

Using Programs in Tandem with Codes and Standards to Transform Markets at Speed and Scale

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ABSTRACT

Establishing a code or standard that requires the use of efficient technologies is often the goal of market transformation (MT) programs. However, a new code or standard can also be a catalyst, enabling efficiency program interventions that both i) maximize the impact of the regulatory change and ii) set the path towards the next, more aggressive policy intervention. This paper describes how the Northwest Energy Efficiency Alliance's (NEEA's) Extended Motor Products (XMP) Initiative leveraged newly established federal standards for commercial and industrial pumps to drive greater market efficiency through program interventions and support the development of future efficiency policy. NEEA developed deemed measures for commercial and industrial pumps based on the Hydraulic Institute's Energy Rating (ER) label and underlying DOE test procedure and pursued research to improve estimates of energy consumption from this equipment. Taking advantage of the market disruption from the new federal standard – which meant pump distributors would need to shift away from business as usual – NEEA calibrated incentives to push pump efficiency well beyond levels required for compliance with standards. This aggressive, midstream, market-transformation-based approach has allowed NEEA to successfully influence the market for pumps and has set the stage to support NEEA's advocacy for DOE to adopt updated regulations. Leveraging the ER label and new Smart Pump technology, NEEA has demonstrated that efficiency levels well beyond those required by law are possible, providing an important case study in how market transformation programs can effectively leverage and, in turn, influence codes and standards.

Introduction

Establishing Standards and Codes requiring the use of new efficient technologies is often the goal of market transformation (MT) programs. However, a new Code or Standard can also be a point of departure, enabling efficiency program interventions that both i) maximize the impact of the regulatory change and ii) set the path towards the next, more aggressive policy intervention. This paper describes how market transformation programs can work synergistically with Codes and Standards developments to drive and accelerate adoption of efficient technologies both in the short- and long-term. We describe how the Northwest Energy Efficiency Alliance's (NEEA's) Extended Motor Products (XMP) initiative leveraged newly established federal standards for Commercial and Industrial Pumps to drive greater efficiency in the market and, in turn, to support development of more aggressive efficiency policy. This efficacious cycle is depicted in Figure 1, which shows the impacts of federal DOE rulemaking (in blue) and a targeted market transformation program (in green) in generating market change.

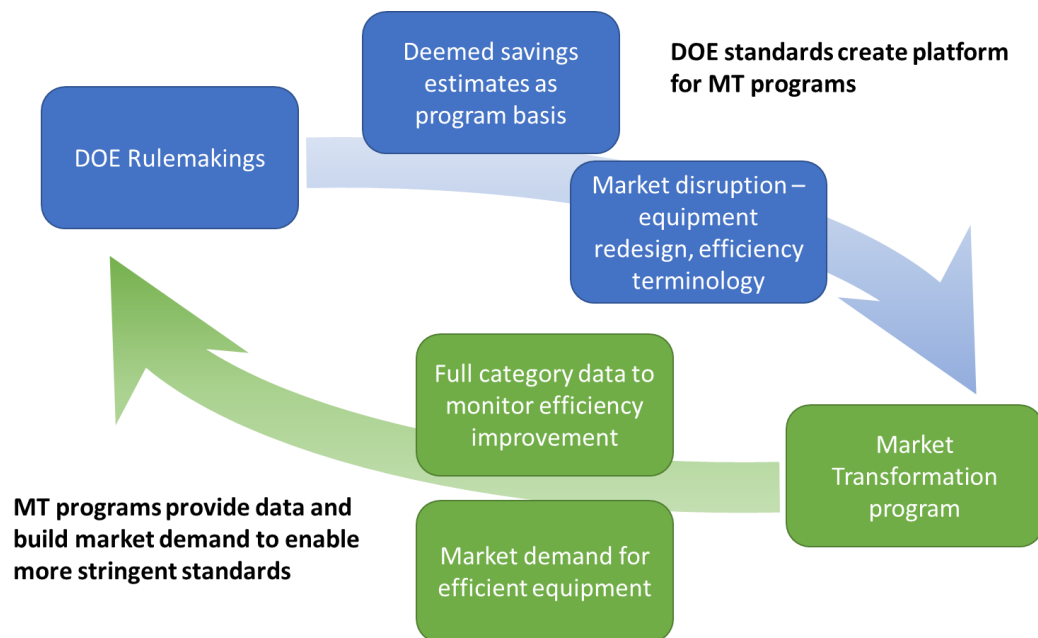


Figure 1. Summary of how DOE regulatory efforts and market transformation programs can work synergistically to advance market efficiency.

