energy conservation standards adopted for the PEI rating will primarily affect the pump and pumping equipment manufacturing industry. The North American Industry Classification System classifies this industry under code 333911. The DOE identified 86 manufacturers of pumps covered under this adopted rule, with 56 of those being domestic manufacturers. The HI is the leading U.S. industry association for the pumps covered under this adopted rule. Under code 333911, which corresponds to pump and pumping equipment manufacturing, there were 4,990 businesses operating in the U.S. in 2020.

Relevant Economic, Technological, or Regulatory Factors

California state codes and standards, including Title 20 California Appliance Efficiency Regulations and Title 24 California Building Energy Efficiency Standards, do not standardize water pumps. Under Title 10 Section 431.462, the DOE developed the Energy Conservation Standard for commercial, industrial, and agricultural clean water pumps. As of January 2020, all clean water pumps sold are required to have an Energy Conservation Standard label with a PEI rating ≤ 1.0. The California Technical Forum has developed a statewide deemed measure, SWWP004-03 Water Pump Upgrade, based on PEI rating. California IOUs launched deemed and custom incentive programs to promote and incentivize high-efficiency PEI-rated pumps for different industry groups and applications. The selection criteria, eligibility, and incentive rates also vary by industry group and application. The California Department of Food and Agriculture administered the State Water Efficiency and Enhancement Program to reduce greenhouse gas emissions and save water by funding the implementation of advanced irrigation systems and technologies. However, the State Water Efficiency and Enhancement Program did not rate the implemented high-efficiency pumps in terms of PEI. Southern California Edison (SCE) offers deemed-measure rebates through their Express Rebate Program for clean water pump upgrades for agricultural customers. Table 2 presents the incentive structure which demonstrates as horsepower (hp) increases, the incentive decreases. For example, a 200 hp CL pump would receive an $800 incentive while a 40 hp CL pump would receive a $1,000 incentive.

Table 2: SCE express rebate program incentive structure.

Solution Code	Solution Description for Water Pump Upgrade (High Efficiency-HE) (Agricultural Installations)	Rebate $/Unit of Measure
PM-21041	High Efficiency Pump – < 3 hp Constant Load, Ag	$35.00/hp
PM-21042	High Efficiency Pump – 3 hp to < 50 hp Constant Load, Ag	$25.00/hp
PM-21044	High Efficiency Pump – 50 hp to ≤ 200 hp Constant Load, Ag	$4.00/hp
PM-21045	High Efficiency Pump – < 3 hp Variable Load, Ag	$35.00/hp
PM-21046	High Efficiency Pump – 3 hp to < 50 hp Variable Load, Ag	$25.00/hp
PM-21047	High Efficiency Pump – 50 hp to ≤ 200 hp Variable Load, Ag	$4.00/hp

Source: (SCE 2021).

The Statewide Water Infrastructure and System Efficiency (SW WISE) program by LINCUS offers deemed-measure-based rebates for agricultural water pump upgrades. Table 3 shows the incentive rates.

Table 3: SW WISE incentive structure.

Measure Name	Measure Size	Rebates
Water pump upgrade	Clean water pump replacement with high pump efficiency index between 1 hp–15 hp	$23.73/hp to $71.20/hp
Water pump upgrade	Clean water pump replacement with high pump efficiency index between 15 hp–50 hp	$8.81/hp to $26.44/hp
Water pump upgrade	Clean water pump replacement with high pump efficiency index between 50 hp–250 hp	$2.99/hp to $8.97/hp

Source: (Lincus Energy 2024).

The Agriculture Energy Savings Action Plan (AESAP) by TRC offers deemed-measure-based rebates for agricultural water pump upgrades in the Pacific Gas and Electric Company (PG&E) service area. Table 4 shows the incentive rates.

Table 4: AESAP rebate structure.

Description	Incentive Amount
Clean water pump, PEI less than or equal to 0.41, variable speed, hp between 1 and 15 (NC or NR)*	$15 per rated hp
Clean water pump, PEI less than or equal to 0.43, variable speed, hp between 1 and 15 (NC or NR)	$15 per rated hp
Clean water pump, PEI less than or equal to 0.45, variable speed, hp between 1 and 15 (NC or NR)	$15 per rated hp
Clean water pump, PEI less than or equal to 0.88, constant speed, hp between 1 and 15 (NC or NR)	$10 per rated hp
Clean water pump, PEI less than or equal to 0.90, constant speed, hp between 1 and 15 (NC or NR)	$10 per rated hp
Clean water pump, PEI less than or equal to 0.92, constant speed, hp between 1 and 15 (NC or NR)	$10 per rated hp
Clean water pump, PEI less than or equal to 0.43, variable speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$20 per rated hp
Clean water pump, PEI less than or equal to 0.45, variable speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$12 per rated hp
Clean water pump, PEI less than or equal to 0.47, variable speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$7 per rated hp

Clean water pump, PEI less than or equal to 0.88, constant speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$20 per rated hp
Clean water pump, PEI less than or equal to 0.90, constant speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$12 per rated hp
Clean water pump, PEI less than or equal to 0.92, constant speed, hp greater than 15 and less than or equal to 50 (NC or NR)	$7 per rated hp
Clean water pump, PEI less than or equal to 0.45, variable speed, hp greater than 50 and less than or equal to 250 (NC or NR)	$4.75 per rated hp
Clean water pump, PEI less than or equal to 0.47, variable speed, hp greater than 50 and less than or equal to 250 (NC or NR)	$2.25 per rated hp
Clean water pump, PEI less than or equal to 0.89, constant speed, hp greater than 50 and less than or equal to 250 (NC or NR)	$7.25 per rated hp
Clean water pump, PEI less than or equal to 0.91, constant speed, hp greater than 50 and less than or equal to 250 (NC or NR)	$4.50 per rated hp
Clean water pump, PEI less than or equal to 0.93, constant speed, hp greater than 50 and less than or equal to 250 (NC or NR)	$2 per rated hp

Source: (AESAP n.d.).

*NC: New construction; NR: Normal replacement.

A comparison of the PEI ratings applied over different programs to incentivize customers in California is shown in Table 5Table 5.

Table 5: A comparison of PEI ratings applied over different programs.

Pump Motor hp	DOE-PEI_{CL}	DOE-PEI_{VL}	eTRM -PEI_{CL}	eTRM -PEI_{VL}	SCE-PEI_{CL}	SCE-PEI_{VL}	SW WISE -PEI_{CL}	SW WISE -PEI_{VL}	AESAP-PEI_{CL}	AESAP-PEI_{VL}
1 ≤ 15	1	1	0.88	0.41	0.96	0.49	0.92	0.45	0.88	0.41
1 ≤ 15	1	1	0.90	0.43	0.96	0.49	0.92	0.45	0.90	0.43
1 ≤ 15	1	1	0.92	0.45	0.96	0.49	0.92	0.45	0.92	0.45
15 ≤ 50	1	1	0.88	0.43	0.96	0.49	0.92	0.45	0.88	0.43
15 ≤ 50	1	1	0.90	0.45	0.96	0.49	0.92	0.45	0.90	0.45
15 ≤ 50	1	1	0.92	0.47	0.96	0.49	0.92	0.45	0.92	0.47
50 ≤ 250	1	1	0.89	0.45	0.96	0.49	0.93	0.47	0.89	0.45
50 ≤ 250	1	1	0.91	0.47	0.96	0.49	0.93	0.47	0.91	0.47
50 ≤ 250	1	1	0.93	NA	0.96	0.49	0.93	0.47	0.93	NA

Source: Project team.

Note: Read all values as less than or equal to (≤). NA: Not Available.

Objectives

This project aimed to:

- Assess market knowledge of the PEI and savings potential of PEI pumps.
- Identify the causes of the hesitancy in adopting new, efficient pumps.
- Quantify LCC savings of PEI pumps.
- Recommend utility interventions to support market adoption.

To achieve these goals, the team conducted a market study as stated under Methodology and Approach. This report presents:

- Collected data and data analysis.
- A summary of analyzed data.
- Findings and results including:
    - An evaluation of key technology barriers, gaps, opportunities, and strategies to overcome barriers for utility intervention to advance adoption.
    - Key factors contributing to delays in market adoption of PEI pumps and a market knowledge assessment of PEI and LCC savings.
    - Existing data and tools to quantify LCC savings of PEI pumps.

    - Expected energy savings and cost effectiveness based on existing data and survey outreach results.
    - Recommendations for the next steps, which includes possible utility program pathways to support broader market adoption of PEI technology.

Methodology and Approach

The project team employed a structured three-phase methodology to evaluate the adoption of PEI-rated pumps within California's agricultural sector. Both qualitative and quantitative techniques were used for data acquisition, analysis, and interpretation.

Phase 1

Phase 1 lasted from February 2025 to April 2025. Key tasks included:

- **Literature Review:** The project team analyzed existing documentation on pump efficiency metrics and PEI rating systems. The following topics were covered:
    - Rationale and development of the PEI rating.
    - Scope of energy conservation standards.
    - Definitions.
    - Inclusions and exclusions.
    - Estimated energy savings.
    - Economic justification and impact on manufacturers and consumers.
    - Review of parallel studies to ensure the study's originality and independence.
- **Stakeholder Identification:** Initial target groups included customers, contractors, engineers and manufacturers. Later, energy efficiency (EE) programmers were added to represent IOUs and third-party EE program administrators (PAs) and institutional programmers. A visual representation of stakeholder knowledge flow is provided in Figure 11.

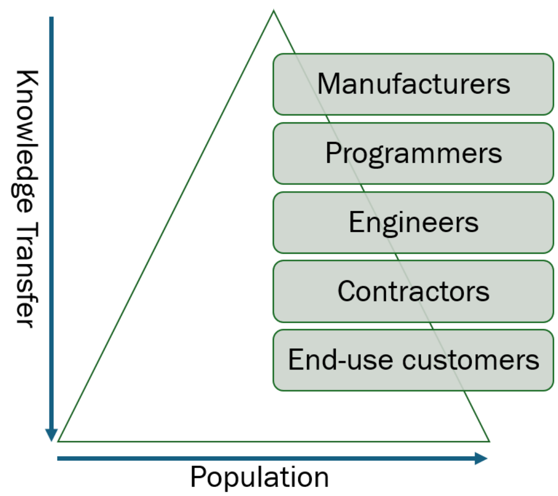


Figure 11: Knowledge transfer pyramid.

Source: Project team.

- **Survey Instrument Design:** The project team developed five distinct questionnaires; each tailored to its respective audience. The question formats included:
  - Open-ended (qualitative insights).
  - Multiple-choice (quantitative analysis).
  - Ranking (quantitative analysis).

Manufacturers provided information on demographics, product availability, market transformation trends, cost data, and knowledge transfer mechanisms. Programmers focused on regulatory aspects influencing product availability, market transformation, and the dissemination of technical knowledge. Engineers contributed perspectives on standard decision-making practices, familiarity with PEI ratings, key decision drivers, and their influence on customer choices. Contractors shared demographic data, decision-making behaviors, awareness of PEI ratings, and their role in shaping customer decisions. Finally, customers offered input on their demographics, familiarity with pumps, decision-making capacity, awareness of PEI ratings, and barriers to adoption. The questionnaires tailored to each stakeholder can be found in Appendix A: Survey Questionnaires.

The team compiled the prospective participant list using:

- **Customers:** California Agricultural Irrigation Association, Association of California Water Agencies, California Farm Bureau, California Department of Agriculture farm data, and previous project contacts.
- **Contractors:** California Secretary of State registry (California Secretary of State 2025), California Agricultural Irrigation Association, and previous project contacts.
- **Engineers:** California Secretary of State registry and previous project contacts.
- **Institutional Stakeholders:** IOUs EE programmers and institutional agricultural program administrators.
- **Manufacturers:** DOE listings, HI members, and pump manufacturer website research.

The team engaged key stakeholders to validate audience selection and ensure unbiased sampling.

Phase 2

Phase 2 lasted from May 2025 to September 2025. The project team executed a structured data collection strategy focused on stakeholder outreach and survey administration. The team:

- Developed and distributed electronic surveys using Microsoft Forms.
- Conducted biweekly follow-ups via email and phone.
- Held virtual meetings with two stakeholders to encourage participation.
- Expanded outreach through LinkedIn to increase response volume.
- Allowed the surveys to remain open for five months.

The initial target was ten responses per stakeholder group for four groups. One additional group was added mid-phase. Figure 12 shows the number of participants targeted per group.

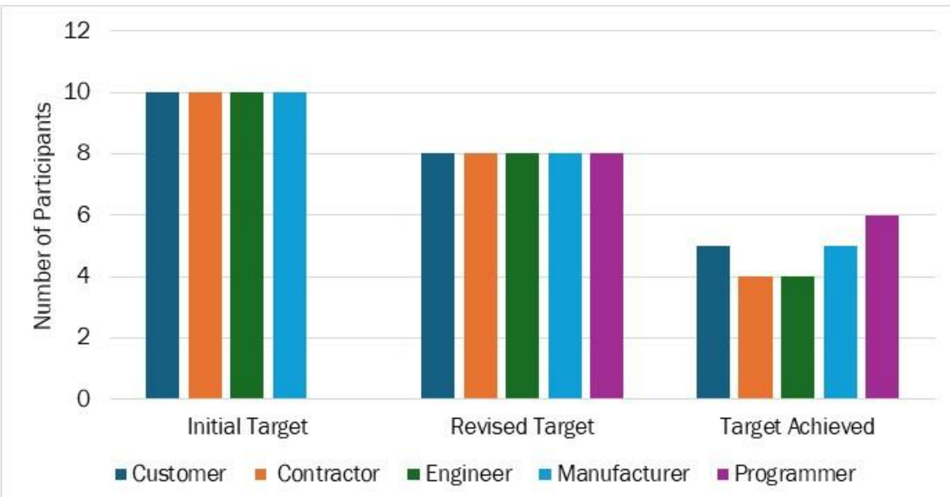


Figure 12: Survey targets and results.

