Industry and Utility Collaboration to Change Midstream Behavior to Increase the Availability and Adoption of Highly Efficient Pumps: Leveraging Utility Programs and Industry Labeling to Prioritize Energy-Efficient Pumps

Christopher Sullivan-Trainor, Consortium for Energy Efficiency
Peter Gaydon and Matthew Derner, Hydraulic Institute and Pump Systems Matter
Warren Fish, Northwest Energy Efficiency Alliance
Adan Rosillo, Pacific Gas and Electric
Mary Jane Poynter, VEIC (Efficiency Vermont)

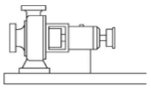
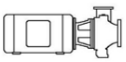
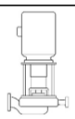
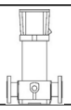
ABSTRACT

CEE members identified an opportunity to accelerate the availability and installation of highly efficient pump systems with the advent of new wire-to-water comparable energy performance metrics. Program administrators defined a voluntary specification for a supportable level of high-efficiency pumps. Through their trade organization, the pump industry embraced the opportunity by certifying their testing, centralizing energy performance data, and introducing point of sale labels to support adoption. The Hydraulic Institute (HI), manufacturers, and utilities continue to collaborate through the CEE Forum to share learnings and identify strategies to accelerate the understanding and prioritization of pump energy performance in the selection process. They identified midstream stakeholders as the vital part of the market to engage, and both the pumps industry and utilities are implementing unique programs to influence these stakeholders. These approaches, which vary based on policy and resources, have seen different levels of success and will continue to evolve. This paper provides an overview and analysis of these different approaches, the need and impact of utility and industry collaboration, and how to go forward and realize equipment level impact as systems take increasing priority. Some utility programs are evolving to focus on market transformation and decarbonization in addition to cost-effective kilowatt-hour savings. Equipment manufacturers are developing more efficient and complex solutions and leveraging connectivity. It takes binational consistent, focused support from both groups to realize new equipment category savings.

Introduction

The United States (US) Department of Energy (DOE) regulation, 10 CFR 431.464(a), announced in 2016, enforced in 2020, introduced PEI or Pump Energy Index, the DOE's new pump test methodology, and required manufacturers to stop making pumps that performed in the bottom 25% for energy efficiency or improve their performance to meet the new standard. This requires a pump to have a PEI of 1.0 or less to be compliant. The PEI can be constant load (CL) for pumps without controls or variable load (VL) if the pump includes controls (i.e., variable frequency drive) 1. Figure 1 summarizes the pump types included. In 2019, Natural Resources Canada (NRCan) introduced an amendment to enforce a similar standard using Canada's new metric and test procedure. PEI can capture the wire-to-water performance of a bare pump, pump, and motor, or pump, motor, and controls. It also allows for direct energy performance comparison of similar pump models. Term Sheets for circulator pumps recommending standard levels and test procedures were also finalized by an Appliance Standards and Rulemaking

Committee working group in 2016. DOE restarted the process to move circulator pumps to a regulation in 2021. The pumps in scope for PEI accounted for an estimated 420,303 units in 2012 or close to 5% of total centrifugal non-submersible pump shipments (US DOE 2015).

Diagram	Nomenclature (DOE) / [Industry]
	End Suction Frame Mount (ESFM) / [OH0, OH1]
	End Suction Close Coupled (ESCC) / [OH7]
	In-line (IL) / [OH3, OH4, OH5]
	Radially Split multi-stage vertical in-line diffuser casing (RSV) / [VS8]
	Submersible Turbine (ST) / [VS0]

Included

- Clean Water Pumps
- BEP Pump Input Power – 1- 200 hp
- BEP Flow – 25 gpm or greater
- BEP Head – 459 ft or less
- Temperature – 14 °F – 248 °F
- Speed – 1800 & 3600 RPM Nominal

Excluded

- Non-clean water
- Mixed & Axial Flow
- Nuclear & Military Spec
- Sealless
- Fire & Sanitary Spec
- Self-Priming and Prime Assist

Figure 1. Clean Water Pumps Included in the DOE 2016 Regulation. *Source:* DOE 2015

This regulation was built on the efforts of ACEEE and the members of the Extended Motor Products Labeling Initiative (EMPLI) who lead the effort for developing a new test method, performance specification, and intervention strategy for pump systems. The group consisted of trade associations (NEMA, HI, AMCA, CAGI), utilities and program administrators (PG&E, SCE, ConEd, National Grid, BPA, NEEA), and pump manufacturers. This group worked with DOE starting in 2014 resulting in the final rule in 2016.

In 2015, leading energy efficiency program administrators, including Pacific Gas and Electric (PG&E), the Northwest Energy Efficiency Alliance (NEEA), and Efficiency Vermont, recognized an opportunity to pull the market toward more efficient pumps and pump systems. They engaged other program administrators across the US and Canada through the Consortium for Energy Efficiency (CEE) Motors Committee, establishing a working group to develop the CEE Commercial and Industrial Pump Systems Initiative (Initiative), which was approved by the CEE Board in 2020.

Similarly, leading pump manufacturers recognized the opportunity and prepared by developing models that significantly exceeded the new federal minimum. The Hydraulic Institute (HI), the largest North American pump manufacturers association, and its members developed the HI Energy Rating (ER) Program to support this opportunity which identifies pump technologies that capture the energy and cost savings. It also includes a unique label intended to show measurable energy performance comparisons. They recently added the HI Circulator Pump Energy Rating (CER), which builds off the Term Sheets proposed in 2016. Circulator pump types include cast-iron commercial and residential hydronic heating pumps and stainless-steel commercial and residential, domestic hot water pumps. Additional details and the HI ER Program are described in section 3.