In the following sections we first describe the new DOE metric, test procedure, and standard for commercial and industrial pumps, which set the stage for deemed measures and midstream programs for pumps. Then we discuss NEEA’s XMP program and how the program leveraged the new DOE standards and test procedures to inform the program design (incentive levels and specifications), while using the market disruption caused by the new standard as an opportunity to work with manufacturers to advance more efficient designs and technologies that went beyond the minimum standard level. Finally, as DOE is looking to revisit and potentially update the test procedure and standard for commercial and industrial pumps, we share how NEEA’s experience in the pumps market and program data provide important insights for NEEA to be able to inform DOE’s future regulations.

DOE Standard and ER Label

In 2016, a Department of Energy (DOE) rulemaking established new Federal regulations for commercial and industrial clean water pumps (DOE hereafter referred to as Federal standard), which went into effect in January of 2020. The standard has two elements:

1. *A Test Procedure* for rating energy performance according to the new Pump Energy Index (PEI) metric (DOE 2016a), and
2. *A Standard* establishing the minimum performance level for covered pumps of PEI = 1.0 (DOE 2016b).

As a result of this Federal standard, all pumps within the scope of the rule and sold in commerce must be rated with a PEI and meet the minimum performance level. The PEI must be

stamped on the pump nameplate, and the pump must be listed in DOE’s Compliance Certification Management System CCMS database. The PEI rating is a decimal range from 1.0 to 0. PEI compares the rated pump to a reference pump representing the minimally-compliant pump. Thus, a PEI of 1.0 represents the minimally-compliant pump and each hundredth of a point below that represents a 1% improvement in energy consumption from that baseline pump. The PEI is calculated separately for constant speed (constant load PEI, or PEI_{CL}) and variable speed (variable load PEI, or PEI_{VL}) operation based on typical load profiles for those cases.

The Hydraulic Institute, the pump industry’s trade association, created a companion efficiency label for pumps built on the DOE’s PEI metric. The consumer-facing Energy Rating (ER) and associated label clearly indicates a pump’s performance by adapting PEI as shown in Equation 1 (Hydraulic Institute 2021). The result is an integer rating that increases with improved efficiency and denotes the extent, in percentage terms, that a rated pump exceeds the efficiency required by the Federal standard.

$$ER = (1 - PEI) * 100$$

Eq. 1

NEEA’s XMP program leverages the more customer-facing ER label, while DOE’s regulatory program continues to leverage the analogous PEI metric. As such, this paper discusses improvements in pump efficiency both in terms of ER (when discussing program metrics) and PEI (when discussing opportunities for more stringent standards).

Table 1 presents the range in ER values for constant speed and variable speed pumps. Constant load pumps range from the minimally-compliant pump, which has an ER value of 0, to an ER value of 30, which represents energy savings of nearly one-third the total energy consumption of the reference pump. Variable load pumps currently range from ER values of 31 to 64, meaning they are much more efficient in all cases, often by a factor of 2 or 3 relative to constant speed models.

Table 1. ER range by pump category¹

Pump Category	Minimum ER	Maximum ER
Constant load	0	30
Variable load	31	64

In the years between the implementation of the standard and the next update, NEEA initiated a midstream program aiming to transform the pumps market towards efficient outcomes. This program has garnered market insights through experience with market actors and collection of comprehensive sales data. Because DOE is required to review all appliance standards at regular intervals and is currently undertaking a new rulemaking for both the pumps test procedure and the standard, NEEA has the opportunity to make recommendations to DOE to support a potential update to the standard

¹ These ranges were derived from review of HI’s Energy Ratings Database. <http://er.pumps.org/ratings/search>.

Market Situation and NEEA’s Opportunity

Adoption of the 2016 rulemakings and rollout of the ER label introduced two major new dynamics in the pump market. First, many older, less efficient pump models did not comply with the Federal standard. This forced manufacturers to introduce new compliant models in their place and meant that, in many cases, users with long-established pump preferences would have to adjust. Pump purchasers, specifiers, and supply chain actors like manufacturers’ representatives had to change their behavior in reaction to the standard-driven change in product availability.

