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Extended Motor Products Market Characterization

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Acronyms

BMS	Building management system
C&I	Commercial and industrial
CBSA	Commercial Building Stock Assessment
DOE	U.S. Department of Energy
ECM	Electronically commutated motor
EMS	Energy management system
HI	Hydraulic Institute
HI ER	Hydraulic Institute Energy Rating
HP	Horsepower
IFSA	Industrial Facilities Site Assessment
MSMA	Motor System Market Assessment
NEEA	Northwest Energy Efficiency Alliance
OEM	Original equipment manufacturer
ROI	Return on investment
SIC	Standard industry classification
VFD	Variable frequency drive
XMP	Extended Motor Products

1 Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) Extended Motor Products (XMP) Initiative is designed to accelerate the adoption of more efficient motor-driven products—such as pumps, fans, and compressors—to transform market habits and capture energy savings. NEEA began work on the XMP Initiative in 2013 and formally launched it in 2018. Currently focused on the pump market, NEEA is working to incorporate increases in federal standards for pumps and leveraging the Hydraulic Institute's (HI) Energy Rating (HI ER) label initiative into their work. The XMP Initiative could provide the foundation for similar initiatives for other motor-driven equipment in the future.

To assist with its efforts to transform the pump market, NEEA contracted Cadmus to characterize the opportunity by profiling the market, describing roles of key market actors, and assessing barriers in the market. Cadmus focused on commercial and industrial (C&I) applications for clean water pumps up to 50 HP and circulator pumps in commercial applications from fractional to 5 HP. Additionally, this report presents market perceptions of energy-efficient pump systems—referred to as smart pumps—a system that combines a pump, drive, and integrated controller.

1.1 Summary of Key Findings

To confirm and build on the existing body of work related to the XMP Initiative, Cadmus collected data through secondary and primary research. Interviews with supply and demand side market actors examined awareness and perceptions about energy efficient pumps, explored distribution channels, information flow, and factors affecting purchase decisions, and inquired about smart pump sales, and market barriers. This section presents Cadmus' key findings about market awareness, market actor roles, and barriers to market transformation.

Market Awareness

The market is aware of energy-efficient smart pump systems, referenced in this report as a pump system that combines a pump, drive, and integrated controller.

The market is in a very fluid state. Both supply- and demand-side market actors expressed interest in smart pumps.

- Energy-efficient smart pumps are present to varying degrees in some product line offerings. The market actors interviewed anticipate that demand for these systems will grow over the next decade.

Smart pump market growth faces some challenges.

- The market does not use a cohesive definition of a smart pump and has not yet settled on what constitutes a smart pump. Some pumps are defined by application rather than by pump characteristics. Some suppliers build custom packages rather than providing off-the-shelf packaged smart pumps, and some prefer familiar control strategies over unfamiliar packaged systems.
- Some market actors are skeptical that an integrated pump system package will become popular. They argue that rigidly defined systems packages represented by a smart pump may not be compatible with systems already in place, they may be difficult to install, and that even if they were installed, the pump systems may be difficult to maintain.
- There may be barriers to how widely smart pumps can be installed. Manufacturers' sales representatives and specification engineers suggest that smart pumps are found in hydronic systems. Process applications may be less well-suited to smart pump applications. These applications often have design characteristics that are more easily addressed with external variable frequency drives (VFD) and controls suitable to unique manufacturing needs.
- Market actors generally appear to lack a robust understanding of the energy savings, non-energy benefits, and life-cycle cost considerations of smart pumps, which affects purchase decision making and return on investment (ROI) calculations.
- The HI ER is being used by some manufacturers and end users and has potential for distinguishing high-efficiency pumps. However, the label is not yet widely recognized as providing value by contractors or specifying engineers. End users were more aware of HI ER pump labeling than were contractors, and were more likely to use the labels to inform their purchase decisions.

Market Actor Roles

This research confirmed the market actors of significance identified by earlier work commissioned by NEEA. These include the manufacturer, manufacturer's sales representative, distributor, specifying engineer, contractor, and end user.

- **Manufacturers and their sales representatives** are key in providing information to all market actors, particularly **distributors** and **end users**. Many are marketing smart pumps by application rather than by pump characteristics. These market actors are a good option for promoting the HI ER.
- **Specifying engineers** are more likely to be involved in new construction projects and less likely to have input into process applications. These engineers will work with distributors and manufacturer representatives.