Source: Project team.

The project team created a targeted email list based on its known contacts in the industry and researching California agricultural customers, irrigation service providers, pumping contractors, engineers, pump manufacturers, and institutional program administrators' associations and individual websites. The survey replies were scrutinized for any artificial intelligence-generated response, verifying participants contacts and engagement with the California agricultural domain.

Survey Effort and Responses

The project team contacted 114 entities, making 293 outreach attempts, and collected 24 verified responses. All responses were screened for authenticity and relevance to California's agricultural sector, including checks for AI-generated content. Figure 13**Error! Reference source not found.** shows the survey effort and responses received.

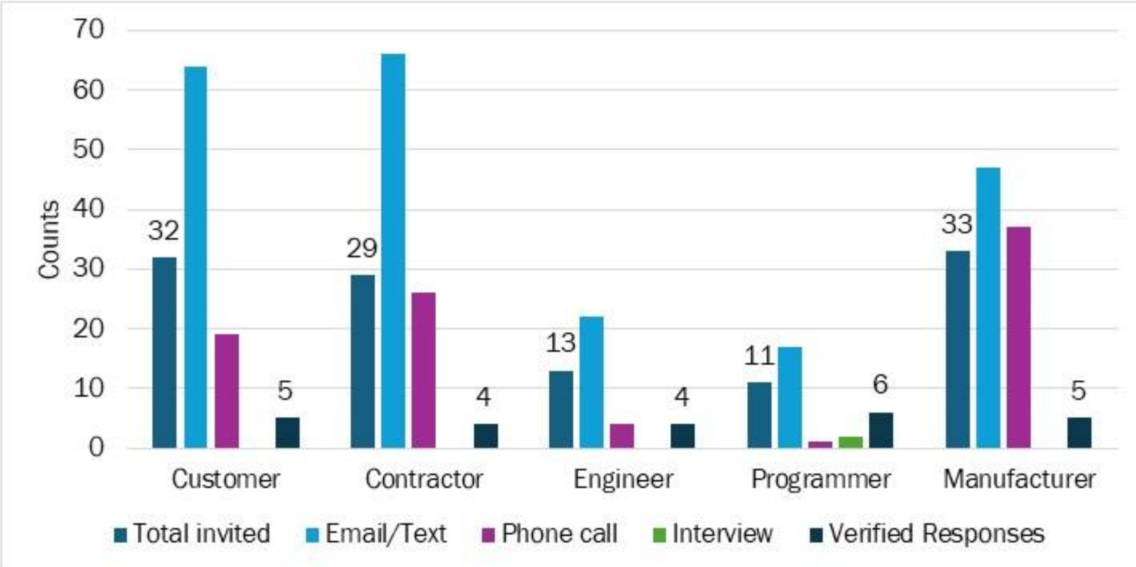


Figure 13: Survey efforts and responses received.

Source: Project team.

Outreach Challenges

The team experienced and identified the following barriers during participant engagement.

- Emails flagged as spam or ignored.
- Calls routed to voicemail or non-technical staff.
- Survey links perceived as suspicious.
- Organizational policies blocking unsolicited links.
- Limited awareness of PEI ratings among technical personnel.
- Difficulty reaching target individuals via general contact numbers.
- Sales teams often lacked technical knowledge or interest.

Phase 3

Phase 3 lasted from September 2025 to October 2025. The project team focused on processing survey data, conducting follow-up interviews, and compiling the final report.

- **Data Processing and Analysis:** Survey responses were tabulated in a structured format to facilitate meaningful interpretation. Both quantitative and qualitative analyses were performed for each survey question and graphical summaries and response distributions were generated to support the findings.
- **Stakeholder Follow-up:** Follow-up interviews were conducted with selected respondents to clarify ambiguous or incomplete survey inputs.
- **Reporting:** Findings were synthesized into this final report, including:
    - Key outcomes and insights.
    - Identified limitations.

- Strategic recommendations.
- Overall conclusions.

The project team presented the analytical results in a top-down approach in Appendix D.

Findings Overview

The findings were presented in a top-down order from manufacturer, EE programmer, engineer, contractor to the customer, focusing on barriers, gaps, opportunities, and strategies to overcome barriers separately keeping the intent of the responder groups intact. Appendix D presents detailed analysis of the surveys.

Barriers

Barriers Identified by Manufacturers

- **Technical and compliance challenges.**
  - Significant investment is required for testing, hydraulic redesign, and capital upgrades to meet PEI standards.
  - Physical limitations in achieving required efficiency levels due to pump design constraints.
  - Burdensome regulatory definition of clean water complicates compliance.
- **Knowledge transfer limitations.**
  - Minimal education efforts toward distributors and customers.
  - Distributors and customers show low familiarity and understanding of PEI ratings.
  - Limited marketing and promotional activities around PEI-rated products.
- **Customer perception and demand.**
  - Low customer interest unless rebates are involved.
  - Negative feedback due to flatter performance curves resulting from compliance.
  - Customers are often unaware of the benefits or existence of PEI ratings.
- **Economic impact.**
  - Incremental cost increases (two to three percent) for PEI-rated pumps.
  - Revenue loss from discontinued non-compliant pump models.

Barriers Identified by EE Programmers

- **Technical and product limitations.**
  - PEI standards exclude commonly used agricultural pump types such as vertical turbine pumps greater than 50 hp.
  - Limited supply and compatibility of PEI-rated pumps for agricultural applications.
- **Economic constraints.**
  - High upfront costs and low perceived payback discourage early replacement.

    - Incentives often cover only one to five percent of project costs, making them financially unattractive.

- **Awareness and education deficits.**
    - Low awareness of PEI ratings among end-users, engineers, and vendors.
    - Continued reliance on traditional pump selection methods using pump curves and BEP.
    - Minimal vendor-led education and knowledge transfer.

- **Programmatic challenges.**
    - Complex and rigid rebate application processes.
    - Narrow eligibility criteria exclude many potential projects.
    - Limited engagement from third-party implementers.

Barriers Identified by Engineers

- **Low familiarity with PEI ratings.**
    - Most engineers reported limited or no experience with PEI-rated pumps.
    - Lack of familiarity was the most cited barrier to adoption.

- **Limited customer awareness.**
    - Engineers noted that customers prioritize cost over efficiency or reliability.
    - Few engineers actively educate customers about PEI-rated pumps.

- **Minimal influence of incentives.**
    - Incentives were ranked low in importance when selecting pumps.
    - Engineers do not view rebates as a strong motivator for adoption.
    - Many projects are already scoped before engineers get involved, limiting their influence.

- **Uncertainty around product availability.**
    - Engineers were unsure whether sufficient PEI-rated pump options exist for agricultural applications.

Barriers Identified by Contractors

- **Limited familiarity with PEI ratings.**
    - Half of the contractors reported minimal understanding of PEI ratings.
    - Only two had received any formal training on PEI-rated pumps.

- **Low influence of incentives.**
    - Incentives were ranked among the least influential factors in pump selection.
    - Contractors prioritize availability, compatibility, and cost over EE or rebates.

- **Customer reluctance and cost sensitivity.**
    - Customers often choose pumps based on cost and ease of replacement.

- PEI-rated pumps are perceived to be 15 percent to 50 percent more expensive than conventional options.

- **Inconsistent performance perception.**
    - Mixed views on whether PEI-rated pumps outperform conventional ones.
    - Some contractors noted performance depends on specific operational parameters.
- **Limited customer education.**
    - Only half of the contractors actively educate customers about energy-saving benefits.
    - The other half do not influence customer decisions toward PEI-rated pumps.

Barriers Identified by Customers

- **Low awareness of PEI ratings.**
    - Only two out of six respondents had heard of the PEI rating system.
    - Most customers were unsure whether they currently use PEI-rated pumps.
- **Limited understanding of efficiency metrics.**
    - Few respondents understood wire-to-water efficiency or PEI ratings.
    - Most relied on general concepts like BEP or VFDs for efficiency.
- **Cost sensitivity.**
    - Cost was ranked as the most influential factor in pump selection.
    - Incentives and codes/regulations were among the least influential.
- **Minimal experience with PEI-rated pumps.**
    - Only one respondent reported decreased energy consumption from using a PEI-rated pump.
    - Most had no experience or were unsure of the impact.
- **Uncertainty about incentive programs.**
    - Half of the respondents were unaware or unsure about available incentives for PEI-rated pumps.

Gaps

Gaps Identified by Manufacturers

- **Awareness.**
    - Lack of widespread understanding of PEI ratings among distributors, contractors, and end-users.
- **Communication.**
    - Limited outreach and education from manufacturers to stakeholders.

- **Market data.**
- **Inconsistent tracking of PEI-rated pump adoption in agricultural applications.**
- **Product fit.**
  - PEI standards do not cover all pump types used in agriculture, especially larger vertical turbine pumps.

Gaps Identified by EE Programmers

- **Data.**
  - Lack of comprehensive tracking of PEI-rated pump adoption in agriculture.
- **Knowledge.**
  - Insufficient understanding of LCC benefits among stakeholders.
- **Communication.**
  - Weak messaging and outreach from EE programs and vendors.
- **Program design.**
  - Existing programs do not adequately support accelerated replacement or custom measures.

Gaps Identified by Engineers

- **Knowledge.**
  - Engineers are unsure about the LCC benefits of PEI-rated pumps.
  - There is a lack of technical understanding and practical exposure to PEI metrics.
- **Communication.**
  - Limited education efforts from manufacturers and EE programs to engineers.
  - Engineers are not consistently informed about PEI-related developments or tools.
- **Engagement.**
  - Engineers are not consistently involved early enough in project planning to influence pump selection.
  - Only one engineer reported regularly proposing PEI-rated pumps.
- **Training.**
  - Most engineers have not received formal training on PEI ratings or their applications.
  - Contractor knowledge of PEI ratings is also minimal or nonexistent.

Gaps Identified by Contractors

- **Training and knowledge transfer.**
  - Lack of standardized training programs for contractors on PEI metrics and applications.
  - Inconsistent ability to interpret and compare PEI ratings.

- **Engagement in program design.**
    - Contractors are not consistently involved in shaping or promoting EE programs.
    - Their practical insights are underutilized in incentive and outreach strategies.
- **Awareness of product availability.**
    - Contractors are unsure about the breadth of PEI-rated pump options for agricultural use.
    - Limited visibility into the market offerings and specifications.
- **LCC understanding.**
    - Contractors and their customers lack clarity on long-term savings and reliability benefits.
    - Decisions are often made based on upfront cost rather than total cost of ownership.

Gaps Identified by Customers

- **Knowledge.**
    - Customers lack clear understanding of PEI ratings and how they relate to energy savings.
    - LCC benefits are not well understood or communicated.
- **Information access.**
    - Customers rely on word-of-mouth or industry workshops for information, which may not be consistent or comprehensive.
    - There is limited direct outreach from EE programs or manufacturers.
- **Decision support.**
    - Some customers rely on contractors to select pumps, reducing their ability to make informed choices.
    - Tools and resources to compare pump options are not readily available.
- **Engagement.**
    - Customers are not actively engaged in EE programs or pump selection processes.
    - There is a lack of tailored communication for different farm types and experience levels.

Opportunities

Opportunities Identified by Manufacturers

- **Growing product availability.**
    - Over 7,800 PEI-rated pump models listed by the HI as of October 2025.
    - Agricultural sector uses many of the pump types now covered under PEI standards.
- **Manufacturer engagement.**
    - Some manufacturers such as Pentair, Grundfos, and Xylem offer training, whitepapers, and product selection tools.
    - Collaboration with IOUs and EE programs is underway.

- **Policy alignment.**
    - PEI adoption supports California's EE and decarbonization goals.
    - Incentive programs such as SCE and SW WISE promote PEI-rated pump upgrades.

Opportunities Identified by EE Programmers

- **Program design enhancements.**
    - Develop user-friendly, deemed savings programs tailored to agricultural needs.
    - Simplify rebate structures and allow incentives to be directed to distributors.
- **Targeted education and outreach.**
    - Focus on educating contractors, pump suppliers, and specifying engineers.
    - Use trusted channels like local pump companies and industry associations.
- **Policy and funding support.**
    - Collaborate with the California Public Utilities Commission (CPUC) to relax adoption criteria and improve program flexibility.
    - Increase funding for high-rigor, cost-effective programs.
    - Promote early retirement and accelerated replacement strategies.
- **Consumer engagement.**
    - Build trust through case studies and word-of-mouth.
    - Highlight LCC savings and operational benefits of PEI-rated pumps.