Second, the ratings of pumps and the rollout of the ER label created a simple, highly visible way for the market to differentiate between pump models on efficiency grounds without having to calculate application-specific performance metrics. Equipment test procedures and efficiency ratings offer opportunities to simplify implementation of energy conservation programs, as PEI and ER offer fair comparisons of efficiency for pumps regardless of application (Widder and Williams 2016).

These two dynamics fundamentally changed the nature of the programmatic efficiency opportunity in the pump market. NEEA’s market characterization research had identified inertia – a basic resistance to change among key market actors – as a barrier to adoption of new efficient technologies (West, et al. 2019). The Federal standard disrupted that inertia and laid the groundwork for market uptake of new products. The ER label addressed another major market barrier. Prior to the existence of the label, efficiency programs addressed the pump opportunity primarily through custom project approaches. Custom projects are time and labor intensive due to the need for project-specific engineering and cost analysis; this poses specific challenges for promotion of small horsepower efficient pumps where the modest energy savings cannot be cost-effectively pursued.

The introduction of the ER label offered a solution to this challenge by providing a straightforward way for programs to specify qualified efficient pumps and calculate energy savings. Specifically, the DOE PEI and HI ER label set the stage for NEEA’s development of deemed measures for commercial and industrial pumps, developed in partnership with the Northwest Power and Conservation Council’s Regional Technical Forum (RTF 2020). NEEA validated these energy savings measures with regional research on pump operational characteristics (Cadeo Group 2019). NEEA leverages these deemed measures in their midstream program design to work directly with manufacturer representatives.

The Federal standard and ER label thus created enabling conditions for programs to promote efficient pumps. In response, NEEA supported development of deemed measures and designed a midstream market transformation pilot program (“XMP program”) with the goal of driving efficiency levels beyond levels required by the Federal standard.

NEEA’s Midstream Pump Efficiency Program

NEEA’s XMP program works with 5 manufacturers’ representative firms (“participants”) that together account for 70% of estimated commercial HVAC pump sales in NEEA’s 4-state

territory (Oregon, Washington, Idaho, and Montana). Participating firms cover many major manufacturers and brands.

At the outset of the partnership with participants, NEEA collected comprehensive historical sales data on the volume and type of pumps sold. This information provided insight into the type, size, quantity, location, and efficiency of pumps sold prior to the standard going into effect. NEEA used this comprehensive market data to design its incentive program in the context of current (or recent past) market conditions.

The historical data indicated three potential opportunities for driving pump efficiency:

1. Increasing the ER of a constant load pump sale
2. Increasing the ER of a variable load pump sale²
3. Converting a pump sale from constant load to variable load

As shown in Figure 2, pumps commonly sold in the Northwest have a significant range of efficiency within the constant load pump category, with minimally compliant pumps at the low end, rising up to pumps with ER values of 20 and greater. Converting a constant load pump to a variable load pump offers a comparatively larger opportunity for energy efficiency, with savings in the range of 50-60% compared to the current DOE standard.

² In cases where code requires a pump to be installed with a variable speed drive, the baseline ER value is the current practice of variable load pumps. Energy savings are derived from increasing the ER of the pump selected above that baseline. For more information, see the RTF's Unit Energy Savings workbook "Efficient Pumps v2.2" CurrentPracticePEIs tab. <https://nwcouncil.app.box.com/v/ComAgIndPumpsv2-2>.