In US manufacturing alone, pumps accounted for close to 155,000 GWh or 27% of the electricity used for industrial systems in 2006 (US DOE 2006). Federally regulated and program-supported, highly efficient clean water pumps may save at least 30% for specific pump types. There are many challenges to realizing these savings: significant expertise required to assess or design a system, high first cost and extended product lifetimes, operator inattention, and timely availability of higher efficiency pump models at operator need. The PEI presents an opportunity to overcome some of these challenges. CEE incorporated PEI into its Initiative, and the HI used it for its ER Program. The federal regulatory process supporting PEI supports program administrator justification of deemed savings, while the HI ER Program supports the communication of relative energy performance. This paper summarizes the opportunity to reduce pump system energy use, save customers money, and contribute to decarbonization through widespread adoption, education, and coordinated use of these wire-to-water energy performance metrics. They can simplify the identification of opportunities for a more efficient pump and communicate the benefits of a more sophisticated pump, motor, and drive. Collaboration between federal agencies, the pump industry, and energy efficiency program administrators resulted in the 2016 federal regulation to push the market and a shared goal to accelerate the availability and installation of highly efficient pumps. The following sections summarize leading programs and resources to realize this goal, how their actions influenced each other's success, and the need for continued collaboration to realize pump system energy performance benefits.

CEE Commercial and Industrial Pump Systems Initiative

CEE is a consortium of efficiency program administrators from across the United States and Canada. Members leverage individual efforts by working together to accelerate energy-efficient products and services in targeted markets. Pump systems represent a significant opportunity for energy savings given energy use, growing market value, technology advances, and recent regulations to establish clear energy performance metrics and power consumption minimums. CEE members (investor-owned or municipal utilities, state or provincial energy offices, government agencies, and nonutility program administrators) came together to identify a unique role for the consortium to transform this market. They defined an opportunity to support products that perform better than the federal minimum using input from HI, pump manufacturers, engineers, and other industry partners. The consensus strategy, described in the Initiative, is a deliberate process to accurately quantify and attribute energy savings associated with the newly regulated equipment category in the US and Canada, creating clarity around which products achieve high performance. CEE analysis identified opportunities for reducing US pump system energy used by over 26% per year through program administrator support for the defined level of equipment performance and manufacturer participation to make and distribute products meeting the same level of performance.

The Initiative establishes a voluntary product specification that publicizes a definition for highly efficient equipment determined through deliberation among program administrators with input from the industry. This specification emphasizes the performance metric, PEI, its complement the HI ER, and transforming the market to incorporate them to make product purchase decisions. Therefore, a single performance tier, Tier 0, was used initially to advance the performance. Tier 0 defines a highly efficient constant load pump as meeting or exceeding a PEI of 0.95 (ER 5) and a variable load pump as meeting or exceeding a PEI of 0.48 (ER 52). Program administrators may use it as the basis for appropriate deemed savings opportunities, including like-for-like end-of-life replacement, new construction, or a checklist for proper pumping

applications, replacing a constant load pump that is being mechanically throttled with a variable load pump that includes integrated controls. Additionally, the Initiative addresses market education and outreach strategies. Finally, to assist program administrators in evaluating pump systems energy savings, it has training programs and certifications covering system efficiency best practices and resources. Different levels of high energy performance may be introduced as the market evolves.

In parallel, CEE members have defined a vision for connectivity in this evolving landscape with input from major equipment manufacturers called Integrated Demand Side Management. Connectivity in this case applies to identifying the need for sharing energy performance data with manufacturers through secure, standardized, and accessible means. CEE envisions a marketplace where consumers and demand-side managers connect to energy-consuming devices through multiple pathways and open standards so that connection costs are minimized, and choice for consumers and utilities is optimized. In the case of bare pumps and bare pumps sold with motors, this could be the addition of controls. As technology and electricity delivery services evolve, program administrators can capture additional value for the grid and their customers through equipment that can connect to system or facility-wide energy management systems to help customers track energy performance and monitor equipment for reliability and maintenance needs. Connected features may also allow customers to participate in utility demand response or flexible load management programs, as appropriate, and help utilities better manage energy across the grid. Program administrators are defining this shared definition and exploring its application to pump systems to communicate with market actors what will be needed in the future as grid needs evolve, such as what should be included in the definition, testing, and labeling of highly efficient pumps. Including compatibility with grid needs may help consumers identify and choose pumps that offer additional benefits such as predictable energy use and operational data, enhanced engagement, and the ability to participate in future demand-side management programs.

How stakeholders are impacting the market

The CEE Pump Systems Committee supports the Initiative and consists of seventeen program administrators across fourteen US states and two Canadian territories. CEE tracks program approaches and tools through annual program summaries to inform market players of market backing and endorsement and evaluate progress. In 2019, most member programs with either non-custom motor or pump-specific programs supported variable speed drives for pump equipment. Member support for variable speed drives increased 6% from 2017 to 2020. The two most common types of pump motor measure control programs supported by CEE members in 2018, 2019, and 2020 were bare pumps and variable speed pumps with electronically commutated motors. The most common pump program supported by members was for the bare pump or pump motor in 2020. As of 2021, utilities in eight states have launched programs supporting wire-to-water energy performance and accelerating highly efficient pump systems installation. Programs in seven states support circulator pumps, and CEE is developing a voluntary specification for these pumps based on the HI CER. This will support increased understanding and adoption of these holistic metrics through increased consistency across pump types. Utilities across the US southwest, northeast, Midwest, and Canada are actively working on approaches.