Opportunities Identified by Engineers

- **Professional development.**
    - Offer targeted training and certification programs on PEI-rated pump selection and LCC analysis.
    - Include PEI education in continuing education for irrigation and mechanical engineers.
- **Early design influence.**
    - Engage engineers earlier in project scoping to influence pump selection toward energy-efficient options.
    - Promote PEI-rated pumps as part of best practices in irrigation system design.
- **Collaboration with contractors.**
    - Engage with engineers that can serve as a bridge between EE programs and contractors to improve adoption.
    - Join education efforts to improve understanding and trust in PEI-rated technologies.
- **Data-driven decision support.**
    - Provide engineers with tools and calculators to evaluate PEI-rated pump performance and cost-effectiveness.

- Share case studies and field data to demonstrate real-world benefits.

Opportunities Identified by Contractors

- **Expand contractor training.**
    - Provide hands-on workshops and certification programs on PEI-rated pump selection and installation.
    - Include training on interpreting PEI ratings and communicating benefits to customers.
- **Leverage contractor-customer trust.**
    - Empower contractors with knowledge, as trusted advisors in pump selection, to drive adoption.
    - Equip contractors with simple educational materials and case studies to share with clients.
- **Incentivize contractor participation.**
    - Offer performance-based incentives for contractors who promote and install PEI-rated pumps.
    - Include contractor services in rebate structures to encourage deeper engagement.
- **Improve product visibility.**
    - Collaborate with manufacturers to ensure contractors have access to updated catalogs and PEI-rated options.
    - Use distributor networks to promote PEI-rated pumps more effectively.

Opportunities Identified by Customers

- **Targeted education campaigns.**
    - Develop simple, farm-friendly materials explaining PEI ratings and pump efficiency.
    - Use trusted channels like agricultural associations and local irrigation providers.
- **Demonstration projects.**
    - Showcase successful PEI-rated pump installations with measurable energy savings.
    - Use case studies to build trust and illustrate benefits.
- **Incentive awareness.**
    - Promote available rebates and incentives through direct outreach and farm networks.
    - Clarify eligibility and application processes to reduce confusion.
- Decision tools.
    - Provide calculators or visual guides to help customers compare pump options based on cost, efficiency, and reliability.
    - Include LCC analysis to highlight long-term savings.

Strategies to Overcome Barriers

Strategies Identified by Manufacturers

- **Enhanced education and outreach.**
  - Develop targeted training for distributors, contractors, and engineers.
  - Create simplified educational materials for end-users explaining PEI benefits and LCC savings.
  - Promote PEI through industry associations and trade events.
- **Improved marketing and communication.**
  - Highlight performance and reliability of PEI-rated pumps in marketing campaigns.
  - Use case studies and testimonials to build trust and demonstrate value.
- **Incentive and program support.**
  - Partner with EE programs to offer rebates that offset incremental costs.
  - Encourage early retirement of non-compliant pumps through accelerated replacement programs.
- **Product development and expansion.**
  - Innovate to include more pump types and capacities under PEI compliance.
  - Work with DOE and HI to refine standards and expand scope.

Strategies Identified by EE Programmers

- **Improve messaging and training.**
  - Enhance distributor and customer familiarity with PEI metrics.
  - Provide technical support and educational resources during program qualification.
- **Expand incentive structures.**
  - Cover at least 25 percent of project costs to make adoption financially viable.
  - Include system-level components like VFDs in incentive packages.
- **Streamline program participation.**
  - Simplify application processes and reduce administrative burden.
  - Replace rigid deemed measures with flexible custom approaches based on degraded baselines.
- **Strengthen stakeholder collaboration.**
  - Work with third-party implementers to overcome resistance.
  - Coordinate with CPUC and IOUs to align PEI adoption with broader energy goals.

Strategies Identified by Engineers

- **Enhance technical training.**
  - Develop and distribute training modules focused on PEI metrics, pump efficiency, and LCC analysis.

- Partner with professional associations to deliver workshops and webinars.

- **Improve communication channels.**
  - Create targeted outreach materials for engineers explaining PEI benefits and program incentives.
  - Encourage manufacturers and EE programs to include engineers in promotional efforts.

- **Simplify access to tools and resources.**
  - Provide engineers with easy-to-use tools for comparing PEI-rated pumps.
  - Include PEI calculators and selection guides in design software and specifications.

- **Strengthen incentive alignment.**
  - Design incentive programs that reward engineers for specifying PEI-rated pumps.
  - Include engineering services as eligible costs in rebate programs to encourage deeper engagement.

Strategies Identified by Contractors

- **Develop targeted training programs.**
  - Create accessible, role-specific training for contractors on PEI ratings, pump efficiency, and LCC.
  - Partner with trade associations and manufacturers to deliver content.

- **Simplify educational tools.**
  - Provide contractors with quick-reference guides, comparison charts, and mobile-friendly tools.
  - Include real-world examples of energy savings and performance improvements.

- **Align incentives with contractor roles.**
  - Design rebate programs that reward contractors for specifying and installing PEI-rated pumps.
  - Offer bonuses for customer education and verified energy savings.

- **Strengthen supply chain collaboration.**
  - Work with distributors and manufacturers to ensure PEI-rated pumps are readily available and promoted.
  - Include contractors in product feedback loops to improve usability and adoption.

Strategies Identified by Customers

- **Simplify messaging.**
  - Use clear, non-technical language to explain PEI ratings and EE.
  - Focus on practical benefits like reduced electricity bills and improved reliability.

- **Strengthen outreach.**

- Partner with farm bureaus, irrigation associations, and local suppliers to distribute educational materials.
- Host workshops or webinars tailored to different farm types and experience levels.

- **Enhance incentive visibility.**
    - Create easy-to-navigate summaries of available programs and rebates.
    - Include examples of how incentives reduce upfront costs and improve return on investment.

- **Empower customer decision-making.**
    - Encourage customers to ask contractors about PEI-rated options.
    - Provide checklists or questions to guide pump selection conversations.

Stakeholder Feedback

Energy Solutions and SCE are the stakeholders in coordination efforts in the project planning stage. The project team addressed the stakeholders' comments on the scope definition of the project and both parties agreed on the resolution. The report encompasses feedback gathered from the five stakeholder groups including manufacturers, EE programmers, engineers, contractors, and end-use customers. The draft report will be shared with these respondents, and any additional comments gathered will be added in the final report for the respective group. This report with the survey questionnaires will be shared with Energy Solutions and SCE for their feedback. During the preparation of this report, no further stakeholder communication has taken place.

Lifecycle Cost Study

Current data on agricultural pump capital and repair costs is outdated or insufficient. Both the DOE and the Northwest Energy Efficiency Alliance (NEEA) relied on 2012 pump price data to develop energy conservation measures based on PEI ratings. Similarly, the California Electronic Technical Reference Manual (eTRM) and PG&E used the same baseline cost data, adjusted to 2023 using a cost factor derived from RSMeans data for 2012 and 2023.

Deemed measures for water pump upgrades in these programs are based on motor horsepower and assume a fixed annual run time of 2,853 hours for agricultural applications. The effective useful life (EUL) of agricultural pumps is currently set at 15 years, although actual lifespans may be significantly longer.

To improve outreach and knowledge transfer, the LCC discussion should be simplified and made more representative of real-world conditions. The project team presents a straightforward example of annual energy savings and total LCC savings using Table 6 and Table 7, respectively.

Table 6: Yearly savings calculations.

Pump#	PEI_{CL}	Motor hp	Run hour/Year	kWh*/ Year	Electric Cost in $/ kWh	Electric Cost in $/Year	$ Savings /Year
Base	1	25	2853	53,187	0.20	10,637	0
2	0.95	25	2853	50,528	0.20	10,106	531
3	0.90	25	2853	47,868	0.20	9,574	1,063

Source: Project team.

*kWh: kilowatt-hour.

kWh/Year = PEI * Motor hp * Run hour/Year * 0.7457

Table 7: Lifecycle savings calculations.

Pump #	Measure Cost	Incremental Measure Cost	Electric Cost in $/ Year	$ Savings / Year	Simple Payback Period	EUL	LCC	LCC Savings
Base	10,000	0	10,637	0	0	15	169,561	0
2	12,000	2,000	10,106	531	3.76	15	163,583	5,978
3	15,000	5,000	9,574	1,063	4.70	15	158,605	10,956

Source: Project team.

LLC = Measure Cost + Electric Cost * EUL

The PEI rating difference shows the percentage of savings resulted from using a lower PEI-rated pump instead of a higher PEI-rated pump. Using a pump with a PEI rating of 0.90 instead of a pump with a PEI rating of 0.95 should deliver 5 percent savings for the same application and operating hours.

Recommendations

Based on the findings and analytical results from the Agricultural Sector Adoption of PEI Pumps Market Study, the following technical recommendations are proposed to enhance EE and accelerate the adoption of PEI-rated pumps in California's agricultural sector.

- **Expand incentive structures to improve cost-effectiveness.**

- Increase rebate levels to cover at least 25 percent of total project costs to make PEI-rated pumps financially viable for agricultural users.
- Include system-level components such as premium-efficiency motors and VFDs in incentive packages.
- Adopt accelerated replacement models that account for degraded baseline performance, enabling more projects to qualify under custom measures.

- **Simplify program participation and eligibility.**
    - Streamline application processes for EE programs to reduce administrative burden and improve accessibility.
    - Relax eligibility criteria to include a broader range of pump types and configurations, especially vertical turbine pumps commonly used in agriculture.
    - Develop deemed measures that reflect real-world agricultural use cases and allow for flexible implementation.
- **Enhance market education and technical training.**
    - Develop targeted training modules for contractors, engineers, and distributors on PEI metrics, LCC analysis, and system optimization.
    - Promote knowledge transfer through collaboration with manufacturers, trade associations, and the HI.
    - Create educational materials for end-users highlighting the operational and financial benefits of PEI-rated pumps, including case studies and performance comparisons.
- **Improve product availability and supply chain engagement.**
    - Encourage manufacturers to expand PEI-rated product lines suitable for agricultural applications, including larger capacity pumps.
    - Support distributors with technical resources and incentives to stock and promote PEI-rated pumps.
    - Facilitate partnerships between utilities, manufacturers, and local pump suppliers to ensure product accessibility.
- **Leverage data and analytics for program optimization.**
    - Establish a centralized database to track PEI-rated pump installations, energy savings, and market penetration across sectors.
    - Use performance data to refine program targeting and improve cost-effectiveness evaluations.
    - Coordinate with the CPUC and IOUs to align PEI adoption strategies with broader decarbonization and water-energy nexus goals.

The project team recommends the following actions to improve the effectiveness of the EE incentive programs:

- **Expand incentive coverage.**

- Revise the incentive structure to include a broader range of PEI-rated pumps available on the market. Currently, between 3 percent and 75 percent of PEI-rated RSV and VTS pumps are excluded from existing EE programs, as shown in Table 8.

Table 8: PEI-rated pumps excluded from the EE programs in California.

Pump Type	PEI range	Available Pumps	PEI Range Beyond SCE Incentive	Pumps Beyond SCE Incentive	% Pump Beyond SCE Incentive	PEI Range Beyond SW WISE and AESAP incentive	PEI Range Beyond SW WISE and AESAP incentive	% Pump Beyond SW WISE and AESAP Incentive
RSV pump with PEI_{CL} rating	1.00-0.82	752	1.00-0.97	19	3%	1.00-0.94	91	12%
RSV pump with PEI_{VL} rating	0.53-0.38	128	1.00-0.5	23	18%	1.00-0.48	54	42%
VTS pump with PEI_{CL} rating	1.00-0.75	219	1.00-0.97	49	22%	1.00-0.94	101	46%
VTS pump with PEI_{VL} rating	0.59-0.32	28	1.00-0.5	20	71%	1.00-0.48	21	75%

Source: Hydraulic Institute pump database as of October 20, 2025, (Hydraulic Institute n.d.).

- Refine incentive tiers: Some current EE program incentive tiers do not align with expected outcomes. For example, a 40 hp high-efficiency pump may receive a $1,000 incentive, while a 50 hp pump with the same efficiency receives only $200, as shown in Table 2. To ensure fairness and effectiveness, incentive tiers should be carefully structured to reflect equipment specifications and incremental costs.
- Update pump price data: In California, irrigation well pumps account for 66 percent of all irrigation sector pumps, with most being VTS types. The price data used in deemed measures and incentive calculations does not include RSV pump pricing. Update the dataset to reflect actual product prices, incremental costs, and appropriate incentives.
- Refine incentive classification: Existing EE programs classify incentives based on pump hp, sector, and PEI rating tiers. In practice, RSV and VTS pumps are more expensive than ESCC, ESFM, or IL pumps of similar size (excluding installation costs). The incentive structure should also account for pump type to ensure fair and effective support for agricultural sector pumps.
- Consider long-term value: Agricultural well pumps are long-term investments with operational life often extending 30 to 40 years, despite EE programs currently assuming a 15-year EUL.

The incentive structure should reflect the long-term kWh savings potential to encourage market transformation.

- Enhance PEI-rating outreach: Outreach efforts should focus on two key areas:
    - Repair vs. replacement decisions: Agricultural customers often rely on local contractors to decide whether to repair or replace pumps. These decisions are influenced by the contractor's business model. Replacing a non-PEI-rated pump with even a minimally efficient PEI-rated pump (PEI < 1) can yield efficiency gains.
    - Promote higher efficiency: Educate local pump installers and contractors on the LCC benefits of high-efficiency PEI-rated pumps to drive broader adoption.