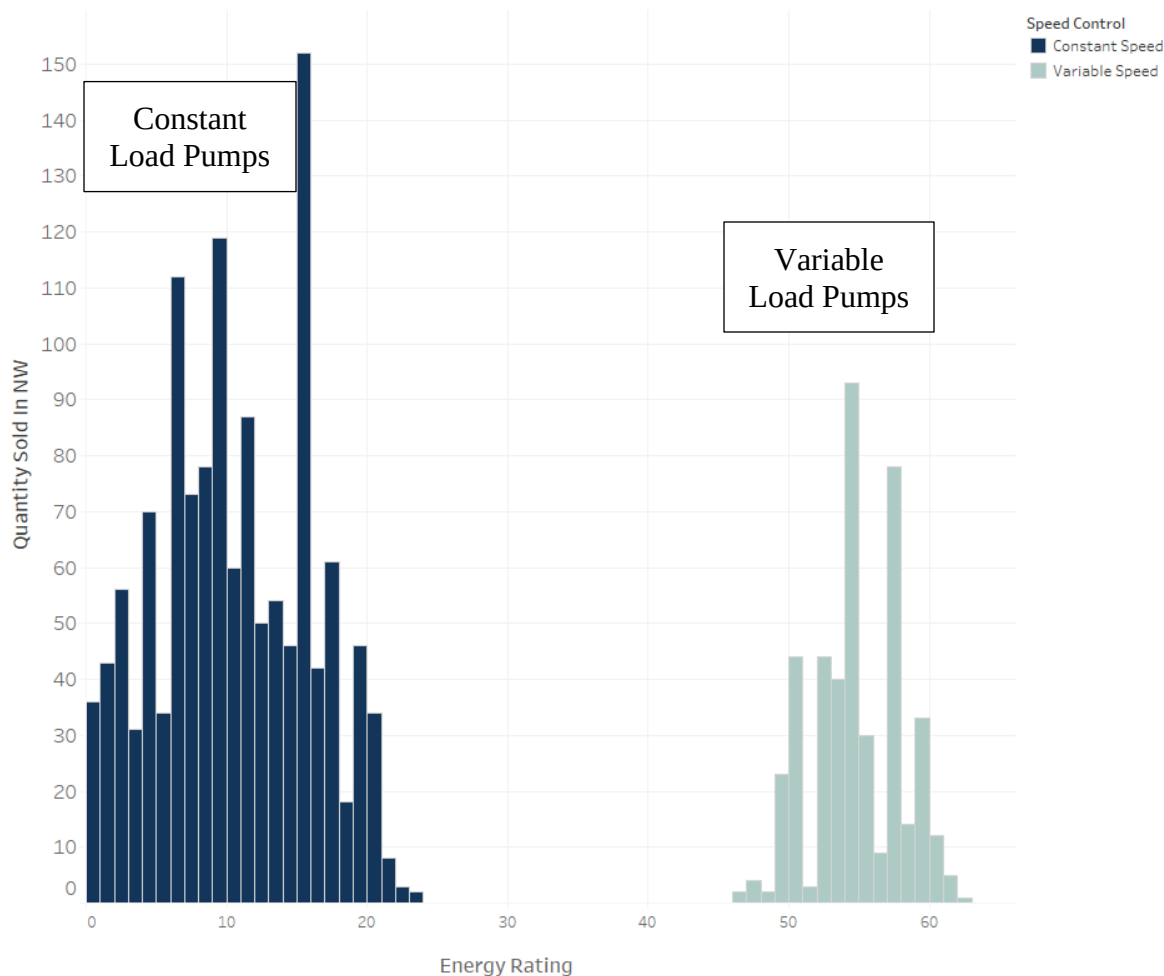


Figure 2. Pump Sales Volume in the Northwest by ER, 2020

With the new Federal standard coming into effect in January of 2020 and labels providing an opportunity to track the pump market at the fleet level, NEEA was interested in testing strategies to affect purchasing behavior using each of these opportunities.

Influencing Constant Load Pump Sales

Informed by historical sales data collected from participants, the NEEA team initially elected to require a minimum ER of 5 (i.e., 5% over the DOE minimum standard for constant load pumps) for any pumps to receive incentives.³ Throughout 2020, the program gained more experience and knowledge of the market opportunity for commercial constant load HVAC pump efficiency. During this time, participants were relatively unsuccessful in shifting their mix of constant load pumps to higher constant load ER levels. NEEA determined that, contrary to first

³ This value was consistent with the average baseline value ER established version 1.1 of the RTF pump measures. <https://nwcouncil.app.box.com/v/ComIndAgPumpsv1-1>.

appearances, there is limited ability to affect the average constant load ER at the midstream level. While pump purchasers have options in the efficiency of pumps by selecting between different manufacturers, manufacturer's reps typically sell exclusively one pump brand and therefore may have only one or two pump models ideally suited to a given application. While still an opportunity, NEEA's program has identified constant load pump efficiency improvement as more affected by manufacturer design decisions and product availability than specific pump selection, particularly for programs working within the mix of pumps sold by specific manufacturers' representatives (as opposed to working across brands).⁴

NEEA therefore pivoted the program strategy to focus on the sale of variable load and, importantly, emergent smart pump technologies (see below). However, NEEA recognizes that customers have options in their pump selections and NEEA does continue to offer an incentive for constant load pumps to broadly influence customers to select models with high efficiency, represented by the pump ER.