In addition to program summaries, CEE publishes a CEE Clean Water Pump Qualified Product List, publicly listing available pump models that meet the definition of the CEE

Voluntary Specification. CEE Staff maintains this list, collecting manufacturer test data through HI and collaborating with the HI ER Program. CEE and HI worked together to ensure the data could meet program administrator needs and has engaged with Natural Resources Canada to determine if additional pumps can be included that are certified through programs in Canada.

As a working group in 2015 program administrators confirmed a bi-national opportunity to advance pump efficiency. Through CEE they conveyed program considerations for testing rigor and data representation to HI and manufacturers as they developed the HI Energy Rating Program. In parallel, CEE members defined Tier 0 (defined above) which can be identified by the HI Energy Rating Label. Throughout both these processes, outputs were shared with HI, pump manufacturers, distributors, engineers, and federal advisors for comment, and these partners were invited to discuss the HI Energy Rating Program, program needs, and the supportable level of highly efficient pumps with program administrators periodically. With verifiable labeling of pump energy performance, discussed in the next section, and clear definitions of highly efficient pumps supportable by energy efficiency programs, all stakeholders benefit as follows:

- Pump end user/owner has a resource to understand the energy consumption of their product better and quantify electricity consumption
- Sales representatives have a tool to communicate why the ER labeled pump is a better option concerning life cycle costs
- Utilities and energy organizations have a qualified public database to use for developing deemed incentive programs and use as eligible products to meet their energy reduction goals
- Manufacturers have a tool to set their products apart and meet their stated organizational objectives around advancing energy efficiency
- The global impact related to carbon footprint related to pumping systems is reduced

Since the Initiative launched in 2020, CEE members have continued to engage with HI, pump manufacturers, engineers, federal advisors, regional distributors, and other trade allies. There remains a significant need for consistent outreach and education about holistic considerations for efficient pump systems, prioritizing lifetime value over the first cost, reducing energy waste from pump oversizing, and increasing awareness of pump system operations and performance degradation. Participation by all market stakeholders identified in the Initiative remains essential to normalizing wire-to-water energy performance metrics into pump selection and realizing deeper savings through holistic system evaluation.

Hydraulic Institute Energy Rating Program

Why the Hydraulic Institute Energy Rating (ER) Program was developed

HI is an ANSI-approved standard development organization and supported the regulatory process by developing a test standard, supporting negotiations, and gathering performance data used by DOE. HI leveraged the data collected and collaborated with energy efficiency organizations to build the ER program, which launched in 2018. These organizations worked together because they had an aligned goal to clearly and uniformly communicate the relative

energy consumption of pumps. The end results of the program include pumps tested in certified laboratories, uniform pump labeling, and a public database of efficient pumps.

ER Labels and Program Scope

The ER Labels for general pumps and circulator pumps are shown in Figure 2, respectively. They contain important information relative to energy consumption for each pump, and describe how to estimate savings against an established baseline.

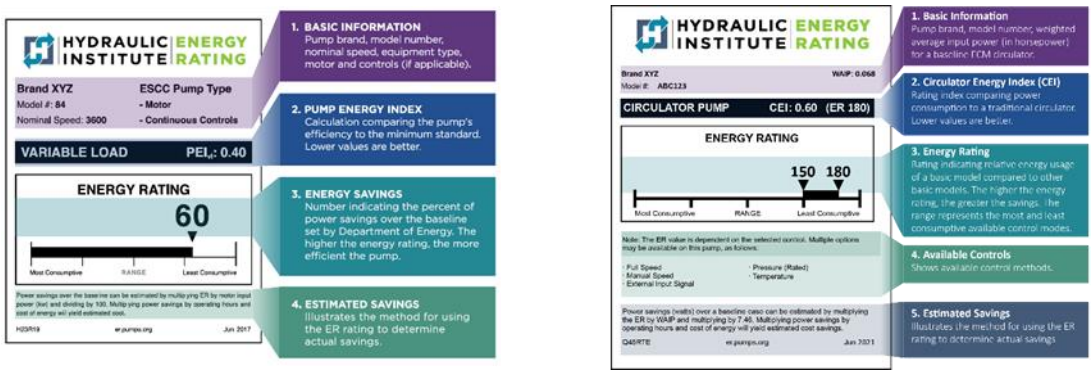


Figure 2. ER Label for General Pumps (Left) and ER Label for Circulator Pumps (Right)

The guidelines can be freely downloaded for full details on the programs, and listed pumps can be accessed at pumps.org/energyrating. The defined scope of the Hydraulic Institute's program guideline for general pumps, HI 40.5 is in-line with DOE's Energy Conservation Program, as discussed in the Introduction. The program guideline for circulator pumps' energy rating is HI 41.5 (HI 2021b). They have a unique design that generally serves hydronic space-heating and cooling or domestic hot water applications. Circulator pumps can be wet rotor (designated as CP1), dry rotor two-piece (CP2), or dry rotor three-piece (CP3) types. They are generally small in-line pumps with horizontal motors and are sold in high volume in the marketplace.

Test Procedure and Performance Metrics

Each program guideline document incorporates *HI 40.6 – Methods for Rotodynamic Pump Efficiency Testing* (Hydraulic Institute 2021a) by reference and is the standard for testing. DOE commissioned this standard and has also incorporated it by reference in its test procedure for general pumps. Since the 2016 regulation was published, the Hydraulic Institute updated HI 40.6 to include additional DOE testing requirements for circulator pumps.