These recommendations aim to address the identified market barriers and gaps while leveraging existing opportunities to drive energy-efficient pump adoption. Implementing these strategies will support California's agricultural sector in achieving measurable energy savings, reducing greenhouse gas emissions, and contributing to the state's long-term sustainability objectives.

Conclusion

Despite federal and state mandates and growing product availability, adoption remains limited due to a combination of technical, economic, and information barriers. The study revealed that low awareness, perception of high upfront costs, limited program flexibility, and gaps in education and outreach are key impediments to market transformation. Stakeholders across the value chain, from manufacturers to end-users, identified actionable strategies to overcome barriers, including expanding incentives, simplifying program design, enhancing technical training, and improving supply chain engagement. By refining incentive structures, updating cost data, and promoting LCC awareness, California can accelerate the adoption of energy-efficient pump technologies. The preceding Recommendations section outlines specific actions to address the barriers identified and support broader adoption.

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Appendix A: Survey Questionnaires

Survey questionnaires for end-user customers: Understanding knowledge of PEI-rated pumps:

1. What kind of farms do you have?

a) Food crop

b) Fruit/vegetable

c) Dairy, fodder

d) Other, _____

2. How many years have you been farming?

   a) +20 years

   b) 10–20 years

   c) Less than 10 years

3. What is your primary source of irrigation water? Check all that apply.

   a) Groundwater

   b) Surface water

   c) Recycled water

4. What types of pumps do you have for groundwater pumping? Check all that apply.

   a) Centrifugal pump

   b) In-line pump

   c) Deep tube well pump

   d) Vertical turbine pump

   e) Submersible pump

   f) Reciprocating pump

   g) Other________________

5. What types of pumps do you have for surface water/recycled water pumping? Check all that apply.

   a) Centrifugal pump

   b) In-line pump

   c) Deep tube well pump

d) Vertical turbine pump

e) Submersible pump

f) Reciprocating pump

g) Other________________

6. How do you select a pump if you need to replace an old one?

   a) I do not select. My contractor selects for me.

   b) I choose a like-for-like replacement (it is easier and economical).

   c) I prefer an energy-efficient pump to replace the old one.

   d) I prefer an energy-efficient pump and a premium-efficient motor to replace the old inefficient pump and motor.

7. How do you select a pump if you need to install a new one?

   a) I do not select. My contractor selects for me.

   b) I choose to install a similar pump I have (it is easier and economical).

   c) I prefer an energy-efficient pump with a premium efficiency motor and VFD.

8. What do you know about a pump's efficiency? Check all that apply.

   a) A pump's efficiency is called "wire to water" efficiency.

   b) A pump has a "duty point" where it should run.

   c) A pump is at maximum efficiency at the best efficiency point (BEP).

   d) A pump with a Pump Energy Index (PEI) rating is a more efficient pump than a non-PEI-rated pump.

   e) A pump with a VFD is more energy efficient.

   f) I do not know much about pump efficiency.

9. Have you heard of the Pump Energy Index (PEI) rating system before this survey?

   a) Yes

   b) No

   c) Not sure

10. How would you rate your understanding of PEI-rated pumps?

   a) Expert understanding

   b) Moderate understanding

   c) Minimal understanding

d) Not familiar with PEI-rated pumps

11. Where did you first learn about PEI-rated pumps? Check all that apply.

    a) Industry publications
    b) Workshops
    c) Word of mouth
    d) Other, ________

12. Do you currently use PEI-rated pumps on your farms(s)?

    a) Yes
    b) No
    c) Not sure

13. What factors would influence your decision to purchase PEI-rated pumps or any other pumps? Check all that apply.

    a) Availability
    b) Codes and regulations
    c) Cost
    d) Compatibility
    e) Energy savings
    f) Rebates or incentives
    g) Reliability
    h) Other, _______________

14. Which factors influence your decision the most? Rank your preferences from 1 to 7 (1 = the most influential, 7 = the least influential).

    a) Availability
    b) Codes and regulations
    c) Cost
    d) Compatibility
    e) Energy savings
    f) Rebates or incentives
    g) Reliability
    h) Other, ____

15. Have you noticed any changes in energy consumption since using PEI-rated pumps?
    a) Increased energy consumption
    b) No change in energy consumption
    c) Decreased energy consumption
    d) Not applicable
16. Will you consider a PEI-rated pump for your next replacement or new installation?
    a) Yes
    b) No
    c) Not sure
17. Provide an estimated percentage of your current pump installation costs.
    a) Pump capital cost _______% of the total project cost
    b) Motor capital cost _______% of the total project cost
    c) Well preparation cost _______% of the total project cost
    d) Electric construction cost _______% of the total project cost
    e) Installation and commission cost - _______% of the total project cost
    f) Permit cost - _______% of the total project cost
18. Do you know energy service providers incentivize the installation of PEI-rated pumps?
    a) Yes
    b) No
    c) Not sure

Knowledge share shown on top of end-user customer and pump contractor survey: On January 27, 2020, the United States Department of Energy (DOE) set a Pump Energy Index (PEI) rating compliance for five types of rotodynamic centrifugal pumps (ESCC, ESFM, IL, RSV, VTS) of 1800 and 3600 rpm, for constant and variable speed application. Constant speed pump has a PEI_{CL} rating and variable speed pump has a PEI_{VL} rating. Both PEI_{CL}, and PEI_{VL} range between 0 and 1. The lower the PEI rating, the more energy-efficient the pump is. Generally, PEI_{CL} ranges between 0.7~1.0, and PEI_{VL} ranges between 0.3~0.7. Energy service providers (i.e. SCE, PG&E, SDGE) will incentivize the customer to purchase PEI-rated pumps.

Survey questionnaires for pump contractors/installers: Understanding knowledge of PEI-rated pumps.

1. Rank your company's presence in terms of industry preferences on a scale from 1 to 3 (1 = the most influential, 3 = the least influential).

a) Clean water

b) Wastewater/recycled water

c) Other__________________

2. Rank your company's presence in terms of industry preferences on a scale from 1 to 5 (1 = the most influential, 5 = the least influential).

a) Agricultural

b) Commercial

c) Industrial

d) Residential

e) Other__________________

3. How do you select a new pump to replace an old pump for your customer?

a) Consult with the pump manufacturer or local distributor.

b) Consult with the engineer.

c) Select a like-for-like replacement.

4. How do you select a pump for a new installation for your customer?

a) Consult with the pump manufacturer or local distributor.

b) Consult with the engineer.

c) Select a pump yourself.

d) Select a like-for-like replacement.

5. What factors influence your decision to select pumps for your customer? Check all that apply.

a) Availability

b) Codes and regulations

c) Cost

d) Compatibility

e) Energy savings

f) Rebates or incentives

g) Reliability

h) Other, __________

6. What factors influence your pump selection the most? Rank your preferences on a scale from 1 to 7 (1 = the most influential, 7 = the least influential).

a) Availability

b) Codes and regulations

c) Cost

d) Compatibility

e) Energy savings

f) Rebates or incentives

g) Reliability

h) Other, ____

7. The DOE introduced the pump efficiency rating, Pump Energy Index (PEI) in 2016. How would you rate your understanding of PEI-rated pumps/pump's PEI rating?

a) Expert understanding

b) Moderate understanding

c) Minimal understanding

d) Not familiar with a pump's PEI rating

8. How often do you install PEI-rated pumps, replacing an old pump in the agricultural sector?

a) Frequently, 75% or more of agricultural projects

b) Occasionally, 50% of agricultural projects

c) Rarely, 25% of agricultural projects

d) Never

9. How often do you install PEI pumps as a new installation in the agricultural sector?

a) Frequently, 75% or more of agricultural projects

b) Occasionally, 50% of agricultural projects

c) Rarely, 25% of agricultural projects

d) Never

10. How do you compare conventional pumps and PEI-rated pumps in terms of performance?

a) PEI-rated pumps perform better.

b) They perform the same.

c) Conventional pumps perform better.

11. What range of energy savings do you expect with PEI-rated pumps compared to conventional pumps?

a) Significant savings, 25% or more

b) Moderate savings, 10 to 25%

c) Minimal savings, 1 to 10%

d) No savings

12. What is your expectation/experience on the reliability of PEI-rated pumps?

a) Very reliable, low maintenance

b) Somewhat reliable, moderate maintenance

c) Not reliable, high maintenance

13. What is your expectation/experience on PEI-rated pumps' life span?

a) Longer than conventional pumps

b) About the same as conventional pumps

c) Shorter than conventional pumps

14. What is your expectation/experience on PEI-rated pumps' initial costs compared to conventional pumps?

a) More than conventional pumps, about ____% more

b) About the same as conventional pumps.

c) Less than conventional pumps, about ____% less

15. Provide an estimated percentage of your current pump installation costs.

a) Pump capital cost – x%

b) Motor capital cost – y%

c) Well preparation cost – z%

d) Electric construction cost – a%

e) Installation and commission cost-b%

f) Permit cost – c%

16. Have you received any training and education on PEI rating from the pump manufacturer or distributor?

a) Yes

b) No

c) Not sure

17. Are you familiar with interpreting PEI ratings and comparing PEI-rated pumps?

a) Yes

b) No

c) Not sure

18. Will you inform your customers of the energy-saving benefits of PEI-rated pumps?

a) Yes

b) No

c) Not sure

19. Would you and how will you influence your customers to purchase PEI-rated pumps for their next pump project?

a) Yes

b) No

c) Not sure

If yes, how would you influence your customers? __________

20. Would you like to know more about PEI-rated pumps?

a) Yes

b) No

Survey questionnaires for engineers: Assessing readiness for PEI-rated pumps in California

1. Please provide your clean water pump selection/design work volume in terms of industry application.

a) Agricultural, ___% of projects

b) Commercial, ___% of projects

c) Industrial, ___% of projects

d) Residential, _____% of projects

e) Other, __________, __ % of projects

2. What are the key considerations when selecting PEI-rated pumps? Rank your preferences on a scale from 1 to 7 (1 = the most influential, 7 = the least influential).

a) Availability

b) Codes and regulations

c) Cost

d) Compatibility

e) Energy savings

f) Rebates or incentives

g) Reliability

h) Other, _____

3. How often did you propose/select PEI-rated pumps for your projects in the last year?

a) Frequently, 75% or more

b) Occasionally, 50%

c) Rarely, 25%

d) Never

Comments_________

4. How often did you propose/select PEI-rated pumps for agricultural clean water projects in the last year?

a) Frequently, 75% or more

b) Occasionally, 50%

c) Rarely, 25%

d) Never

Comments_________

5. Could improving market understanding of the PEI metric help end-customers choose efficient pumps?

a) Yes

b) Not sure

If yes, how can market understanding be improved? _______

6. Is market knowledge of PEI-rated pumps' lifecycle costs less developed?

a) Yes

b) Not sure

If yes, how can it be improved? ______

7. Have end-customers shown reluctance to adopt PEI-rated pumps?

a) Yes

b) Not sure

If yes, what reasons for reluctance have you experienced? ______

8. What is your expectation/experience on the reliability of PEI-rated pumps?

a) Very reliable, low maintenance

b) Somewhat reliable, moderate maintenance

c) Not reliable, high maintenance

9. What is your expectation/experience on PEI-rated pumps' life span?

a) Longer than conventional pumps.

b) About the same as conventional pumps.

c) Shorter than conventional pumps.

10. What are the main barriers to the adoption of PEI-rated pumps?

a) Higher capital costs

b) Lack of familiarity with PEI-rating

c) Lack of knowledge of savings potential

d) Unavailability of specific PEI-rated pumps

e) Other, ___

11. How do you address market barriers for PEI-rated pumps?

12. Provide an estimated percentage of your current pump project costs.

a) Pump capital cost – x%

b) Motor capital cost – y%

c) Well preparation cost – z%

d) Electric construction cost- a%

e) Installation and commission cost-b%

f) Permit cost – c%

13. How do you educate your customers (contractors/end users) about the benefits of PEI-rated pumps?

14. How do you rate the contractors' understanding of PEI rating?

a) Advanced understanding

b) Moderate understanding

c) Minimal understanding

d) Not familiar with PEI rating

15. Are there enough options for agricultural customers to select PEI-rated pumps for clean water applications?

Survey questionnaires for pump manufacturers: Assessing market readiness for PEI-rated pumps

1. Please provide a summary of the US market size of clean water pump quantity.

   a) Agricultural ____%

   b) Commercial _____%

   c) Industrial _______%

   d) Municipal _____%

   Comments___________________

2. Please provide a summary of the pump quantity you manufacture.

   a) Agricultural _____%

   b) Commercial _____%

   c) Industrial _______%

   d) Municipal _____%

   Comments___________________

3. What percentage of your manufactured pumps are PEI-rated?

4. What percentage of your pumps are PEI-rated, considering only agricultural clean water applications?

5. What are the impacts on the pump manufacturing industry from the standardization of pump energy conservation through PEI rating?