- **Contractors** rely on manufacturers, their sales representatives, and distributors for information on both retrofit and new construction applications. In retrofit work, they are less likely to consider options with which they are not familiar.

This research confirmed findings from earlier research that the roles of each market actor vary according to the purchase decision backdrop (such as replacement versus new project or new construction).

- In **replacement** scenarios, such as when a pump breaks down, the end user will call a contractor. The exigencies of the situation require quick response. The contractor is likely to select a replacement pump that is similar in characteristics to the failed pump, replace like-for-like, or select another familiar pump type. Program implications for this scenario are that the replacement market can be best served if smart pumps are more present in the product lines of manufacturers, representatives, and distributors serving contractors.
- In the **new construction** scenario, a specifying engineer working with the design team will create specifications for any required pumps. The contractor will bid specified pumps, but is following direction rather than leading the selection process. In this scenario, the market is best served when specifiers and purchasers are fully versed in smart pump options and applications.

Barriers to Market Transformation

The research revealed that NEEA correctly identified the barriers in its program logic model.

- There are several barriers to **supply-side** inertia: distributors do not stock or promote the strategic value of efficient pump systems, there is no common definition of efficient or smart pumps, and many suppliers provide efficiency in terms of customized systems rather than off-the-shelf solutions. The unclear and open-ended definition, coupled with a lack of full pump category sales data, means there is no clear way to mark evidence of progress in smart pump sales.
- There are also several barriers to **demand-side** inertia: buyers are unaware of energy-efficient options; buyers lack knowledge of the energy, non-energy, and life-cycle benefits of efficient pumps; and first cost is difficult to lower through incentives.

The research showed that barriers are addressable.

- Working with HI and other market actors, NEEA can assist the market with developing a common understanding of energy efficient or smart pumps.

- Creating a broader understanding of the smart pump value proposition could lower supply-side resistance among manufacturers and distributors to carrying off-the-shelf systems. At the same time, demand-side reliance on first cost could decrease with greater understanding of the value offered by efficient pumps.

In addition to confirming barriers found in the logic model, the research uncovered additional potential barriers to consider adding to the XMP logic model.

- **Supply-side** barrier additions include:
  - The lack of experience applying smart pump systems solutions means these solutions are not considered as an option when decisions are made to purchase pumps.
  - Suppliers prefer to sell customized systems rather than pre-packaged off-the-shelf ("black box") solutions. By offering customized solutions, the supplier limits the number of in-stock items needed in stores. In addition, as controls are found externally on the system, the custom installed solutions are easier to maintain and replace.
- **Demand-side** barrier additions include:
  - End users have limited awareness and understanding of non-energy benefits (e.g. lower install costs, easier maintenance, etc.) available from smart pumps.
  - Installers and end users lack training, experience, and infrastructure support (such as management systems and support staff).
  - With no knowledge of how smart pump systems operate, end users are concerned about reliability and maintenance, in particular access to controls that may be embedded in the system using proprietary technology.
  - Ease of pump maintenance is a factor in purchase decisions for end users.
  - Compatibility with other equipment, particularly as pump horsepower increases, is a concern of contractors and end users.

The remainder of this report includes several sections:

- Background research overview
- Market Profile
- Market Actor Roles, Information, and Product Flow
- Logic Model and Barriers Research
- Conclusions

Appendices include the data collection approach and instruments, as well as additional information about supply- and demand-side barriers.

2 Background

2.1 Initiative Overview

The NEEA XMP Initiative is designed to accelerate the adoption of more efficient motor-driven products, such as pumps, fans, and compressors, to transform these markets and capture energy savings cost-effectively. Toward this end, the NEEA XMP Initiative will work to increase awareness of energy-efficient pumps, increase stocking and sales of efficient clean water and circulator pumps, and provide training and communication support to inform purchase decisions. By broadening awareness of the benefits of packaged pump systems with integrated controls (smart pumps), expanding product options, and increasing use of an energy rating label, purchasers and decision makers will be able to more easily identify efficient equipment with lower operating costs and other advantages.

The U.S. Department of Energy (DOE) kick-started this initiative as part of a federal standards process in 2012. Soon after, energy efficiency stakeholders joined. In 2013, the American Council for an Energy-Efficient Economy led the way by creating the Extended Motor Products Label Initiative. This initiative took advantage of work being done at HI and supported by HI's pump manufacturer members, in establishing the Pump Energy Rating. That same year, NEEA's emerging technology group saw the opportunity to join the effort to transform how motor products are manufactured and used.