Similar to the PEI value, the ER is calculated from a ratio of powers relative to a baseline condition. Thus, it can be used to estimate power and energy savings over a baseline case or another ER. The bottom of each label describes the method to calculate power savings over the baseline case.

Energy Savings Calculations and Circulator Pump Example

The following energy savings example compares two ER-labeled circulator pumps that meet the requirements of a variable flow multi-zone hydronic heating system. Pump 1 has no speed control, and Pump 2 contains a pressure control to match the variable flow demand, their performance curves are plotted in figure 4. Table 1 consists of the label information for each pump, and equations 6a and 6b in figure 3 detail energy savings calculations based on this data.

Table 1 – Label information for circulator pumps with the max duty of 14 gallons per minute at 7.25 feet of head (four heating zones), operating an estimated 4,000 hours per year.

Label Information	Pump 1 – full speed	Pump 2 - pressure control
ER	70	150
Weighted average input power (WAIP) (CER_{REF}) in horsepower	0.091	0.091

$$\text{Annual Energy Savings (kWh)} = (\text{ER2} - \text{ER1}) \cdot \text{WAIP} \cdot \frac{7.46}{1000} \cdot \textit{Operating Hours} \qquad \text{Eq. 6a}$$

$$\text{Annual Energy Savings (kWh)} = (150 - 70) \times 0.091 \times \frac{7.46}{1000} \times 4000 = 217\text{kWh} \qquad \text{Eq. 6b}$$

Figure 3. Equations 6a and 6b detail energy savings calculations from HI 41.5 Program Guide. *Source.* HI 2022

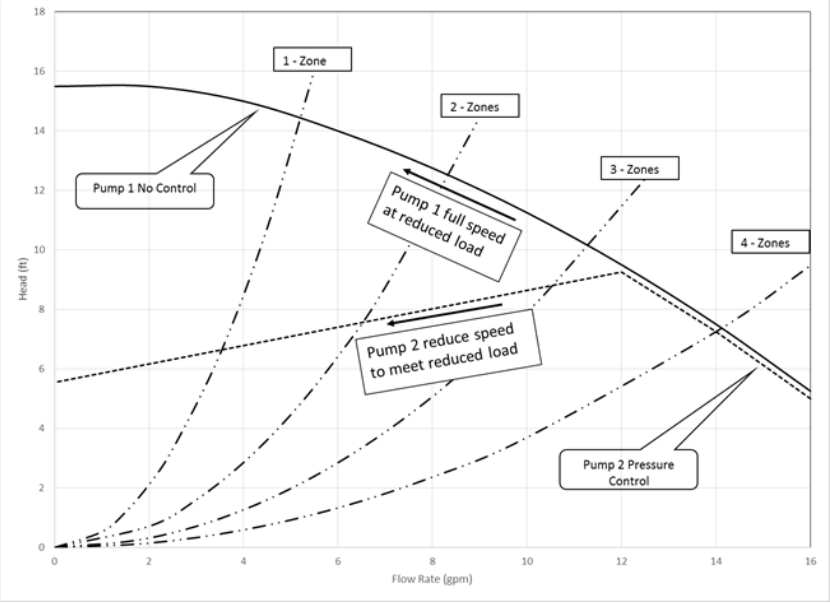


Figure 4. Pump 1 and Pump 2 flow rates, across four zone types.

Available Resources to Overcome Challenges

A primary objective of the ER Programs is to provide trusted data to utilities so that deemed incentive programs can offset the incremental cost of more efficient pumps. Although several solid program examples have proven their value throughout the United States, widespread adoption is slow. The low rate of acceptance is substantially due to program administrator challenges rolling pump systems into efficiency programs limiting targeted efficiency program funding to expand the market, limited regional sales data, and the need for due diligence to design and develop new programs to ensure customer and grid benefit.

To help bridge this gap, HI and its education subsidiary Pump Systems Matter are striving for greater workforce training (including training for specifiers and pump owners) by providing certification processes and marketing to help raise awareness of ER and the pump industry's most efficient products. Courses involve pump system fundamentals and optimization and the Pump System Assessment Professional (PSAP) certification. Utilities can use certified PSAPs to improve pumping systems, and can access the ER database of efficient pumps and utility resources, such as Technical Reference Manuals (Hydraulic Institute 2022).

Northwest Energy Efficiency Alliance Extended Motor Products Program

NEEA's Extended Motor Products (XMP) program seeks to transform the market for pumps and circulators by intervening with market actors across the hydraulic systems supply chain. NEEA works with manufacturers, Northwest pump distributors, and the Hydraulic Institute, on numerous fronts, as detailed below. NEEA began work on pump systems in 2013 with ACEEE and the other EMPLI members. A formal program was started in 2016. NEEA's XMP program focuses on emphasizing the value proposition of high-efficiency pumps and removing market barriers to broader adoption of the highest efficiency models. The most significant barriers NEEA has identified are lack of awareness, lack of availability, uncertainty of the product performance of Smart Pumps, and high first cost. Smart Pumps—a particular focus of the program—consist of a pump packaged, at the point of sale, with a variable speed drive, internal sensors, and pre-programmed controls.