NEEA's growing understanding of the opportunity with constant load pumps results in three main conclusions about the DOE standard.

- Pump ratings and labels may be compelling to customers as they select between manufacturers. However, within a manufacturer, there is limited ability to select constant load pumps with higher ERs.
- The average constant load efficiency of pumps sold in the Northwest region is significantly higher than the current federal standard, and there may be an opportunity to raise the bar with the next update of the DOE standard.
- Conversion to variable speed operation offers significantly greater scale of energy savings compared to increasing savings within the constant load category.

Variable Load Pump Opportunities

NEEA's program included variable load pump incentives from inception. As illustrated above in Figure 2, the efficiency opportunity represented by an upgrade to variable load is significant compared to most opportunities within the constant load category. NEEA's experience with manufacturer's reps indicates that they have more influence over customers to upgrade to variable speed products, including traditional variable load equipment combinations and smart pump packages, making them a more compelling intervention at the midstream level.

⁴ Programs focused at the midstream level (working with manufacturer representatives) are well-suited to influence which specific products are sold within a given manufacturer's line. With limited opportunity to choose constant load pumps of different efficiency levels once application specific design needs are met, manufacturer representatives were best positioned to attempt to convert sales from constant to variable load products. This 'within-brand' opportunity differs notably from what is possible when working 'across-brand', where different manufacturers offer pumps of different efficiencies for the same design conditions. Improvements in constant load efficiency are possible, but they arise from consumers selecting between different brands rather than selecting different pumps within a single brand.

NEEA has also found increasing interest from manufacturers and the participants in new smart pump technologies (integrated pump, motor and drive packages that are programmed to operate as variable load without necessarily requiring system sensors).^{5, 6} NEEA believes that these technologies present a significant market transformation opportunity. While in many ways similar to traditional variable load installations, they offer significant improvements in efficiency and overcome many barriers to variable speed installations, including:

- Integration of pump, motor, drive, and integral sensors into one streamlined package, which simplifies installation burden and reduces hardware costs.
- Pump-specific performance maps of pump curves that allow the drive to optimize operation.
- Simplified startup procedure reduces potential for errors in sensor installation and drive programming.
- In some pump models and sizes, smart pumps are often driven by advanced motor technologies such as electrically-commutated motors, which further enhances efficiency benefits compared to standard NEMA Premium motors.

In 2021, NEEA adjusted the program approach to more heavily weight incentives at the variable load and Smart Pump efficiency opportunity. These priorities were developed jointly with participants based on how they perceived the efficiency opportunities in the market, and were combined with bonus payments tied to achievement of specific Smart Pump targets (calibrated relative to 2020 sales volume). Under this basic framework, the program observed 5% growth in Smart Pump sales from 2020 to 2021 as shown in Figure 3.

⁵ For example: “A Design Envelope (Smart) pump will operate at high efficiency levels and will provide the exact pumping performance that supports the hvac system and keeps costs at a minimum.” http://armstrong-pompy.pl/onewebmedia/100.11_DesignEnvelope_brochure.pdf.

⁶ NEEA worked with HI to develop a Smart Pump Video compiling these benefits: <https://www.youtube.com/watch?v=-YxmnFDIoD4>