NEEA's XMP Initiative is in the process of creating an intervention strategy to encourage supply chain market actors to stock and promote more efficient pump models. The initiative also intends to coordinate with utilities to target several key barriers, such as high first cost, by offering incentives, minimizing the issue of split incentives,[1] and raising awareness. The XMP Initiative could drive greater adoption of packaged pump systems and provide the foundation for similar initiatives for other motor-driven products.

2.2 Research Overview

NEEA contracted with Cadmus to characterize the commercial market for smart pumps, focusing on C&I applications for clean water pumps up to 50 HP and circulator pumps in commercial applications from fractional to 5 HP.

[1] A split incentive refers to incentives that are directed at the entity that sells the product, but the benefit of the product is experienced by a different market actor.

NEEA set three primary research objectives to inform the XMP Initiative:

- Profile the market
- Identify the roles of supply- and demand-side market actors
- Assess market barriers

Cadmus' assessment focused on applications of packaged pump systems with integrated controls—clean water pumps up to 50 HP and circulator pumps from fractional horsepower up to 5 HP—in the region covered by NEEA (Idaho, Oregon, Washington, and Montana).

2.2.1 Research Activities and Methodology

Table 1 summarizes the objectives and key activities for this research. Secondary research involved a literature review. Primary research included market actor interviews and surveys.

Table 1. Research Objectives and Activities

Research Objective	Key Activities			
	Secondary Research and Literature Review	In-Depth Interviews		Pump Purchaser Survey [b]
		Market Actor [a]	NEEA Staff	
Develop a common understanding with NEEA of the current research on smart pumps and identify addressable research gaps	✓		✓	
Assess NEEA Definition of Smart Pumps	✓	✓	✓	✓
Characterize Pump Distribution and Identify Key Distributors	✓	✓	✓	✓
Assess Supply- and Demand-Side Barriers	✓	✓	✓	✓
Characterize Market Actor Roles and Map the Supply Chain for Pump Purchases	✓	✓	✓	✓

[a] Market actors included manufacturers, manufacturers' sales representatives, specification engineers, and HI representatives.
[b] Pump purchasers included end users (facility managers and building operators) and contractors.

2.2.2 Literature Review

Cadmus completed a review of XMP-related documents provided by NEEA. We also conducted online research for additional information about products and companies to prioritize topics requiring further research and identify the market actors who would be most appropriate for discussions on those topics. We obtained the baseline information needed to characterize the current and future market, reviewed the roles of market actors, and identified known barriers to smart pump adoption.

Cadmus met with NEEA staff to discuss the findings of the literature review, ascertain the roles of market actors, and in particular, establish the definition of a smart pump that could then be used in interviews and surveys. See *Appendix A* for sources used in the literature review.

2.2.3 Market Actor Interviews and Surveys

In collaboration with NEEA, Cadmus identified categories of the pump manufacturers, specifiers, installers, and purchasers to contact for interviews or surveys about pump selection and awareness of smart pumps in the market. We prepared interview and survey questions that focused on C&I clean water pumps up to 50 HP and circulator pumps from fractional up to 5 HP. Questions covered all pump system options for these sizes to gauge market actors' familiarity with the smart pump technology. *Appendix B* summarizes Cadmus' survey approach and provides an attrition table. *Appendix C* presents findings from barriers research. *Appendix D* and *Appendix E* provide the data collection instruments.

In-depth interviews with pump supply chain market actors and influencers included the following:

- Manufacturers
- Manufacturers' sales representatives
- Specification engineers
- Representatives of the HI

The three manufacturers' sales representatives who were interviewed represented four different manufacturers. Two represented one manufacturer apiece (different manufacturers) while the third represented two manufacturers. The three manufacturers primarily offer hydronic equipment and systems (pumps, boilers, and HVAC). We did not interview distributors, equipment suppliers, or wholesalers.