NEEA currently works with eight manufacturers' representative firms that sell leading brands of pumps and circulators in the Northwest. Each participating firm can earn incentives for the sale of efficient products, bonuses for large-scale changes to the composition of sales, funding awards to support customer-oriented initiatives for inventory and training, and stipends to support regular data submissions. In addition, the NEEA team communicates with distributors monthly to track performance, discuss strategies for selling qualified products, and learn about pump technologies and market dynamics. These frequent check-ins allow the team to discuss the strategies manufacturers and their local representative firms implement around Smart Pumps and other highly efficient products.

The program also offers manufacturers' representatives opportunities to leverage Program Support Plan funding from NEEA, which can be used to augment and enhance their education, outreach, and inventory management efforts. Examples of how funding has been used include: videos promoting efficient products, hands-on training-lab upgrades, training events, outreach events with efficient equipment displayed, lunch-and-learn sessions, inventory support programs to enhance shelf stock of efficient models, and expanding trainings to reach secondary audiences such as installation contractors and commissioning agents.

Manufacturers' representatives are key midstream-market actors central to NEEA's program design. These firms work closely with the engineers, specifiers, contractors, and other market actors who make or influence most pump purchase decisions. In addition to their pivotal role on the demand side of the Northwest market, manufacturers' representatives are also uniquely positioned to influence the supply side of the market by informing and influencing their manufacturers to design and produce high-efficiency products, and changing inventory stocking practices.

Participating firms provide full-category sales data each month. NEEA then matches each participating firms' qualifying pump sales with HI's database of 12,250 models to identify the ER of each model sold and determine incentive amounts directly tied to each unit's market baseline score. The ER of each model indicates its lab-tested, wire-to-water performance and used in conjunction with the Northwest Regional Technical Forum (RTF) pump measure sets (NW RTF 2022a, NW RTF 2022b), enables NEEA to account for the savings impact of efficient sales.

The ER label also supports efforts to raise awareness of the energy-efficiency differences between models and highlights the higher efficiency of Smart Pumps. Most manufacturers offer Smart Pumps and Smart Circulators which provide significant potential benefits compared to traditional pumps and wall-mounted variable speed drives.

The benefits of Smart Pumps include:

- Energy Benefits: pump-specific performance maps to optimize the operation, adaptive mapping capabilities (some models)
- Installation and Cost Benefits: no sensors, reduced wiring, conduit, and mounting hardware, reduced space requirements
- Operational Benefits: connects to automation systems, electronically commutated motors are significantly smaller and lighter than induction motors, which simplifies maintenance

Standards

The ER and PEI are critical metrics that enable a more streamlined approach to capture pump energy savings versus the old custom-project paradigm—previously the only way to account for pump energy savings before the passage of the federal standard. The federal standard, wire-to-water testing, and new energy-efficiency metrics enable NEEA to apply a midstream program design to the pump market.

Influencing the existing federal standard and supporting efforts to create a federal standard for circulators are other critical elements of NEEA's market transformation program. NEEA views standards as an essential way to lock in savings by raising the bar for manufacturing of entire product categories, and is supportive of and involved in the U.S. DOE's federal standard processes for pumps and circulators.

Results

From summer 2019—the start of the XMP program's work with pump manufacturers' representatives—through the end of 2021, NEEA provided unit incentives for more than 9,000 pumps and circulators. Other highlights include:

- Paid more than $600,000 in per-pump incentives.
- Supported 80 outreach events.
- Completed three case studies.
- Reached more than 850 individuals involved with specifying or installing pumps and circulators.
- Saved approximately 4,700 MWh of energy, with a benefit to cost ratio of 1.9:1[1].

Growing the share of overall sales comprised of Smart Pumps or Smart Circulators is a focus and priority of NEEA's XMP program. This focus is reflected in the tiered bonus structures used to reward excellent performance in Smart Pump sales penetration. NEEA has observed positive trends in the growth of Smart Pumps and Smart Circulators as a percentage of overall sales since mid-2019; However, the COVID-19 pandemic and global supply chain challenges have affected product lead times across the pump market, reducing availability of Smart Pumps in some cases. Even so, NEEA observed the following positive growth in the Northwest on Smart Pump as a percentage of overall sales for 2021:

- Sales of Smart Pumps comprised 19% of total commercial pump sales, up from 18% of total commercial pump sales in 2020.
- Sales of Smart Circulators comprised 17% of total circulator sales, up from 13% of total circulator sales in 2020.

Pacific Gas and Electric Efficient Pumps Program

History

PG&E has run the Clean Water Pump efficient-pump program since 2018, based on a working paper approved by the California Public Utility Committee, and recently updated in 2022. (PG&E 2022). The approved working paper enables program administrators across California to adopt similar programs. This paper leveraged data collected as part of the Northwest Regional Technical Forum Efficient Pumps measure, supported by NEEA analysis and applied across Northwest utilities. It also helped inform the CEE Working Group in developing its initiative recommendations. PG&E's program administrators wanted to support consistent definitions of using PEI, HI ER, and how to differentiate efficient equipment. PG&E continues to serve as co-chairs to the CEE Committee to support this goal.

The Clean Water Pump efficient-pump program's initial objective was to promote the adoption of PEI, which defines wire-to-water efficiency and is on the nameplate of all clean water pumps sold as of 2020. The program was paused in 2021 due to changes in the program implementation contract with vendors. It focuses on distributors and was managed by a third-party vendor. Two major distributors participated in the program year-over-year. A total of 1,042 projects were implemented in 2018-2020, primarily in the large commercial buildings sector.