6. How do you educate your distributors about the benefits of PEI-rated pumps?

7. How do you rate the distributors' understanding of PEI rating?
    a) Advanced understanding
    b) Moderate understanding
    c) Minimal understanding
    d) Not familiar with PEI rating
8. How do you educate your customers about the benefits of PEI-rated pumps?
9. How do you rate the customers' understanding of the PEI rating?
    a) Advanced understanding
    b) Moderate understanding
    c) Minimal understanding
    d) Not familiar with PEI rating
10. What feedback have you received from customers regarding PEI-rated pumps?
11. What marketing strategies do you use to promote PEI-rated pumps?
12. How much is the incremental cost for a PEI-rated pump compared to a conventional pump for the same application?

    _______% increase

Survey questionnaires for EE program administrators: Assessing opportunities and barriers of adopting PEI-rated pumps in CA agricultural sector

1. How widely adopted are PEI-rated pumps in CA?
2. How widely adopted are PEI-rated pumps in the CA Agricultural Sector?
3. What are the main barriers to the adoption of PEI-rated pumps?
4. How are these barriers being addressed by EE program administrators?
5. What are the opportunities for EE program administrators to encourage PEI-rated pump adoption?
6. If you have an EE program incentivizing PEI-rated pumps, how would you rate the program's success in terms of participation?
    a) Above average
    b) Average
    c) Below average
    d) Not applicable

7. If you have an EE program incentivizing PEI-rated pumps, how would you rate the program’s success in terms of energy saving goals?
    a) Above average
    b) Average
    c) Below average
    d) Not applicable
8. Why may the EE program not receive satisfactory results?
9. What initiatives are in place to encourage awareness of PEI-rated pumps’ incentives?
10. How can incentives benefit the initial costs of the pumping project? How much offset of initial costs do you expect?
11. How can incentives benefit the total project cost compared to the measured cost?
12. If the current $/hp incentives do not attract potential participants, what other methods or resources can encourage customers?
13. How can programs simplify rebate structures and application requirements to encourage customer participation?
14. How can programs increase funding to encourage customer participation?
15. Do you plan to start a new program targeting agricultural customers to adopt PEI-rated pumps? If yes, when?

Appendix B: Formulas

Pump Efficiency Terms

Equation 1

$$Wire\ to\ water\ efficiency = \frac{Water\ horsepower\ (whp)}{Electric\ power\ input, in\ horsepower\ (hp)}$$

Where,

$$Water\ horsepower = \frac{Gallons\ per\ Minute * Total\ head, in\ ft}{3960}$$

$$Electric\ power\ input, in\ hp = \left[\sqrt{3} * L - L\ Voltage * Ampere * power\ factor\right]/0.7457$$

This can be broken into the following efficiency terms.

Bowl or hydraulic efficiency accounts for the hydraulic design of the pump's volute casing or diffuser and impeller. In other words, bowl loss accounts for the hydraulic losses in the pump.

$$Bowl\ efficiency = \frac{Water\ horsepower}{Pump\ shaft\ horsepower}$$

Transmission efficiency accounts for the shaft, coupling, bearings, seals, gaskets, stuffing boxes, etc. In other words, transmission loss accounts for the frictional and transmission losses.

$$Transmission\ efficiency = \frac{Pump\ shaft\ horsepower}{Motor\ brake\ horsepower}$$

Electric efficiency accounts for the electric motor and the VSD's efficiency (if any). In other words, electric loss accounts for the magnetic and resistive losses in the electric motor and losses in the drive (if any).

$$Electric\ efficiency = \frac{Motor\ brake\ horsepower}{Electric\ power\ input\ in\ horsepower}$$

Wire-to-water efficiency is the product of these three efficiencies.

$$Wire\ to\ water\ efficiency = Bowl\ efficiency\ *\ Transmission\ efficiency * Electric\ efficiency$$

Appendix C

Nomenclature, definitions, and scope of the standardized pumps have been summarized below (Hydraulic Institute n.d.).

End-Suction Frame-Mount (ESFM) [OH0, OH1]

An end-suction frame-mounted (ESFM), or own bearings pump is defined as a mechanically coupled, dry rotor, end suction pump with a shaft input power of greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter. However, this type of pump is not a pool filter pump. Figure 14 shows a cross-sectional view of an ESFM pump (Hydraulic Institute n.d.).

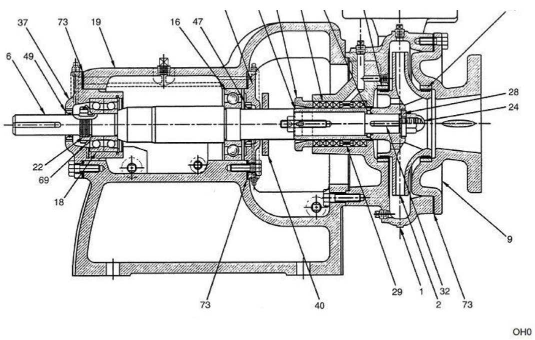

Figure 14: ESFM pump.

Source: (Hydraulic Institute n.d.)

End Suction Close Coupled (ESCC) [OH7]

An end suction close-coupled (ESCC) pump is a close-coupled, dry rotor, end suction pump that has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter. This type of pump is not a pool filter pump. Figure 15 shows a cross-sectional view of an ESFM pump (Hydraulic Institute n.d.).

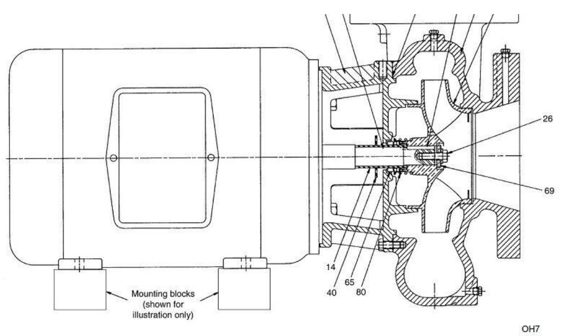

Figure 15: ESCC pump.

Source: (Hydraulic Institute n.d.)

In-line (IL) [OH3, OH4, OH5]

An in-line pump is a pump that is either:

a) A twin-head pump.

b) A single-stage, single-axis flow, dry rotor, rotodynamic pump.

The in-line pump has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter, where liquid is discharged through a volute in a plane perpendicular to the shaft. Figure 16 shows a cross-sectional view of an IL pump (Hydraulic Institute n.d.).

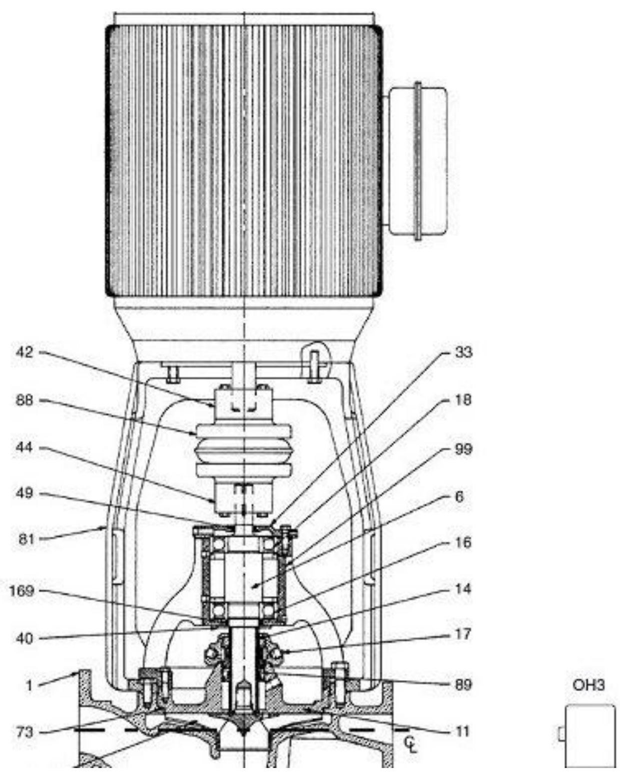

Figure 16: IL pump.

Source: (Hydraulic Institute n.d.)

Radially Split Multi-Stage Vertical In-Line Diffuser Casing (RSV) [VS8]

A radially split, multi-stage, vertical, in-line, diffuser casing (RSV) pump is a vertically suspended, multi-stage, single axis flow, dry rotor rotodynamic pump. This type of pump has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter. The pump operates at the specified shaft input power and full impeller diameter for the number of stages required for testing to standard. The liquid is discharged in a plane perpendicular to the impeller shaft. Each stage consists of an impeller and diffuser, but no external part of the pump is designed to be submerged in the pumped liquid, as shown in Figure 17.

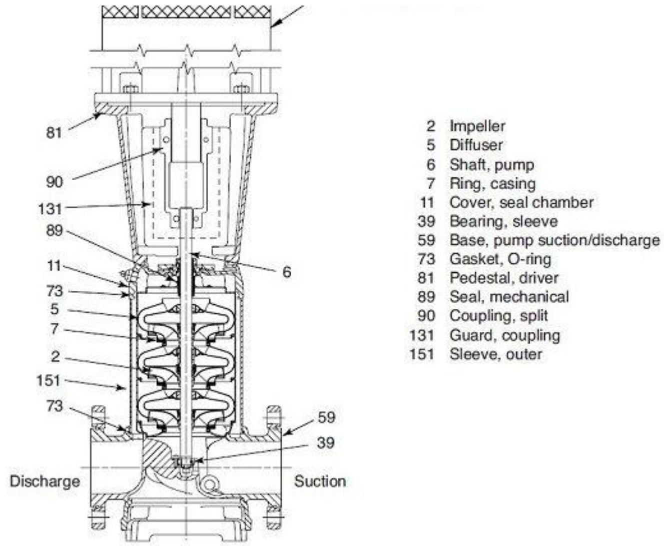

Figure 17: RSV pump.

Source: (Hydraulic Institute n.d.)

Submersible Turbine (VTS) [VS0]

A submersible turbine (VTS) pump is a single-stage or multi-stage, dry rotor rotodynamic pump. This type of pump is designed to be operated with the motor and stage(s) fully submerged in the pumped liquid. The pump has a shaft input power greater than or equal to 1 hp and less than or equal to 200 hp at BEP and full impeller diameter. The pump operates at the specified shaft input power and full impeller diameter for the number of stages required for testing to standard. Each stage of this pump consists of an impeller and diffuser, where liquid enters and exits each stage of the bare pump parallel to the impeller shaft. Figure 18 shows a cross-sectional view of a VTS pump (Hydraulic Institute n.d.).

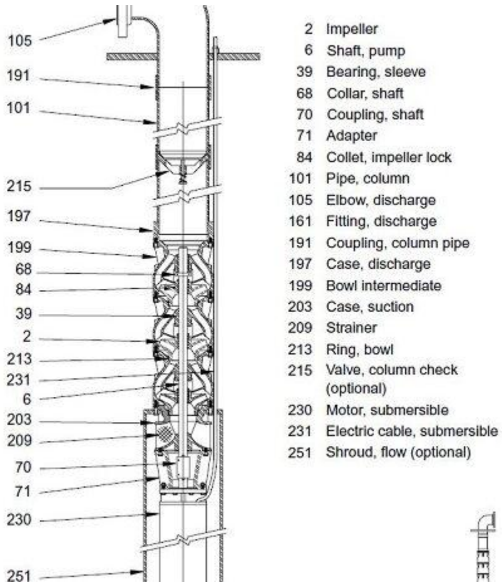

Figure 18: VTS pump

Source: (Hydraulic Institute n.d.)

Scope Refinement

There are some inclusions and exclusions in the DOE standardization.

Inclusions are:

- Clean water pump.
- Flow rate 25 GPM and greater (at BEP at full impeller diameter).
- 459 feet of head maximum (at BEP at full impeller diameter and the number of stages specified for testing).
- Design temperature ranges from 14° to 248°F.
- Pumps designed to operate with either (1) a 2- or 4-pole induction motor, or (2) a non-induction motor with a speed of rotation operating range that includes speeds of rotation between 2,880 and 4,320 revolutions per minute and/or 1,440 and 2,160 revolutions per minute, and in either case, the driver and impeller must rotate at the same speed.
- For VTS pumps, 6-inch or smaller bowl diameter.
- For ESCC and ESFM pumps, the specific speed is less than or equal to 5000 when calculated using United States customary units.

Exclusions are:

- Non-clean water pump.
- Mixed and axial flow pumps.
- Nuclear applications.
- Military specification pump.
- Seal-less pump.
- Self-priming pump.

- Fire pump.
- Sanitary (3-A Std.) pump.
- Circulator (hydronic) pump.
- Pool pumps.
- VTS pumps with more than 6 inches bowl diameter.

Appendix D

Manufacturers' Survey

The manufacturers' survey consisted of 12 questions focused on demographics, PEI rating impact, knowledge transfer, and cost. The project team received a total of eight responses, of which five were verified as originating from distinct manufacturers. Among these, three were clean water pump producers, while two represented the chemical, oil and gas sectors. Verified responses were analyzed and presented according to the survey's focus areas. The following verified organizations completed the survey dedicated to manufacturers:

- Franklin Electric
- Afton Pumps, Inc.
- Pentair
- Carver Pump Company
- Hidrostal

Demographics: Participants provided varied responses regarding their market share in the U.S. clean water pump sector. Agricultural market representation ranged from 1 percent to 35 percent. PEI-rated pump adoption also varied:

- Total PEI-rated pump share: 5 to 10 percent.
- PEI-rated agricultural pump share: 20 to 100 percent.