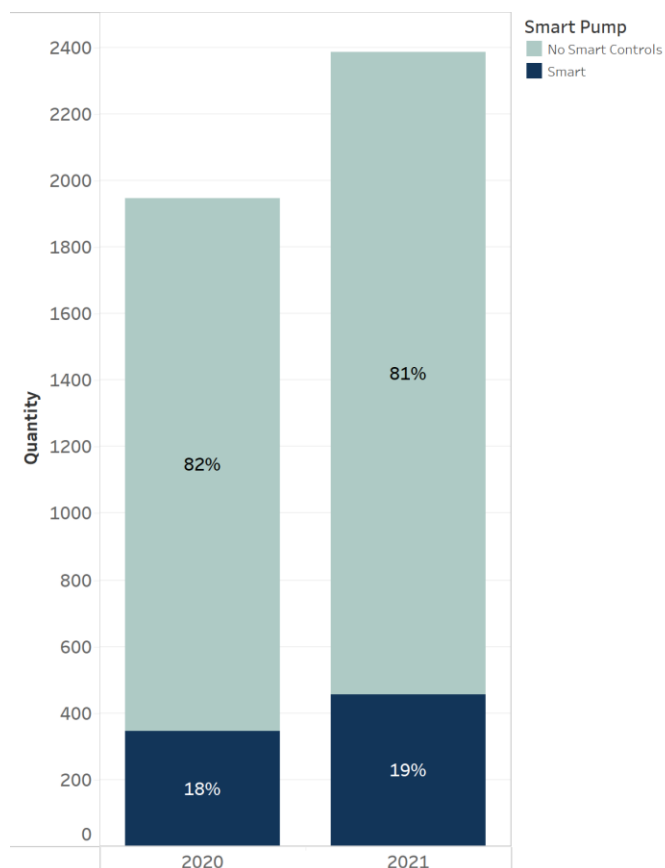


Figure 3. Smart Pump Sales in NW by Year, Share of Total

With their experience promoting variable load pump sales in the Northwest, NEEA recognizes two significant opportunities for the DOE standard to encourage penetration of the technological advances in the variable load category:

- DOE should consider variable speed in its evaluation of efficient technologies.
- DOE should adjust the test procedure to reflect benefits of emerging smart pump and advanced motor technologies in PEI.

Raising the Bar and Driving the Next Standard

DOE's standard and test procedure created a unique market opportunity for NEEA and other energy efficiency organizations to leverage the new metric and market situation to drive manufacturers and the market towards more efficient options. In turn, NEEA's program creates opportunities to leverage its experience implementing the XMP program and collecting full category market data from participants to help inform and strengthen the Federal standard over time. Based on the market knowledge generated by the program, NEEA developed a strategy to improve the DOE's standard using four key tactics:

- 1) **Raising the bar:** making the standard more stringent based on improved market average efficiency if appropriate.
- 2) **Aiming high:** revisiting the analysis based on the more efficient pumps currently available.
- 3) **Embracing innovation:** considering new efficient technology options.
- 4) **Expanding the scope:** broadening the coverage of the standard to eliminate competition between covered and non-covered pumps.

Raising the Bar

First, through the experience of implementing the program and insights available from the full-category sales data (not limited to incentive-eligible pumps) sold by distributors, NEEA is able to identify and document changes in market efficiency for the Pacific Northwest (Van Clock, Joe and Lieb, Noah 2021). NEEA has observed that the market is adopting more efficient pumps than previously assumed. Table 2 shows that the market average PEI is significantly more efficient than both the minimum compliance level and the current practice baseline (an energy efficiency planning assumption). These data suggest that more stringent standards may be appropriate and feasible for commercial and industrial pumps in the upcoming rulemaking. While this data is limited to the Northwest, we see indications of national progress towards efficient products in the higher levels of equipment efficiency offered by manufacturers (discussed in the Raising the Bar section) and in the fast pace of technological innovation (discussed in the Embracing Innovation section).

Table 2. Average PEI by equipment class for minimum compliance level and NEEA market average (RTF 2020, NEEA 2022)

Equipment Class	Nominal Speed	Federal Standard	Current Practice Baseline from RTF analysis ⁷	NEEA Market Average (2017 -2021)	Difference between Minimum Compliance Date and NEEA Market Average
ESCC	1800	1.00	0.94	0.90	-0.04
	3600	1.00	0.88	0.90	0.02
ESFM	3600	1.00	0.93	0.89	-0.04
	1800	1.00	0.94	0.89	-0.05
IL	1800	1.00	0.95	0.90	-0.05
	3600	1.00	0.92	0.85	-0.07
RSV	1800	1.00	0.99	0.92	-0.07
	3600	1.00	0.97	0.91	-0.06
ST ⁸	1800	1.00	0.91	-	-
	3600	1.00	0.90	-	-

⁷ The current practice baseline analyzes data available from the TSD and assumes that all non-compliant pumps in the market were replaced with code minimum pumps with no change to the composition of pumps that are more efficient than the standard (RTF 2020).

⁸ Participants have not sold enough ST pumps for NEEA to reliably report on the market.

Aiming High

Second, NEEA has observed that the most efficient pump technology available is more efficient now (as measured by PEI) than the data submitted to DOE in 2016 during the standard rulemaking. NEEA understands that some manufacturers redesigned their pump lines in response to the standard. Table 3 shows that the most efficient technology currently available has increased compared to that which was published in the TSD in four of ten pump categories (DOE 2015). This suggests that technology has improved beyond what DOE considered possible in the previous 2016 rulemaking and that there may be more opportunities for energy savings in the upcoming rulemaking.