The program provided incentives based on performance by type of load (variable or constant), equipment family, and nominal speed. Constant load pumps required a baseline PEI of 0.96, and qualified high-efficiency pumps needed to meet a PEI of 0.94 or better. Variable-load pumps had a defined baseline of 0.54, and high-efficiency pumps needed to meet a PEI of 0.52 or better. The program applies to new construction and retrofits and includes six measures

[1] Savings results are preliminary and have not yet been validated through third-party research.

divided by horsepower and load type. Results show that most of the projects used constant-load pumps, shown in Figure 5, with 6% being variable load. While very few variable-load projects were implemented during the three years, PG&E is currently working on program modification to improve the results. Program changes in the new Clean Water Pump efficient-pump program will target the industrial and agricultural sectors to expand the opportunities for those customers.

Some focus on constant-load pumps was based on distributor relationships in PG&E's territory. The distributor that engaged in the most projects from 2018 worked primarily with commercial facilities. However, these facilities also have significant variable-speed opportunities. These projects often focused on lower cost or familiar models and brands. A few significant brands dominated.

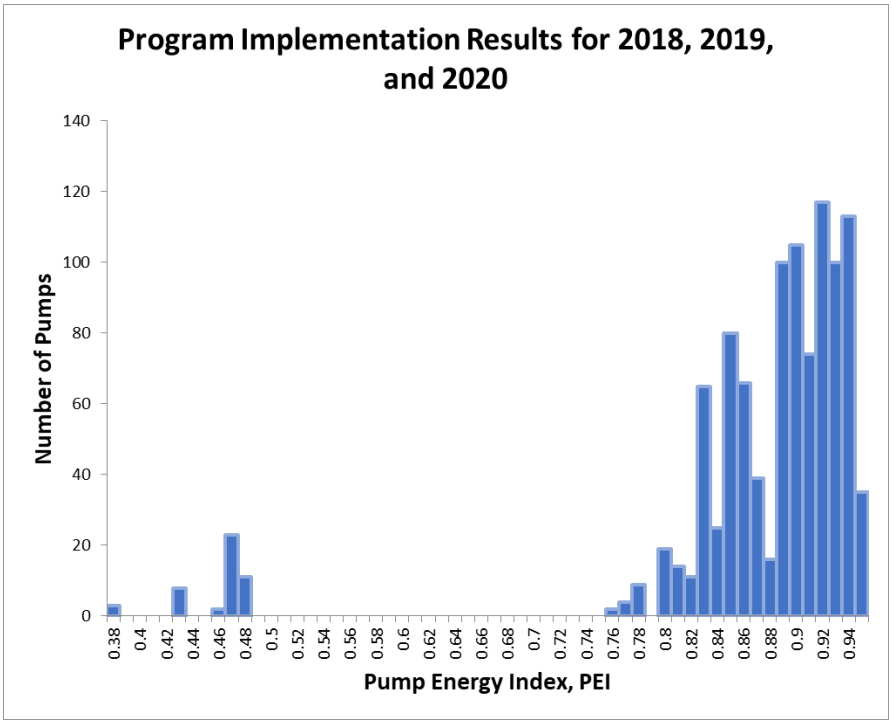


Figure 5. Program Implementation Results for 2018, 2019, and 2020.

Evolution and Future Considerations

As the program evolves, PG&E is interested in growing the number of distributors engaged in the program to reach a wider variety of customers. Additionally, more research is needed to understand the reason for primarily constant-load projects when variable-load pumps are also supported, and can offer better energy performance. To better define and communicate how to differentiate products that use wire-to-water metrics and realize the energy-performance benefits of higher-rated pumps, PG&E is reviewing the estimated savings versus measured and verified savings. The experiences of other programs and ongoing work within the CEE Committee will help inform the evolution of PG&Es.

As California shifts to a market transformation-driven energy-performance program, this impacts how PG&E can support highly efficient pump systems and informs how it continues to engage with implementers and distributors. PG&E's working paper will evolve to account for

these changes. Program administrators will work with implementers to help adopt programs that support differentiating efficient pumps, adopt wire-to-water metrics, and engage distributors to reach commercial and industrial customers. PG&E and other California utilities will need to determine which programs remain in the new landscape and can look to other states such as Vermont or Wisconsin that previously made this transition.

Efficiency Vermont Circulator Pump Program

History

Efficiency Vermont had an existing downstream program for circulator pumps starting in 2012 but had a very low uptake of about 20-30 pumps per year. This was partly due to a lack of interest from customers and contractors in filing for downstream rebates for a relatively small rebate, and pump selection decisions were often based on local stock, least cost, and matching the failed pump. Efficiency Vermont worked with a pump manufacturer whose products included higher efficiency circulator pump models to develop a system that made it easy for contractors to pick the better circulator pump and made it worthwhile for the supply house to stock and promote these pumps. They partnered with pump manufacturers and supply houses to offer a time of purchase incentive to the contractor for the more efficient circulator, thus bringing down the added cost and providing an administration fee to the supply house for every high-efficiency circulator sold. This was a win for the supply house because the more efficient circulators are a higher-margin product. That value proposition helped get the high-efficiency circulators on the shelves.

Efficiency Vermont does not have a midstream program for larger clean water pumps. They have a "structured custom incentive" for a small list of qualified pumps with integral controls and variable speed. They require in-house engineering staff to do a custom calculation comparing the existing baseline pump to the new efficient pump at several points on the pump curve. If the existing pump is unknown or a new application, the engineer must use their best judgment to select a hypothetical baseline pump. The quantity of custom high-efficiency pumps is in single digits per year with integral controls.