The pump purchaser survey included people who recommended, specified, selected, or purchased both circulator pumps up to 5 HP and C&I clean water pumps up to 50 HP:

- End users (facility managers and building operators)
- Contractors

We compiled a list of market actors from contacts provided by NEEA, the United Association of Plumbers and Steamfitters, Google searches, and Cadmus staff. We also extracted contacts from Dunhill International's database of facility managers, building operators, and contractors, (representing 766 unique business standard industry classification [SIC] codes) in Idaho, Washington, Oregon, and northern California.[2] We also compiled lists of site contacts from

[2] The survey is not intended to be representative of the four-state Northwest region (Oregon, Washington, Idaho, and Montana), rather to indicate opinions from a range of end users.

these Cadmus studies: The Commercial Building Stock Assessment (CBSA), the Motor System Market Assessment (MSMA), and the Industrial Facilities Site Assessment (IFSA).

Cadmus made multiple attempts to identify the small subset of end users, including facility managers, building operators, and contractors who specified, purchased, or installed pumps. Cadmus found that many did not work with pumps, and as a result, completed fewer surveys than anticipated. Nevertheless, we gathered a variety of perspectives across market actor groups and drew conclusions about their awareness of and the market for smart pumps.

Table 2 shows interview and survey sample sizes. *Appendix B* provides additional detail.

Table 2. Interview and Survey Sample Sizes and Completes

Market Actor Group	Target Completes	Interview Mode	Completed Interviews and Surveys
NEEA Project Manager and Subject Matter Experts	1 to 3	Roundtable discussion	1 roundtable discussion with 5 NEEA staff
Manufacturers	5	Phone interview	5
HI Representatives	1	Phone interview	2[a]
Specification Engineers	4 commercial and 2 industrials	Phone interview	5
Manufacturers' Sales Representatives [b]	Up to 5	Phone interview	3
End Users including Facility Managers and Building Operators	100 stratified across Northwest	Online survey/ direct dial	18
Specification and Installation Contractors	Up to 10	Online survey/direct dial	6

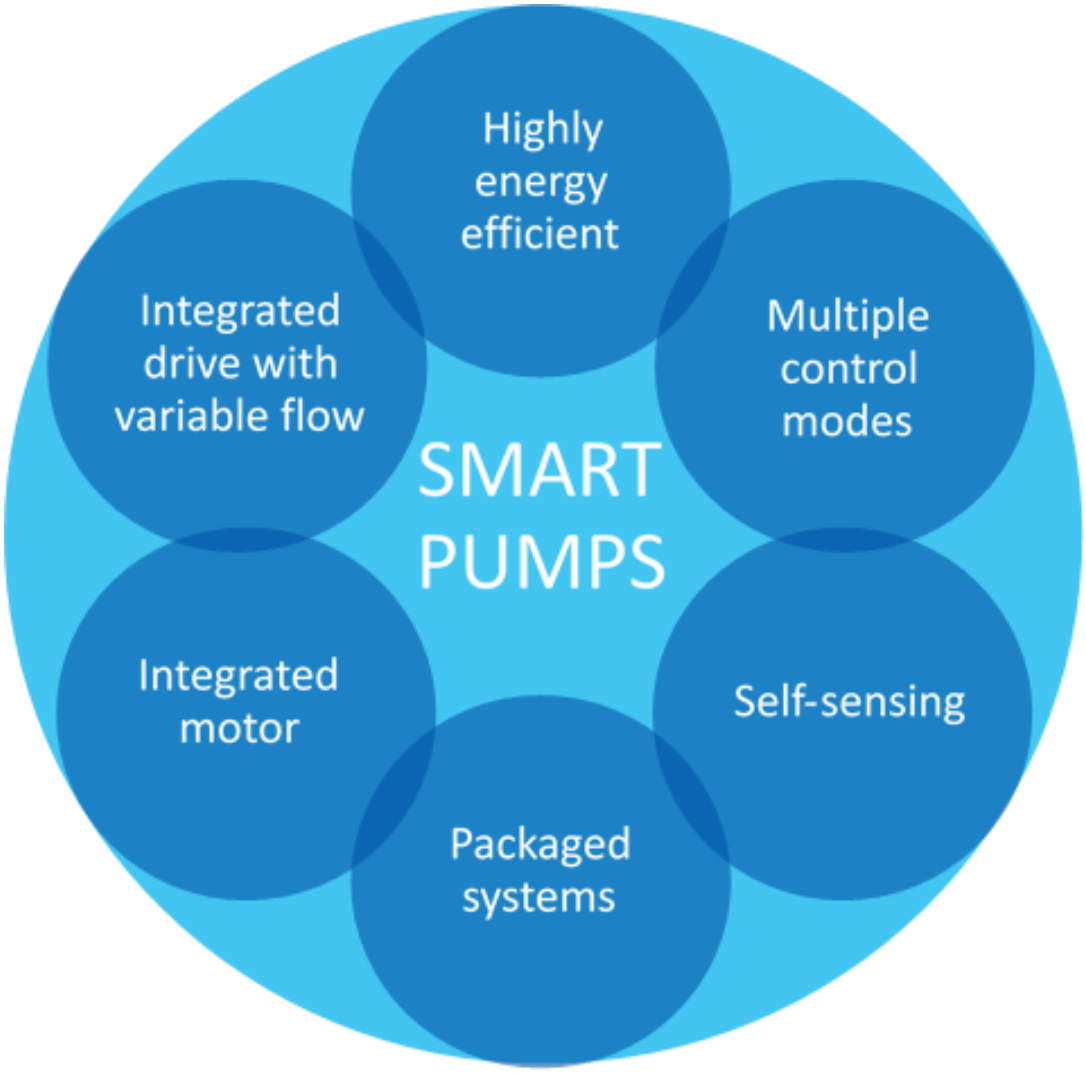
[a] Executive Director and Technical Director