Table 3. Pump PEI values for the maximum technology available during the 2016 DOE rulemaking compared to the current market (DOE 2022)

Pump Family	Nominal Speed	Max Tech PEI from 2016 DOE Rulemaking ⁹	Max Tech PEI from DOE CCMS Database	Improvements to Max Tech PEI
ESCC	1800	0.88	0.78	-0.10
	3600	0.62	0.67	
ESFM	1800	0.61	0.70	
	3600	0.79	0.77	-0.02
IL	1800	0.70	0.79	
	3600	0.80	0.74	-0.06
RSV	1800	0.75	0.87	
	3600	0.67	0.69	
ST	1800	0.74	0.62	-0.12
	3600	0.75	0.75	

Embracing Innovation

In implementing the XMP program, NEEA also works with manufacturers and distributors to identify and promote specific energy-saving features and technologies available in the pump market. As discussed previously, NEEA's program is particularly focused on savings from variable speed drives, advanced motor technology and smart pumps and has been seeing increased adoption in the Northwest as a result of program activity. NEEA has observed increased penetration of energy efficient technologies, as well as increased offerings (e.g., new products and expanded product lines) as manufacturers react to the increasing demand for these high efficiency offerings.

As DOE considers new efficiency analysis for this second round of rulemaking, NEEA also encouraged DOE to consider additional technology options in the standard. Through

⁹ "Max-tech is the efficiency level that provides the maximum improvement in energy efficiency that is technologically feasible...across the entire scope of the equipment class" (DOE 2015, 5-20).

conversations with XMP participants and analysis of sales data, NEEA has found that the market is adopting multiple technologies that are not addressed in the Federal standard:

- Addition of variable speed drives (VSDs)
- Improvements in VSD efficiency
- Advanced motors
- Smart pumps

While some of these technologies may be reflected in a pump's tested PEI, DOE does not consider them in the engineering analysis that they conduct to set the stringency of the standard. As a core part of DOE's standard analysis in the pumps Technical Support Document (TSD), DOE reviews all efficiency technologies available in the market (in the Market & Technology Assessment (DOE 2015, 3-1)), screens those technologies to identify the technologies included in its analysis¹⁰ (Screening Analysis (DOE 2015, 4-1)), and then creates representative cost-efficiency curves to understand the likely incremental costs and savings resulting from specific improvements (Engineering Analysis (DOE 2015, 5-1)). It is important that DOE's analyses consider all available efficiency options in its analysis to ensure that DOE identify the most efficient and effective technology pathway to achieve potential standard levels in different situations. If a technology is not considered in DOE's analysis, it cannot be considered as part of setting the standard.

Expanding the Scope

Finally, NEEA leveraged the XMP pump sales database to recommend adjustments to the scope of the Federal standard. NEEA has observed in the sales data a significant number of pumps that are excluded from the standard but are sold into similar applications and customer types as covered pumps. This gap in coverage creates a potential competitive advantage for pump families that did not experience any compliance costs. It is also a potential loophole undermining the impact of the standard.

Pumps might be excluded from the DOE standard for two reasons. First, DOE originally limited the standard to the five pump classes that make up the bulk of the market for clean water pumps. However, NEEA observes enough crossover to classes that DOE did not regulate based on their perceived small market share that it believes they should be covered by the Federal standard. Secondly, DOE limits the scope to a range of operating conditions, with low and high cutoffs for specific criteria including input power, head, and flow. The TSD does not provide justification for the limits selected, and NEEA has found that the standard may apply inconsistently to pump models within the same pump family (DOE 2015). Many models within the family will be covered by the standard and listed with a PEI, while others will be excluded based on a specific operating parameter and not listed with a PEI.

¹⁰ DOE excludes technologies that are not technologically feasible; not practical to manufacture, install, and service; have adverse effects on product utility, availability, health, or safety; or other reasons subject to DOE's discretion.