Efficiency Vermont's redesigned circulator program was launched in 2013. It was included in the white paper Swimming to Midstream: New Residential HVAC Program Models and Tools, published as part of the 2016 ACEEE Summer Study on Energy Efficiency in Buildings (VEIC (Efficiency Vermont) 2016).

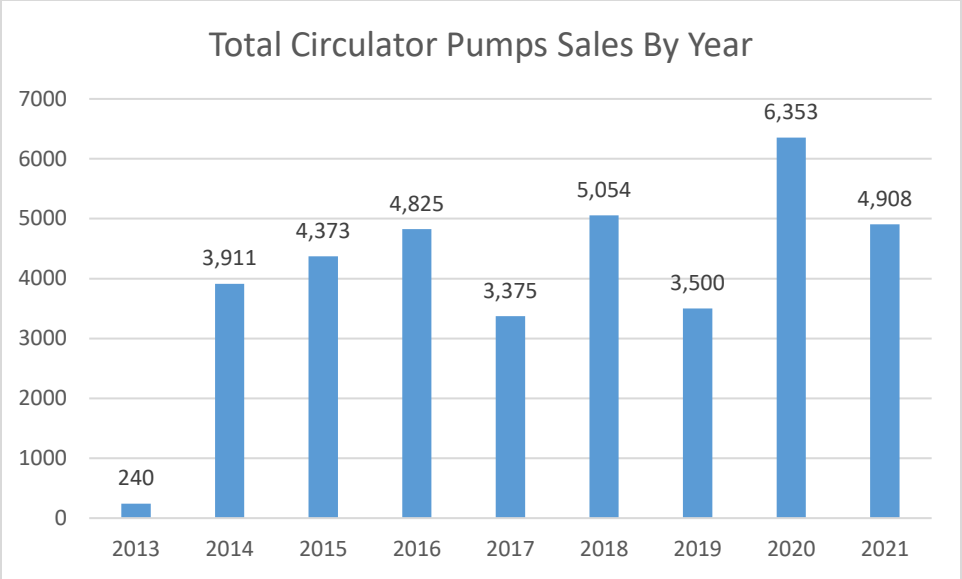


Figure 6. Efficiency Vermont High-Performance Circulator Pump Sales.

Evolution and Future Considerations

The program has evolved since it started back in 2013. Originally it was just one manufacturer on the qualified product list (QPL). Other manufacturers noticed this, putting pressure on them to promote and sell their high-efficiency circulators. Many manufacturers relaunched their brand, focusing on the efficient pumps they offer. As of 2022, Efficiency Vermont's midstream circulator pump program has expanded to include five manufacturers, 253 qualified pumps, and sizes up to 3hp. The program to date has been very successful, as seen in the pump sales data summarized in Figure 6 above. Note that most of the program's circulator pump sales were in the residential market per figure 7. There is a significant savings opportunity in the commercial market, both in circulators and clean water pumps.

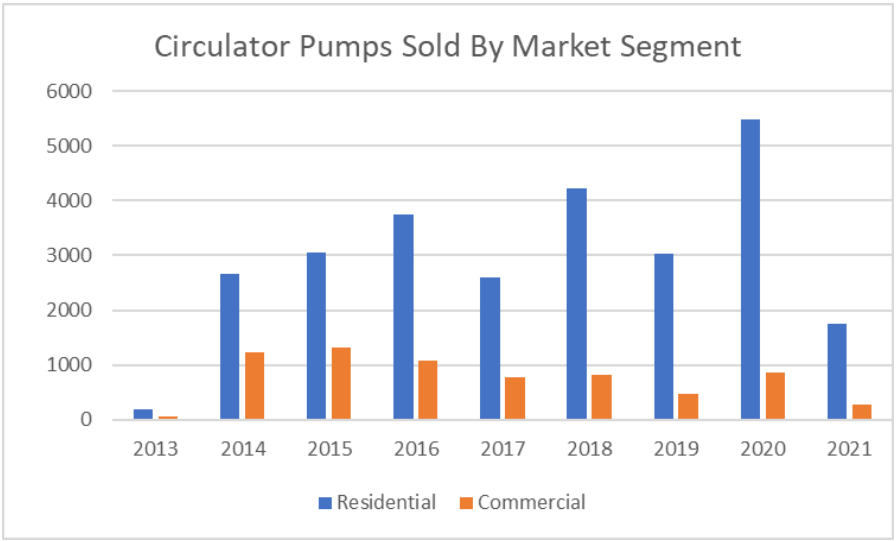


Figure 7. Circulator Pumps Sold By Market Segment.

When the program was launched, there were no standards for circulator pump efficiency, such as the wire-to-water metrics defined in the Term Sheets and HI ER Program. Efficiency Vermont established its standards evaluation system and put together a QPL. Manufacturers were very critical of the system, and rightfully so. There was no 3rd party testing, and the program relied 100% on manufacturer data. Everyone claimed that their product was better than the other and was critical of what was being considered in the standards and calculations. Jump to January 2020, and there is now a federal minimum efficiency standard for clean water pumps. The new standard provides a testing methodology for all clean water pumps and allows supply houses, HVAC contractors, and facility managers to compare pumps and make informed pump purchases. This levels the playing field for all pump manufacturers, and as an energy efficiency utility, it provides a universal method of measuring and comparing products.