[b] At the time of the interviews, NEEA was working with several manufacturers and limited the available pool to avoid overlapping or competing contacts with Cadmus.

2.3 Smart Pump Definition

For the purpose of this market characterization, Cadmus and NEEA agreed on the following definition, used in interviews and surveys conducted with market actors and purchasers. Discussion of market actor responses to this definition are described in *Section 3.1 Market Awareness*.

Smart pumps are defined as a packaged pump unit consisting of a pump, variable speed drive, internal sensor, and pre-programmed controls. *Smart pumps* have multiple control modes, can operate on constant flow or variable flow systems, and do not require integration to an external sensor or building management system (BMS). *Smart pumps* are designed to minimize the use of energy in operation, that is, to be highly energy efficient while maintaining performance to meet the demands of the application.



3 Market Profile

To profile the smart pump market in the Northwest, Cadmus looked at the C&I market for clean water pumps up to 50 HP and circulator pumps from fractional horsepower up to 5 HP. We spoke to market actors who supply pumps as well as those who drive demand through specifying, purchasing, or installing pumps. Where possible, we segmented the markets for new construction and existing buildings. We comment on the portion of existing pumps that could theoretically be converted to smart pumps.

In profiling the market, we evaluated factors such as market actor awareness, perception and application of smart pumps, as well as the sources, disbursement, and influence of information about efficient pumps. Cadmus asked about the topics listed in Table 3, as well as related topics.

Table 3. Market Profile Research Objectives

Market Characterization Focus	Research Question
Market Awareness	• How aware are market actors and purchasers of smart pumps? • Who do purchasers rely on for information about energy-efficient pumps? • How do market actors and purchasers perceive smart pumps? • What role does labeling play in awareness of high-efficiency pumps?
Estimated Market Growth	• How will the market for smart pumps grow over 20 years?

3.1 Market Awareness

NEEA proposed a smart pump definition, which Cadmus explored through secondary research. Cadmus and NEEA agreed upon the modified definition shown below, which Cadmus subsequently used in surveys and interviews.

Smart pumps are defined as a packaged pump unit consisting of a pump, variable speed drive, internal sensor, and pre-programmed controls. Smart pumps have multiple control modes, can operate on constant flow or variable flow systems, and do not require integration to an external sensor or building management system. Smart pumps are designed to minimize the use of energy in operation, that is, to be highly energy efficient while maintaining performance to meet the demands of the application.

Cadmus interviewed market actors involved in hydronic pump distribution and sales and surveyed pump purchasers (end users and contractors with a role in selecting, specifying, recommending, or purchasing pumps). We explored whether market actors and purchasers agreed with the smart pump definition stated above, or used a common or specific set of characteristics when referencing smart pumps; the response was mixed.

Although all respondents were familiar with smart pumps, neither market actors nor purchasers agreed on a consistent definition of smart pumps. Approximately half of market actor interviewees (7 of 15 respondents) endorsed the smart pump characteristics as defined. The other half agreed with some but not all elements of the definition. At a minimum, all market actors were familiar with pumps that partially fit the definition. However, few agreed that the term "smart pump" was the best description for packaged efficient pump systems with self-sensing capabilities. Importantly, not all market actors distinguish between smart pumps and high-efficiency pumps.