In implementing the XMP program and its discussions with participating distributors and manufacturers, NEEA has observed that these inconsistencies in coverage create confusion in the market around what is covered and why certain similar pumps do or do not have PEI ratings. As such, NEEA recommends that DOE analyze market data to adjust the parameter limits and reduce inconsistencies in coverage to the extent possible. In addition to limiting market confusion and removing loopholes that could create unfair market dynamics for competing pumps, expanding the covered pump types would increase the savings from the standard with limited impact on manufacturers due to the similarities of these adjacent pumps to the already covered pump types.

In supporting DOE to continuously improve the Federal pumps standard, NEEA's close connection to the Northwest pump market through the XMP program provides important insight into the current state and future trajectory of the market. NEEA is able to provide DOE with insights into the current average efficiency of the Northwest market, potentially allowing DOE to raise the bar in the next standard. NEEA also provides an on-the ground perspective into trends in advanced technology, which, along with recent research, indicate that DOE should consider technology options that were screened out in the 2016 standard. Finally, NEEA's comprehensive pumps sales database allows for insight into the market share of pump classes and pump operational characteristics that create uneven coverage of the standard.

Summary and Conclusion

New standards taking effect often disrupts business as usual. This is all the more the case in industries, like commercial and industrial pumping, that have historically been averse to adopting technological change. For commercial and industrial pumps, the 2016 rulemakings established a new metric and label that enabled a more simplified and robust description of pump energy consumption that consumers, market actors, and programs can use to identify and promote efficient equipment. NEEA's XMP program leveraged the new ER label to develop a deemed, midstream pump offering for commercial and industrial pumps. In addition, while the mandated changes improve efficiency in their core requirements, they also create an opportunity for programs to push for changes above and beyond those mandated by standards. NEEA's XMP program also leverages the coattails of the DOE standard to aggressively push market partners to sell pumps that significantly exceed Federal requirements. This market demand in turn influences manufacturers to develop more efficient offerings, further enhancing market offerings for high efficiency equipment. Robust data collection from NEEA's market transformation effort is also used to demonstrate and document market progress and inform the next iteration of Federal standards. This synergistic cycle, depicted in Figure 1 at the start of this paper, demonstrates how market transformation programs and regulatory efforts can work hand in hand to continually push efficiency improvements. NEEA's XMP program provides an excellent example of how this strategy can successfully work in practice.

References

Cadeo Group. 2019. *Extended Motor Products Savings Validation Research on Clean Water Pumps and Circulators*. Portland: Northwest Energy Efficiency Alliance (NEEA).

- Hydraulic Institute. 2022. *Energy Ratings Home*. Accessed 2022.
<http://er.pumps.org/ratings/home>.
- . 2021. "HI 40.5-Program Guideline for HI Energy Rating Program." *Hydraulic Institute*.
<https://www.pumps.org/product/hi-40-5-2016-program-guideline-for-hi-energy-rating-program/>.
- Northwest Energy Efficiency Alliance (NEEA). 2022. "Unpublished Confidential Sales Data." Regional Technical Forum (RTF). 2020. *UES Measure: Efficient Pumps*. Accessed 2022.
<https://rtf.nwccouncil.org/measure/efficient-pumps/>.
- U.S. Department of Energy (DOE). 2015. "2015-03 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial and Industrial Pumps." CIP NOPR TSD 03-17-2015, Washington, D.C.
- . 2022. *Compliance Certification Database*. Accessed 2022.
https://www.regulations.doe.gov/certification-data/CCMS-4-Pumps_-_General_Pumps.html#q=Product_Group_s%3A%22Pumps%20-%20General%20Pumps%22.
- . 2016a. *Energy Conservation Program: Energy Conservation Standard for Pumps*. Washington, DC: Federal Register, Vol. 81, No. 16, pp. 4368-4433.
- . 2016b. *Energy Conservation Program: Test Procedure for Pumps*. Washington, DC: Federal Register, Vol. 81, No. 15, pp. 4086-4158.
- Van Clock, Joe, and Lieb, Noah. 2021. *Extended Motor Products Pump and Circulator Baseline Assumptions Review*. Portland: Northwest Energy Efficiency Alliance (NEEA).
- West, Anne, Ryan Hughes, Bitsy Broughton, David Ladd, and Chris Kramer. 2019. *Extended Motor Products Market Characterization*. Portland: Northwest Energy Efficiency Alliance (NEEA).
- Widder, Sarah, and Alison Williams. 2016. "Capturing Energy Savings Opportunities for Pumps." *ACEEE Summer Study on Energy Efficiency in Buildings*.