Efficiency Vermont now recognizes an opportunity to revamp its midstream circulator program and add clean water pumps to our offerings due to the 2016 federal regulation, the CEE Initiative, the DOE Term Sheets, and HI ER Program. Efficiency Vermont as a part of a CEE circulator pump subcommittee is working toward establishing a minimum performance criterion, a voluntary specification for high-efficiency circulators, and a QPL. The subcommittee includes NEEA and is working with HI and pump manufacturers to recommend a savings calculation algorithm that could be adopted by other utility programs such that they can create their TRM or deemed savings. Efficiency Vermont plans to take advantage of the final work produced by this CEE subcommittee. The program will be able to use the work products to shift from in-house created standards and QPL lists to a national test standard and QPL. The work CEE has already completed paves the way for Efficiency Vermont to implement a clean water pump midstream program. The program will be able to utilize the CEE/HI QPL and proposed TRM. Efficiency Vermont's next steps include mapping the sales of clean water pumps in Vermont and, similar to creating the circulator midstream program, partnering with suppliers and manufacturers to develop a midstream program offering.

Conclusion

Collaboration among program administrators enabled leading programs to demonstrate an emerging opportunity for commercial and industrial pumps and work with their colleagues to define a bi-nationally supported strategy and level of performance for highly efficient pumps. This started with ACEEE and EMPLI efforts in 2013, leveraged the DOE regulation in 2016, and is expanding through work on the CEE Initiative. This consistency across regions is essential for differentiating highly efficient products and working with customers, system designers, distributors, and implementers to understand and make decisions based on the new wire-to-water metrics.

This consistency and singular voice supported interactions with manufacturers, the HI, and other trade allies to align strategies and resources to increase the availability and installation of highly efficient pump systems. Program administrators defined supportable energy performance evaluation and differentiation as regulated entities serving customers and grid needs. With their market and technical expertise, HI and leading manufacturers defined testing and reporting guidelines for pumps to communicate pump energy performance and train their workforce. Consistent messaging about which products are highly efficient, the importance of system consideration, and lifetime value from trusted brands and utilities can accelerate stakeholder comfort with wire-to-water metrics and accelerate demand for more efficient pumps.

This messaging can also accelerate the design and installation of more efficient pump systems. The impact of this consistency to avoid market confusion can be seen in the initial results of the programs summarized in this paper, and the future as these and other programs grow from these learnings.

Furthermore, as the market evolves for energy efficiency programs and equipment manufacturers, ongoing communication as new tools and strategies are developed is essential to this consistency. Manufacturer input throughout the development of the CEE Initiative was essential to ensuring a realistic approach. Program administrator input to the development of the HI ER Program is essential to ensure widespread adoption and alignment with programs. Utilities need to work closely with their trade allies and implementers to ensure the program meets customer needs while supporting the grid. This will be essential as states continue to transition their energy efficiency programs to focus on market transformation.

Finally, pump systems and grid operations are getting more complex. Technology increasingly can adapt to demand and is connected to the system and building management systems. The grid needs are evolving to rely on more flexible energy demand and prioritize the time of use and the amount.

These market evolutions impact our energy grid, equipment manufacturers, suppliers, facility owners, and operators. Continued collaboration and transparency about technical capabilities, the needs of grid operators, and the needs of facilities will be essential to maximize the performance of our energy systems while minimizing costs. Early engagement helped ensure the resources developed as a part of the program and strategies covered in this paper could be readily adopted across multiple parties. Deliberate determination of consistent goals and definitions of highly efficient equipment enabled straightforward communication and avoided market confusion. These themes will remain core tenants as the CEE Pump Systems Initiative, Energy Efficiency Programs, HI Energy Rating Program, and manufacturer product development continues to evolve and adapt to changing technical and policy landscapes.

References

Hydraulic Institute. 2022. “Utility Resources.” Parsippany, NJ: Hydraulic Institute. www.pumps.org/utility-resources.

Hydraulic Institute. 2021a. *Hydraulic Institute Program Guideline for Methods for Rotodynamic Pump Efficiency Testing.* Parsippany, NJ: Hydraulic Institute. www.pumps.org/product/hi-40-6-2016-methods-for-rotodynamic-pump-efficiency-testing/.

Hydraulic Institute. 2021b. *Hydraulic Institute Program guideline for Circulator Pump Energy Rating Program.* Parsippany, NJ: Hydraulic Institute. www.pumps.org/product/hi-41-5-2021-program-guideline-for-circulator-pump-energy-rating-program/.

NW RTF (Northwest Regional Technical Forum). 2022a. *Efficient Pumps UES Measure.* Portland, Oregon: Northwest Power and Conservation Council. https://rtf.nwcouncil.org/measure/efficient-pumps/

NW RTF (Northwest Regional Technical Forum). 2022b. *Circulator Pumps UES Measure.* Portland, Oregon: Northwest Power and Conservation Council. https://rtf.nwcouncil.org/measure/circulator-pumps/

PG&E. 2022. *eTRM California Energy Efficiency Measure Data: Measure Characterization, SWWP004-02 Water Pump Upgrade*. https://www.caetrm.com/measure/SWWP004/02/

U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Pumps*, December 2015, https://www.regulations.gov/contentStreamer?documentId=EERE-2011-BT-STD-0031-0056&attachmentNumber=1&contentType=pdf

US Department of Energy 2006. *Improving Pumping System Performance*. Second Edition. US Department of Energy, Energy Efficiency and Renewable Energy, Industrial Technologies Program. Washington, DC. p. 3. https://www.energy.gov/sites/prod/files/2014/05/f16/pump.pdf

VEIC (Efficiency Vermont). 2016. *Swimming to Midstream: New Residential HVAC Program Models and Tools*.