Table 4 shows how many market actors identified smart pumps by the various characteristics. Defining elements and characteristics varied widely. The most consistent across groups was that a smart pump includes self-sensing characteristics and an integrated drive with variable flow. At least one respondent from each group also mentioned energy efficiency.

Table 4. Smart Pump Characteristics

Characteristic	Manufacturers (n=5)	Manufacturers' Sales Representatives (n=3)	Specifying Engineers (n=5)
Energy efficient	2	1	1
Self-sensing (or sensorless)	2	2	2
Integrated drive with VFD	2	1	3
Integrated motor (electronically commutated motor [ECM])	1		3
Pre-programmed controls			2

Source: Market actor interview questions, B2 "How does your business define smart pumps?", B3 "Have you seen or heard a common definition for smart pumps used and understood among pump manufacturers, distributors, pump specifiers, and purchasers?", "[If yes:] What is that definition?", "[If no:] Have you heard different definitions across these businesses? What definitions or characteristics have you heard for smart pumps?"

Specifying engineers were the most likely to mention integrated motors. Additionally, one manufacturer advocated for installing external sensors, ECMs, and VFDs on efficient pumps instead of self-sensing packaged pump systems. Some manufacturers said they approach the idea of smart pumps differently. These manufacturers build custom systems that are essentially smart pumps, tailored to a customer's needs, rather than providing "off-the-shelf" smart pumps. Similarly, one surveyed end user explained the reason for not installing smart pumps in retrofits by stating: "We will typically design our own system with a VFD and pressure switches for efficiency." Several manufacturers and their sales representatives said they market pumps by their application rather than the pump's characteristics.

Although market actors do use the term "smart pump," the term is not yet used by all market actors across the supply chain. When asked about the terminology used to market smart pumps and differentiate between high efficiency pumps and smart pumps, three manufacturers or manufacturers' sales representatives and one specifying engineer said they did not draw a

distinction between "smart pumps" and "high-efficiency pumps," stating that the definitions are not mutually exclusive. A fourth manufacturer and one manufacturers' sales representative did use the term smart pump.

None of the specifying engineers who were interviewed used the term smart pump, but two used "ECM pumps," one used "IntelliPump" (defined as a pump with ECM and internal sensing capabilities), and one used "pumps with packaged VFD."

Most end users and contractors preferred to use the term "high-efficiency pumps," though a few did refer to them as "smart pumps." All responses are summarized in Table 5.

Table 5. Terminology Used by Market Actors to Differentiate Smart Pumps

Manufacturers (n=5)	Manufacturers' Sales Representatives (n=3)	Specifying Engineers (n=5)	Contractors (n=6)	End Users (n=14)
Do not differentiate between smart pumps and high-efficiency pumps (2)	Do not differentiate between smart pumps and high-efficiency pumps (1)	Do not differentiate between smart pumps and high-efficiency pumps (1)	High-efficiency pumps (3)	High-efficiency pumps (9)
Smart pumps (1)	Smart pumps (1)	ECM pumps (2)	Smart pumps (1)	Smart pumps (3)
Integrated pump system or high efficiency pump system (1)	Pump with integrated drive and internal sensors (1)	Pumps with packaged VFD (1)	Smart pumps or Eco pumps (1)	Intelligent pumps (1)
Self-sensing or sensorless pumps (1)		IntelliPump (with internal sensor and ECM) (1)	Pumps with integral speed drive (1)	Packaged system (1)

Source: Market actor interview questions, B2 "[Prior to this interview,] had you heard the term smart pump?", "Is this a term used in your business for a pump that has the above-mentioned characteristics?", "How do you differentiate between high-efficiency pumps and smart pumps?" Survey question D5, "What have you heard [pumps with these characteristics] called?"

Respondents also elaborated on the energy efficiency of pump systems. They said that smart pumps and non-smart pumps achieve energy savings through thoughtful pump specification and installation. Improperly specified (such as oversized pumps) or poorly installed pumps will reduce energy savings.