Two manufacturers provided notable insights into market segmentation. Manufacturer #2 was significantly involved in the municipal water and wastewater sector. These insights are visualized in Figure 19.

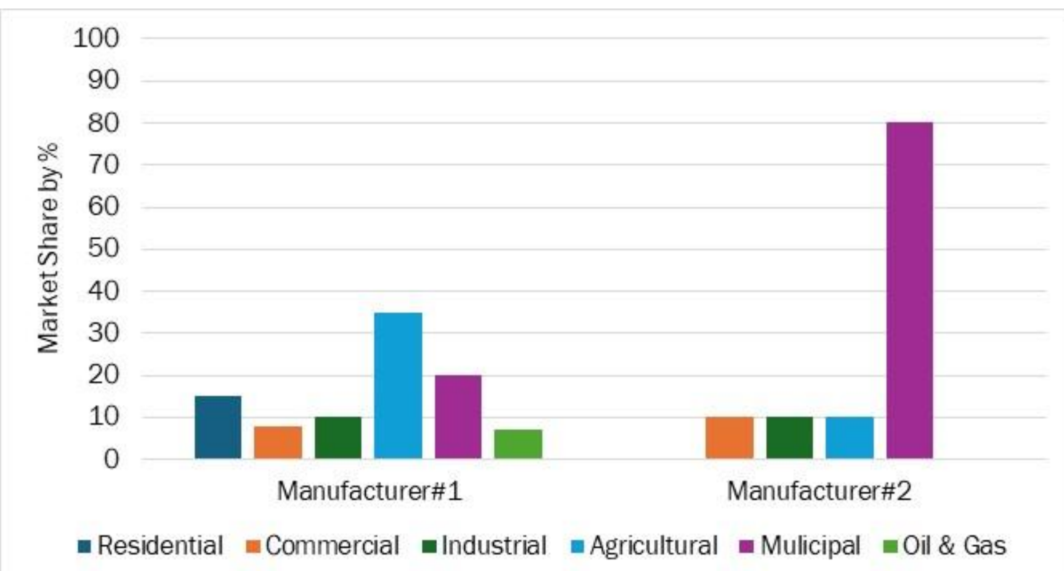

Figure 19: Pump market share.

Source: Project team.

Impact of PEI rating on the manufacturers: Manufacturers were asked about the impact of PEI rating standardization on their operations. Three responses were particularly noteworthy:

- "Heavy investment in testing, updated hydraulics, capital, etc. to bring pumps into compliance."
- "It requires a massive amount of design and development, and sometimes the physics don't allow for a solution to meet the efficiency rating. The definition of clean water is extremely loose, and the requirements are overly burdensome."
- "Limited impact; we were required to update certain ratings through engineering development, not sure."

These responses indicate significant disruption and cost implications due to compliance requirements.

Knowledge transfer: Six questions were designed to assess manufacturers' efforts in educating distributors and customers about PEI-rated pumps.

- Distributor education.
  - "Limited, we share PEI rating in catalog, but do not focus on it. Most customers do not care about PEI rating."
  - "Yes. Presentations in conjunction with the Hydraulic Institute to explain what the regulation is, how it came to be, how pumps were tested and improved to bring into compliance, etc."
- Distributor understanding of PEI rating.
  - All responses indicated minimal to no familiarity.
- Customer education.
  - "We have partnered recently with NEEA with rebate incentives in Northwest and worked with some distributors on ratings that exceed PEI and/or smart pumps."
  - Another manufacturer referenced collaboration with the HI.
- Customer understanding of PEI rating.
  - All responses indicated minimal understanding.
- Customer feedback.
  - "Limited interest except where there are requirements or rebates."
  - "Most do not care, do not understand how it would benefit them, etc. Additionally, because compliance has typically resulted in flatter performance curves, the feedback has been negative."
- Marketing strategies.
  - Responses ranged from null to limited promotion efforts.

Cost implications: One question addressed the incremental cost of PEI-rated pumps compared to conventional pumps:

- One manufacturer reported no incremental cost.
- Another cited a 2 to 3 percent increase, stating:
- "Equating the investments in testing, any new hydraulic designs, capital, etc., spread across the entire portfolio, probably does not result in much more than a 2 to 3 percent increase in the product's cost. However, pumps that would not pass the DOE requirements and have been removed from the industry, also bear a revenue loss to the pump manufacturers."

Product availability: Although the survey sample was limited, broader product availability was assessed using DOE and HI data:

  - DOE: 3,332 pump models identified for standardization in January 26, 2016 (DOE 2016).
  - HI: 7,843 PEI-rated pump models listed as of October 8, 2025. (Hydraulic Institute n.d.).

Table 9 shows the breakdown of PEI-rated pumps by type and load as found in the HI database (Hydraulic Institute n.d.) This information shows the increase in the availability of newer PEI-rated pumps.

Table 9: PEI-rated pumps on HI database.

Pump Type	ESFM	ESCC	IL	RSV	ST
CL	1,522	1,534	1,123	752	219
VL	719	931	887	128	28
Total	2,241	2,465	2,010	880	247

Source: (Hydraulic Institute n.d.)

The agricultural sector utilizes most of these pump types, particularly those with larger capacities.

Manufacturer actions toward market transformation: The project team reviewed manufacturer websites to assess their engagement with PEI-rated pump promotion and education:

- Pentair: Offers "Pentair DOE Training – Efficient Pumping" with certification (Pentair n.d.).
- Taco: Presentation on DOE regulation and HI energy rating program (Taco n.d.).
- Grundfos: "DOE Pump Efficiency Ratings Explained" (Grundfos n.d.) and "There's More to PEI than Meets the Eye" (Grundfos n.d.).
- Xylem: Whitepapers on PEI rating "What engineers need to know" (Xylem n.d.) and "Helping engineers sort out PEI in pump selection and efficient system design" ((Xylem n.d.).
- Crane Pumps & Systems: Webpage titled "Early Compliance with DOE 2020 Pump Regulations" (Crane Pumps & Systems n.d.).

Summary of manufacturer actions:

- Whitepapers on DOE standards and PEI ratings.

- Dedicated webpages on PEI-rated products.
- Product selection guidelines.
- Training for engineers, sales teams, distributors, and contractors.
- Collaboration with investor-owned utility (IOU) EE programs.

EE Programmers

The project team received six responses from various EE program entities. Select responses are presented verbatim to retain the tone and intent of the participants. The following verified organizations completed the survey dedicated to EE programmers:

- 2050 Partners
- PG&E
- SCE
- Cascade Energy
- Lincus, Inc.
- Center for Irrigation Technology, California State University, Fresno

Figure 20 shows the demographic distribution of the respondents.

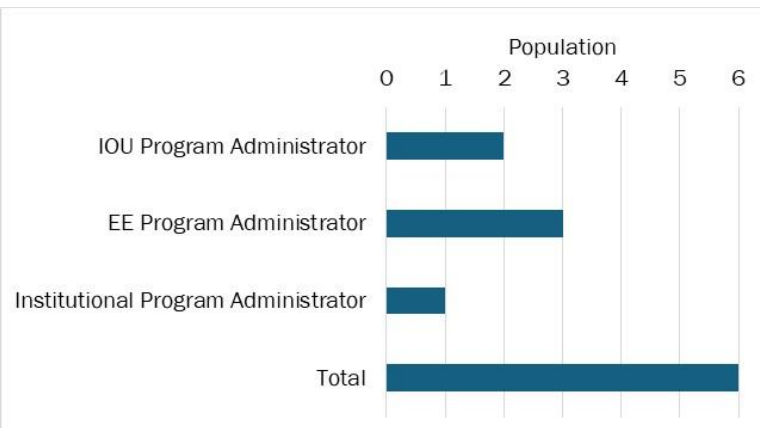

Figure 20: EE Programmers survey participants' demographics.

Source: Project team.

The questionnaire comprised 15 strategically designed questions, grouped into five thematic areas:

- Perception of market adoption.
- Barriers to adoption.
- Strategies for overcoming barriers.
- Impact of incentives.
- Future planning.

Responses from this group were considered highly valuable and are presented in detail.

Perception of PEI-rated pump adoption

Question: How widely adopted are PEI-rated pumps in CA?

- Responses:
  - “Our program promoting the use of PEI started in 2020, since then a couple of 1000s project were implemented. I assume some engineers have adopted the PEI but not sure how much penetration exist today.”
  - “I'm not sure. Much more adoption in the commercial and residential sector due to regulations and frequent replacement of pumps.”
  - “Although federally it is mandated that all new clean-water pumps (of certain pump types) in the U.S. carry a Pump Energy Index (PEI) rating of 1.0 or less, we are finding many cases in which customers are still utilizing and repairing old pumps as well as pump types that are excluded from this mandate such as vertical turbines.”
  - “Not sure. I've never seen an ag pump where PEI was used/published.”
- Summary:
  - Adoption data is largely unavailable.
  - One IOU administrator reported a high volume of projects since 2020.
  - PEI-rated pumps are more prevalent in commercial and residential sectors.
  - Agricultural users often repair older pumps or use types excluded from DOE mandates.
  - One institutional respondent has never observed PEI-rated pumps in agricultural applications.

Adoption in the CA agricultural sector

Question: How widely adopted are PEI-rated pumps in the CA agricultural sector?

- Responses:
  - “Unclear if there is detailed data for this. I have seen a number of C&I incentives for pump rebuilds, so I would estimate there are a subset of long running ag irrigation pumps with below PEI minimum efficiencies, in the designs of VT (vertical turbine) and Submersible Turbine. Many agricultural wells were drilled (to my sense) in the more recent 20–25 years, due to a couple long running droughts and challenges with surface water in those times. CA does have a well database that I consult for this, including year drilled, diameter, and depth.”
  - “Most engineers still using the pump curves and pump efficiency to select pumps, more education is needed to increase adoption.”
  - “Seldom.”
  - “Unknown to me, however, I have worked with some businesses that have installed PEI-rated pumps in Dec. 2024 and in order to qualify for the EE Program Rebate, they had to ensure that the PEI rating was at a certain value.”
  - “Although new-sales compliance is effectively 100 percent, the overall share of PEI-rated pumps across agriculture sector is not comprehensively tracked. From our interactions with Ag customers, most of the pumps we see are vertical turbine pumps >50 hp, which are not subject to DOE pump efficiency requirements. Only the <25 hp submersible irrigation pumps or <50 hp centrifugal booster pumps are subject to DOE requirements.”

- “I've never seen it used in the ag sector.”

- Summary:
  - Adoption of PEI-rated pumps in agriculture is largely unknown and likely limited.
  - Some installations have occurred, particularly where rebate programs are involved.
  - Vertical turbine pumps (>50 hp), commonly used in agriculture, are excluded from DOE requirements.
  - Education and awareness among engineers remain key barriers to broader adoption.

Barriers to adoption of PEI-rated pumps

The survey aimed to assess the challenges faced by EE program administrators in promoting PEI-rated pumps within California’s agricultural sector. Six responses were received, with several presented verbatim to retain participant tone and context.

Question: What are the main barriers to the adoption of PEI-rated pumps?

- Responses:
  - “PEI is a tough metric. At best, distributors I or my team have interviewed indicated that they consider PEI_CL to be a useful sign of good hydraulics, but it can be tough to tie actual savings that would be interesting to an ag end user. Anecdotally, ag end users are sensitive to initial cost and payback, so would likely not perform an early pump replacement or pay a significant premium for efficient products. Also, historically, PEI pumps have limited ST pumps to a total head of 459 ft wc and a bowl diameter of 6", so this would not include some of the larger 8"–12" bowl ag irrigation pumps. VT products I recall were excluded from PEI coverage.”
  - “Most engineers still using the pump curves and pump efficiency to select pumps, more education is needed to increase adoption.”
  - “Infrequent pump replacements. Additional cost. Limited supply.”
  - “When I was qualifying the pump for the ag customer, I had to reach out to the Hydraulic Institute to have someone send me a calculator that worked so PEI could be calculated. I don't think Vendors are educating customers about the PEI ratings.”
  - “Affordability of the upfront improvements and lack of sufficient cost savings in comparison to baseline overhaul scenario. Additionally, there is a lack of education and awareness of PEI ratings. These financial hurdles, along with low awareness of PEI’s lifecycle cost benefits, continue to slow deep market penetration beyond new equipment sales.”
  - “Not sure.”

- Summary of Identified Barriers:
  - Uncertainty regarding actual energy savings.
  - High upfront cost and long payback periods.
  - Limited product availability for all agricultural pump types.
  - Continued reliance on traditional pump selection methods.
  - Lack of vendor-led education and knowledge transfer.
  - Preference for repair over replacement.

- Low awareness of LCC benefits.

Strategies to overcome barriers

Two questions were asked to understand how EE program administrators are addressing these challenges.

Question: How are these barriers being addressed by EE program administrators?