3.2 Market Growth Discussion

Cadmus asked interviewees about drivers for the smart pump market and their perception of market growth over the next 20 years. Although this information is not used to estimate market growth, the opinions suggest potential drivers of market growth and illustrate the mix of perceptions. Energy efficiency standards, government policy goals, trade associations, building codes, and incentives all impact the growth of the market for smart pumps.

3.2.1 Market Drivers

The DOE energy efficiency standards for pumps will be implemented in 2020 and may increase the adoption of smart pumps by reducing the selection of non-smart pumps that satisfy the pump efficiency standard requirements. The federal standard does not, however, mandate the use of smart pumps. Other federal policy goals toward energy efficiency or reduction in fossil fuel emissions may increase the adoption of smart pumps by encouraging market actors to prioritize energy efficiency. For new construction projects, building codes could also have an impact on growth by requiring smart pump controls capability or energy efficiency that exceeds the 2020 DOE standard.

The following topics highlight responses that reflect market actors' perceptions of the factors affecting smart pump market growth.

Standards

Cadmus found that about 25% of currently available clean water pumps less than 200 HP in size can no longer be sold following a DOE standard scheduled to be implemented in 2020.[3] Two respondents believe the 2020 DOE standard will increase smart pumps' share of the market.

The DOE standard requires all pumps be tested for a pump energy index[4] . To satisfy the standard, the pump energy index must be lower than 1.00. Smart pumps have a greater chance of achieving a low pump energy index than do pumps without variable speed drives. Pump manufacturers must comply with the new standard by January 27, 2020.

Building Codes

Respondents believe building code changes will drive smart pump installations. For example, the Washington building code changes require that, by 2031, new construction be 75% more efficient than the 2006 energy code.

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[3] The pumps are limited to clean water applications only, best efficiency point power input: 1-200 HP, best efficiency point flow rate: 25 gallons per mile or greater, best efficiency point head: 459 feet or less ,Temperature: 14-248 degrees Fahrenheit , Nominal speeds: 1,800 and 3,600 revolutions per minute. Pumps & Systems. "2020 Pump Efficiency, DOE Requirements." https://www.pumpsandsystems.com/2020-pump-efficiency-doe-requirements

[4] Pump Energy Index (PEI) is the ratio of a pump's energy rating divided by the energy rating of a minimally compliant pump. A pump with a PEI greater than 1.00 consumes more energy than is allowed under the DOE's energy conservation standard.

Government Policy Goals

Two specifying engineers said a Washington state goal to reduce emissions by 2030 was a driver of smart pump adoption. Another respondent suggested that this growth will be faster for pumps with higher horsepower because they are more likely to be specified by engineers.

Trade Association Support

One manufacturer said many constituents will support the trade associations, such as Applied Science and Performance Institute and American Society of Heating, Refrigerating and Air-Conditioning Engineers, that offer guidelines for more efficient pumps. Two contractors reported that they consulted resources from the American Society of Plumbing Engineers when researching pump options.

Incentives

One manufacturer indicated that high efficiency pump sales have been greatly facilitated where incentives are present and that the transition to smart pumps could be slow without incentives (or unless driven by state or federal regulation). Other manufacturers echoed the sentiment that incentives play an important role in the market adoption of smart pumps.

3.2.2 Pace of Smart Pump Adoption

Cadmus interviewed market actors about the pace of smart pump adoption beyond 2019. Most of the 11 market actors who commented about the pace of adoption saw the majority of growth happening over the next 10 years. Their opinions were mixed on how much of that growth would occur within the next five years or in the five- to 10-year timeframe.

None of the market actors predicted substantial growth after 20 years. One specifying engineer and one manufacturers' sales representative said smart pump growth will slow after 20 years because by then these pumps will likely become the baseline installation choice.

Several additional comments offer perspectives about factors that could affect the pace of market adoption and are areas that NEEA may want to address. One specifying engineer was skeptical that integrated pump systems will ever capture a large share of C&I pumps since external controls are easier to maintain and replace on higher horsepower systems. One contractor viewed converting constant to variable volume systems as a significant barrier for smart pumps; this was mentioned by several end users. One manufacturer said that it was hard to predict future adoption rates, since the price of electricity is a major motivator for energy efficiency, but future energy prices are unpredictable. One manufacturers' sales representative said pump manufacturers are waiting for ECM manufacturers to partner with them since the pump manufacturers are unlikely to invest in motor technologies.