- Responses:
  - “I think the messaging around PEI is improving and distributors are getting used to the metric.”
  - “Most PAs have programs to promote the use of PEI, however, there is some resistance from 3P and customers to go the extra mile when adopting the PEI.”
  - “Incentives/rebates. Technical support. Education.”
  - “When customers come to my program to qualify their pump, I educate them about the PEI rating and eligibility requirement for the rebate.”
  - “Program administrators provide engineering services and incentives to support end-use customers in their decision making when evaluating a pump. An example is the SW WISE program, which provides incentives to cover the upfront cost difference between a lower PEI-rated pump and a standard PEI-rated pump. Unfortunately, most customers and trade allies find the application process too cumbersome commiserate with the incentive amount. Additionally, the program evaluates the options of applicable pumps and recommends the most efficient option with best life cycle cost for the customer with consideration of incentives to cover the difference in upfront incremental costs.”
  - “As far as I can tell, they aren't.”
- Summary of Strategies:
  - Gradual improvement in PEI messaging and distributor familiarity.
  - Incentive and rebate programs to offset upfront costs.
  - Technical support and educational outreach.
  - Engineering services to assist in pump selection.
  - Need for simplified application processes.
  - Mixed levels of engagement across programs.

Opportunities for program enhancement

Question: What are the opportunities for EE program administrators to encourage PEI-rated pump adoption?

- Responses:
  - “I think widespread easy-to-use deemed savings program designs would be the best way to drive the market. So long as it is painless for end users, they wouldn't object to incentives, but if the program is challenging to participate in, likely won't have a lot of traffic.”

    - “Working with 3P and implementers to overcome the resistance by engineers and customers, perhaps offering extra incentives to specifying engineers.”
    - “Focus on the local pump companies and the companies that supply the pumps. Most ag customers trust their pump company and don't have time to get into the details of the efficiency.”
    - “General email campaigns through the program customer lists, or associations email "bulletin boards.”
    - “Program administrators must work with CPUC to relax adoption criteria for programs to service this end use. Lack of flexibility and ease of participation are major barriers for customers that want to work with incentive programs and adopt efficient technology. As the customer must install PEI-rated pumps upon replacement, the focus should be on early retirement/accelerated replacement approaches that can make large impacts in the market. Another approach is to increase funding for incentive programs that are most effective at targeting this end-use to allow them to spend additional time and resources to meet the ever-increasing data requirements and rigor of review associated with such projects. However, this has to be balanced with cost effectiveness of offerings.”
    - “Educate consumers about what PEI is and why it matters to them.”

- Summary of Opportunities:
    - Develop user-friendly deemed savings program designs.
    - Increase accessibility and reduce complexity of EE programs.
    - Target education efforts toward contractors and pump suppliers.
    - Promote early retirement and accelerated replacement strategies.
    - Expand funding for high-rigor, cost-effective EE programs.
    - Enhance consumer education on PEI relevance and benefits.

Impact of incentives

Question: Respondents were asked to rate the success of their EE programs, incentivizing PEI-rated pumps in terms of participation.

- Responses:
    - Above average – 0
    - Average – 0
    - Below average – 4
    - Not applicable – 2

Energy savings achievement

Question: Respondents also rated the success of these programs in meeting energy savings goals.

- Responses:
    - Above average – 0
    - Average – 1
    - Below average – 3
    - Not applicable – 2

Reasons for limited program performance

Question: Why may the EE program not receive satisfactory results?

- Responses:
  - "Education and the lack of effort by implementers."
  - "Perhaps the rebate is too low. Perhaps education plays a part. Perhaps it's not at the top of the priority list for ag customers."
  - "The savings are low compared to other EE savings measures."
  - "The EE programs incentivize lower PEI-rated pumps (efficient pumps) that go above and beyond the industry standard practice. Programs have not been successful as most project opportunities identified will have eligibility issues such as PEI criteria not met or project does not meet the strict deemed workpaper requirements – not clean water pump for example. Finding deemed workpaper eligible opportunities has been rare (1/20 estimated) and above standard practice are typically too low to meet cost effectiveness criteria for custom route rigor. The current programs with this measure have recently reached the steady state phase and are on target to hit 50 percent of energy saving goals this year. The initial program design anticipated ~40 percent of goals coming from the success of this PEI-rated pumps measure. The program has had to pivot and is anticipated to achieve even greater savings attainment in 2026 and 2027 from an alternative measure mix."
- Summary of Barriers:
  - Limited awareness and education among end users.
  - Insufficient implementer engagement.
  - Low rebate attractiveness.
  - Narrow eligibility criteria and limited qualifying project scope.

Incentive impact on project costs

Respondents provided estimates on how incentives affect upfront project costs:

  - "The incentives work as the incremental measure cost in some instances."
  - "The incentive covers only 5% of the project cost and hence is unattractive."
  - "Incremental cost covers only 1% of a pump project cost. Accelerated replacement should be applied to attract end user investment."
  - "The incentive should cover at least 25 percent of the project cost."

Total project cost considerations

Additional feedback on broader cost impacts:

  - "A variable load PEI-rated pump should receive an incentive for the VFD also."
  - "Deemed measure should be replaced with accelerated replacement, or a custom measure considering actual impact on grid, considering the degraded baseline."

Alternative engagement strategies

Question: If current $/hp incentives are ineffective, what other approaches could be used?

- Responses:
  - “Build trust from end users. End customers trust word of mouth or case studies more than EE program promotion.”
  - “Educating customers on the life cycle savings and benefits of PEI-rated pumps.”

Simplifying rebate structures and applications

Question: How can programs simplify rebate structures and application requirements to encourage customer participation?

- Responses:
  - “Fast and simple incentive application process.”
  - “Provide incentive to distributor rather than the end user.”
  - “Allow and simplify accelerated replacement using degraded baseline to encourage customer participation.”

Increasing program funding

Question: How can programs increase funding to encourage customer participation?

- Responses:
  - “Allow early retirement or accelerated replacement to encourage market adoption.”
  - “Funding may exist but adoption is low.”
  - “Adopt an aggressive incentivization policy.”

Future program planning

Question: Do you plan to start a new program targeting agricultural customers to adopt PEI-rated pumps?

- Response:
  - “Existing third-party programs are in action. No new programs planned.”

ENGINEERS

The project team received four verified responses from engineering professionals. The participants included:

- Two design, consulting, and installation engineers.
- One program design engineer.
- One institutional engineer involved in irrigation training and research.

The following verified organizations completed the survey dedicated to engineers:

- Mechanical, Water, and Energy Efficiency, also known as MWE2, LLC.
- RMS Energy Consulting, LLC.

- Imperion.
- Cal Poly, Irrigation Training & Research Center.

A total of 14 survey questions were administered. The results are summarized below.

Sector involvement

Question: Please estimate your clean water pump selection/design work volume by application sector (Agricultural, Commercial, Industrial, Residential, Other).

The distribution of sector involvement is illustrated in Figure 21.

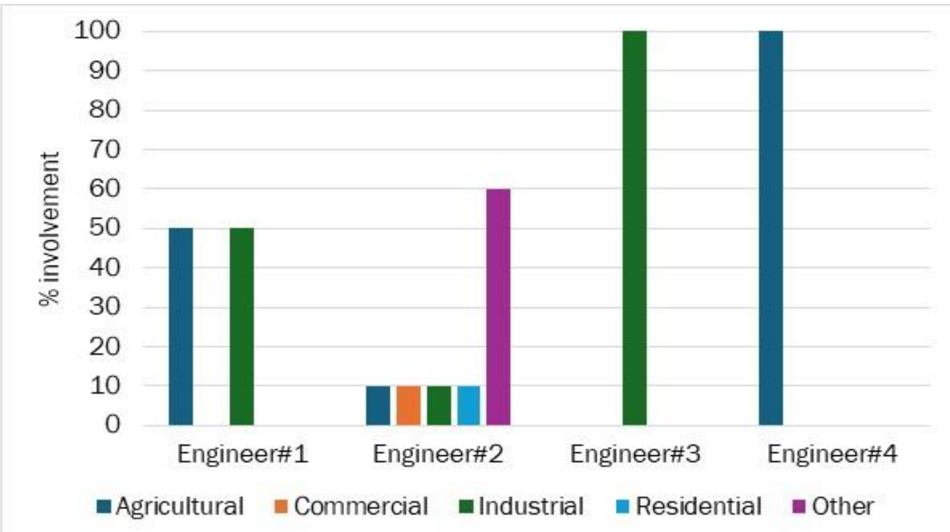

Figure 21: Participating engineers' pump-sector involvement.

Source: Project team.

Selection criteria

Question: Rank the key considerations when selecting PEI-rated pumps (1 = most influential, 7 = least influential).

- Responses:
  - Cost was ranked as the most influential factor, followed by reliability, energy savings, and compatibility.
  - Incentives were not considered a primary driver in pump selection.

Figure 22 shows factors influencing pump selection by engineers.

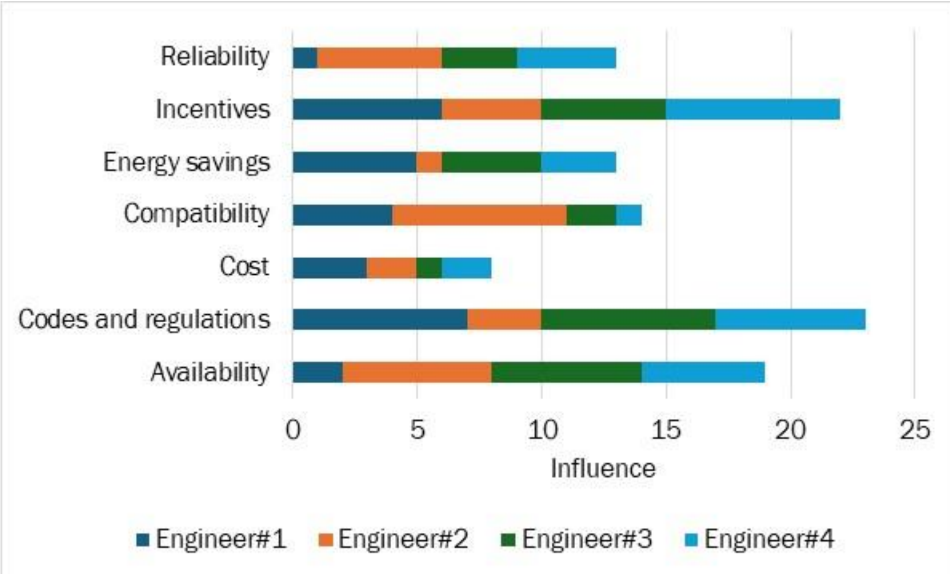

Figure 22: Factor of influence selecting a pump.

Source: Project team.

Adoption frequency

Question: How often did you propose or select PEI-rated pumps in the last year?

- Responses:
  - 1 response: Frequently (≥75%)
  - 1 response: Rarely (≈25%)
  - 2 responses: Never

Question: How often did you propose or select PEI-rated pumps for agricultural clean water projects in the last year?

- Responses:
  - 1 response: Frequently
  - 2 responses: Rarely
  - 1 response: Never

Market understanding

Question: Could improving market understanding of the PEI metric help end-customers choose efficient pumps?

- Responses:
  - 3 responses: Not sure
  - 1 response: Yes

Question: Is market knowledge of PEI-rated pumps' lifecycle costs underdeveloped?

- Responses:
  - All respondents selected: Not sure
  - One engineer commented: "I have not dealt with PEI ratings."

Customer adoption

Question: Have end-customers shown reluctance to adopt PEI-rated pumps?

- Responses:
  - 2 responses: Not sure
  - 1 response: No
  - 1 response: Yes — "Cost is more important than reliability."

Reliability and lifespan

Reliability

Question: What is your expectation/experience with PEI-rated pump reliability?

- Responses:
  - 2 responses: Very reliable, low maintenance
  - 1 response: Somewhat reliable, moderate maintenance
  - 1 no response

Lifespan

Question: What is your expectation/experience with PEI-rated pump lifespan?

- Responses:
  - 2 responses: About the same as conventional pumps
  - 1 response: Shorter than conventional pumps
  - 1 no response

Adoption barriers

Question: What are the main market adoption barriers for PEI-rated pumps?

- Responses:
  - Lack of familiarity with PEI-rating was the most cited barrier.
  - Lack of knowledge of savings potential and higher capital costs were also noted.

Barrier mitigation strategies

Question: How do you address market barriers for PEI-rated pumps?

- Responses:
  - "Rely on vendors and the availability of EE funding."

- "Getting stakeholder buy-in early on and education."
- "Education on PWI pumps and their applications."

Customer education

Question: Do you educate your customers on PEI-rated pumps?

- Responses:
    - 1 engineer responded affirmatively.
    - 3 engineers responded negatively, citing unfamiliarity with PEI ratings.

Contractor knowledge

Question: How do you rate contractors' understanding of PEI rating?

- Responses:
    - 1 response: Moderate understanding
    - 1 response: Minimal understanding
    - 1 response: Not familiar with PEI rating

Product availability

Question: Are there sufficient PEI-rated pump options for agricultural clean water applications?

- Responses:
    - "Hard to answer, most projects come my way after already being developed."
    - "Not sure."
    - "Not to my knowledge."
    - "I don't know. I don't look at PEI rating."

CONTRACTORS

The Project Team received four verified responses from contractors with diverse expertise:

- Two design-built contractors
- One dairy systems contractor
- One pump testing and inspection contractor

The following verified organizations completed the survey dedicated to contractors:

- Pentair.
- Hyhuis Development, LLC.
- Pump Check, Inc.
- Hidrostal, LLC.

The varied skillsets provided valuable insights. The survey included 20 questions covering demographics, decision-making practices, familiarity with PEI ratings, and customer influence.

Demographics

All contractors reported working with clean water, wastewater/recycled water, and other applications across multiple sectors: agricultural, commercial, industrial, residential, and miscellaneous.

Decision-making practices

Pump Replacement

Question: How do you select a replacement pump for a customer?

- Responses
  - 3 contractors: Consult with the engineer.
  - 1 contractor: Consult with the pump manufacturer or distributor.

New Installations

Question: How do you select a pump for a new installation?

- Responses
  - 2 contractors: Consult with the engineer
  - 2 contractors: Consult with pump manufacturer or distributor

Decision Drivers

Question: What factors influence pump selection? Options included: Availability, Codes and regulations, Cost, Compatibility, Energy savings, Incentives, Reliability, Other. (1 = Most influential, 7 = Least influential).

- Responses.
  - Top factors: Availability, Compatibility, Cost.
  - Medium influence: Reliability, Energy savings.
  - Least influence: Codes and regulations, Incentives.

Figure 23 shows the factors influencing pump selection.

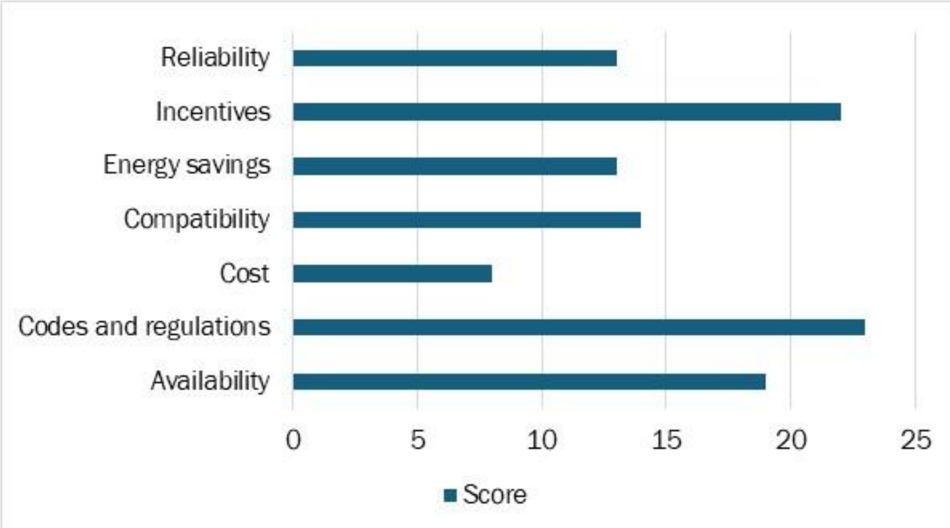

Figure 23: Factors influencing pump selection.

Source: Project team.

Familiarity with PEI ratings

- Understanding of PEI Rating
  - 1 contractor: Expert understanding
  - 1 contractor: Moderate understanding
  - 2 contractors: Minimal understanding
- PEI-Rated Pump Installations (Replacement in Agriculture)
  - 2 contractors: Occasionally (≈50% of projects)
  - 2 contractors: Rarely (≈25% of projects)
- PEI-Rated Pump Installations (New in Agriculture)
  - 1 contractor: Frequently (≥75% of projects)
  - 3 contractors: Rarely (≈25% of projects)
- Performance Comparison
  - 1 contractor: PEI-rated pumps perform better
  - 1 contractor: Perform the same
  - 1 contractor: Conventional pumps perform better
  - 1 contractor: Depends on head/capacity and operational parameters
- Expected Energy Savings
  - 2 contractors: Significant savings (≥25%)

- 1 contractor: Moderate savings (10–25%)
    - 1 contractor: Minimal savings (1–10%)
- Reliability
    - 3 contractors: Somewhat reliable, moderate maintenance
    - 1 contractor: Very reliable, low maintenance
- Lifespan
    - 2 contractors: Longer than conventional pumps
    - 1 contractor: About the same
    - 1 contractor: Shorter than conventional pumps
- Initial Cost Comparison
    - 1 contractor: 15% higher than conventional pumps
    - 1 contractor: 50% higher
    - 2 contractors: No response
- Estimated Installation Cost Breakdown - One response provided.
    - Pump capital cost: 35%
    - Motor capital cost: 30%
    - Well preparation: 10%
    - Electrical construction: 10%
    - Installation and commissioning: 10%
    - Permits: 5%

Training and customer engagement

- Training on PEI Ratings
    - 2 contractors: Received training
    - 2 contractors: No training
- Ability to Interpret PEI Ratings
    - 2 contractors: Familiar
    - 2 contractors: Not familiar
- Customer Education
    - 2 contractors: Educate customers on energy-saving benefits
    - 2 contractors: Do not educate customers
- Influencing Customer Decisions
    - 2 contractors: Would influence customers if conditions support PEI-rated pump selection
    - 2 contractors: Would not influence

- Interest in Learning More
    - 3 contractors: Interested
    - 1 contractor: Not interested

Customers

The project team received six verified responses from agricultural customers. An additional 15 responses were excluded due to being from out-of-state or unverifiable sources. The following verified organizations completed the survey dedicated to customers. Two responses were collected from AvidWater.

- AC Foods, LLC.
- Farmers Irrigation Company
- Costa View Farms
- AvidWater, LLC.

The survey consisted of 20 questions focused on:

- Demographics
- Pump Familiarity
- Decision-Making Ability
- Decision Drivers
- Familiarity with PEI Rating

Demographics

- Farm Type
    - 4 respondents: Fruit/Vegetable
    - 1 respondent: Food Crop
    - 1 respondent: Dairy/Fodder
- Years Farming
    - 3 respondents: More than 20 years
    - 1 respondent: 10–20 years
    - 2 respondents: Less than 10 years
- Primary Irrigation Source
    - All respondents: Groundwater
    - 4 respondents: Surface water
    - 2 respondents: Recycled water

Pump familiarity

- Groundwater Pump Types
    - Submersible and deep tube well pumps were most common

- Moderate use of vertical turbine and centrifugal pumps

- Surface/Recycled Water Pump Types
  - Centrifugal and submersible pumps were most common
  - Moderate use of vertical turbine and in-line pumps

Figure 24 shows the responses.

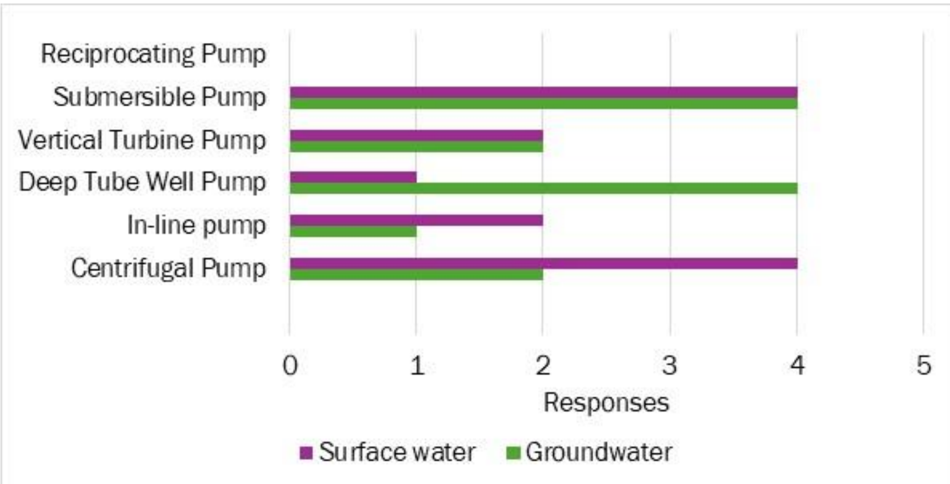

Figure 24: Customer response about the use of pumps.

Source: Project team.

Decision-making ability

- Pump Replacement
  - 3 respondents: Prefer energy-efficient pump
  - 2 respondents: Prefer energy-efficient pump with premium motor
  - 1 respondent: Contractor selects pump

- New Installations
  - 4 respondents: Prefer energy-efficient pump with premium motor and VFD
  - 1 respondent: Install similar pump (easier and economical)
  - 1 respondent: Contractor selects pump

- Pump Efficiency Knowledge
  - 1 respondent: Wire-to-water efficiency
  - 3 respondents: Duty point
  - 4 respondents: Best Efficiency Point (BEP)
  - 1 respondent: PEI-rated pumps are more efficient
  - 5 respondents: VFD improves efficiency
  - 1 respondent: Not familiar with pump efficiency

Figure 25 shows customer perception of pump efficiency.

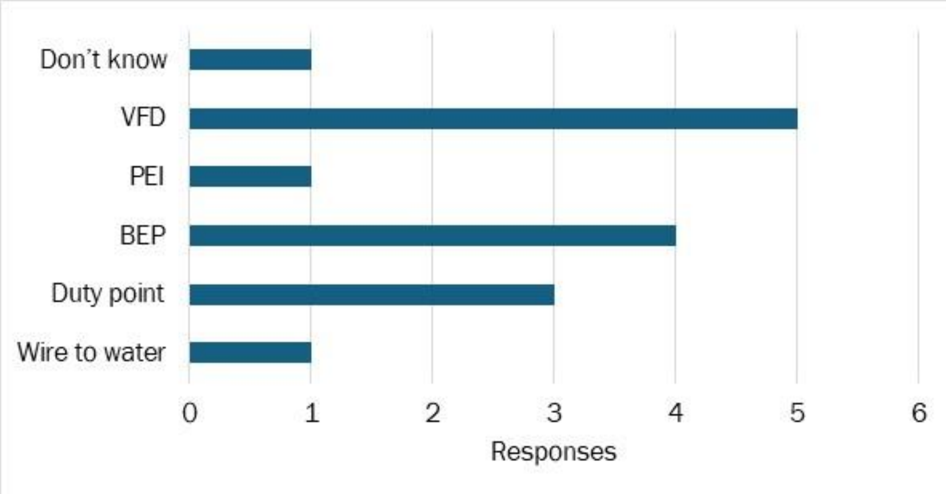

Figure 25: Customer perception of pump efficiency.

Source: Project team.

Familiarity with PEI rating

- Awareness of PEI Rating System
    - 2 respondents: Yes
    - 4 respondents: No
- Understanding of PEI-Rated Pumps
    - 3 respondents: Moderate understanding
    - 2 respondents: Minimal understanding
    - 1 respondent: Not familiar
- Source of PEI Information
    - 2 respondents: Industry publications/workshops
    - 2 respondents: Word of mouth
    - 2 respondents: Never heard of PEI
- Current Use of PEI-Rated Pumps
    - 1 respondent: Yes
    - 5 respondents: Not sure

Decision drivers

- Factors Influencing Pump Purchase

    - Options included: Availability, Codes and regulations, Cost, Compatibility, Energy savings, Rebates/incentives, Reliability, Other.
- Ranking of Influencing Factors (1 = Most influential, 7 = Least influential)
    - Most influential: Cost
    - Followed by: Reliability, Availability, Energy savings
    - Least influential: Codes, Compatibility, Incentives

Figure 26 shows ranked factors influencing pump selection.

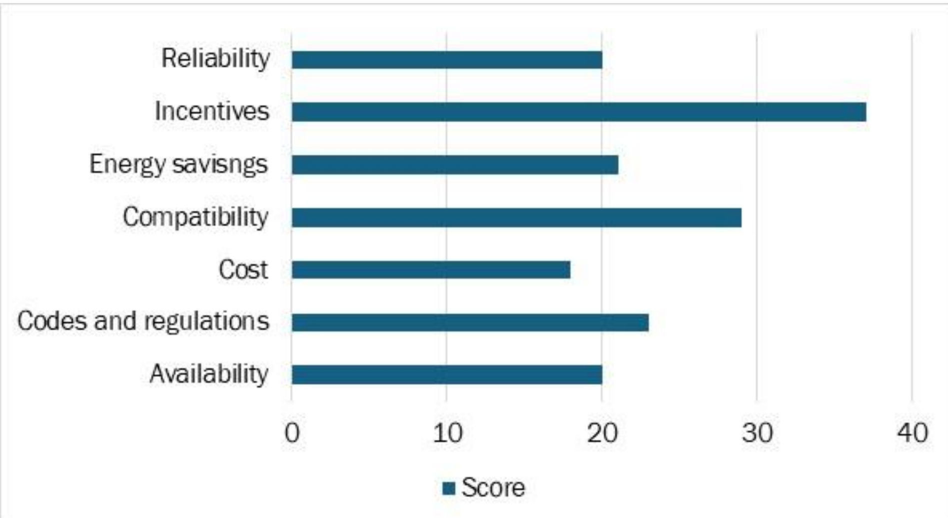

Figure 26: Ranked factors influencing pump selection.

Source: Project team.

Experience with PEI-rated pumps

- Energy Consumption Impact
    - 1 respondent: Decreased energy consumption
    - 1 respondent: No change
    - 4 respondents: No experience
- Future Consideration of PEI-Rated Pumps
    - 3 respondents: Yes
    - 3 respondents: Not sure
- Estimated Installation Cost Breakdown
    - Responses summarized in Figure 27.

Figure 27: Customer pump installation cost estimation.

Source: Project team.

Awareness of incentive programs

- Awareness of Incentives for PEI-rated Pumps
    - 3 respondents: Yes
    - 3 respondents: Not sure