Six respondents estimated the range of pump sales in the Northwest for new construction and replacement projects. Respondents estimated half or more of C&I pumps up to 50 HP are installed in new construction applications. Conversely, half or more of the retrofit applications are circulator pumps up to 5 HP. Distribution channels for new construction include manufacturers and their sales representatives. Retrofit distribution channels include distributors and wholesalers in addition (Table 6).

Table 6. Estimated Pump Sales by Distribution Channel

Type	Installations	% of Sales Circulator Pumps up to 5 HP	% of Sales C&I Pumps up to 50 HP	Distribution Channels
New	**New construction** *e.g., design build*	25%–50%	50%–75%	Manufacturer direct sales Manufacturers' sales representatives
Existing Replacement	**Component failure** *e.g., replace broken pump*	50%–75%	25%–50%	Manufacturers' sales representatives Distributors Wholesalers
	Updated HVAC system *e.g., replace boiler/chiller plus pump*			
	Redesigned heating system *e.g., reconfigure heating system by adding additional zone*			

Additionally, Cadmus asked end users and contractors about the distribution of pumps they specified or installed by size (n=22). Both groups reported, on average, more than 50% of all pumps installed (new construction and retrofit) were circulator pumps up to 5 HP and about 40% were C&I pumps up to 50 HP.

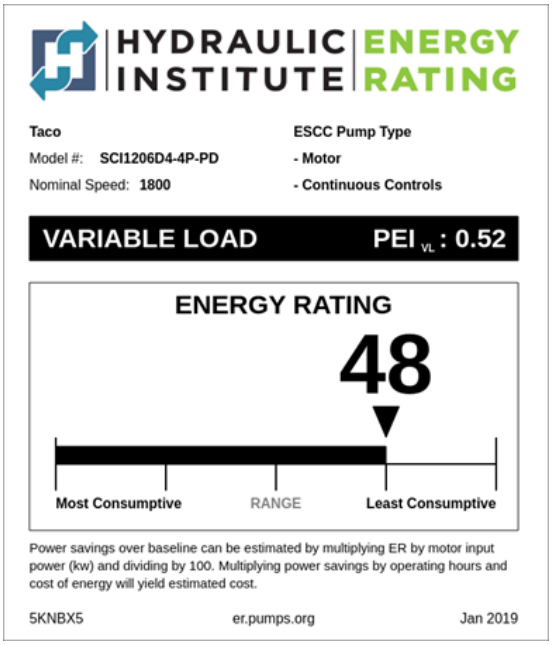
Further, Cadmus asked manufacturers and manufacturer's sales representatives to estimate the percentage of all pump sales that were smart pumps. Smart pumps can be found in the market to varying degrees. Respondents offered a range of estimates, including two who estimated 80% of their sales of circulator pumps up to 5 HP were smart pumps, and one who said 15%. For C&I pumps up to 50 HP, the three estimates were 100%, 15%, and 10%. Therefore, data collected do not support a clear conclusion about the proportion of smart pumps sold, but it does show there is a market for smart pumps.

One manufacturer did not consider that self-sensing pumps were smart pumps and said smart pumps accounted for none of the company's sales. Another manufacturer did not sell smart pumps over 5 HP and instead recommended installing external sensors and drives with the company's pumps. This manufacturer sold these products together about 30% of the time, though customers could also buy drives separately. This same manufacturer estimated that 30% of the circulator pumps up to 5 HP sold were smart pumps. A third manufacturer

estimated that 70% of circulator pumps up to 5 HP and 30% to 35% of the C&I pumps up to 50 HP sold were smart pumps.

3.3 Hydraulic Institute Energy Rating Labeling

The HI representative reported that five large manufacturers participate in the HI ER Label program, with about 2,500 pumps included in the HI database. According to the HI representative, this could reach 5,000 models "as 2020 gets closer." All eight manufacturers and manufacturers' sales representatives interviewed by Cadmus were familiar with the HI ER label, as were seven of 16 end users but only one of six contractors.



Source: Hydraulic Institute

The HI representative said some manufacturers are "waiting to see incentives from utilities before committing" to putting the HI ER label on their smart pump. Additionally, some market actors—two of five manufacturers and one of three manufacturers' sales representatives—said an important aspect of the HI ER label is that it could encourage utilities to provide incentive programs.

Some market actors reported issues with the HI ER label. One manufacturer said it was confusing and could be misleading; e.g. it was his understanding that the pump efficiency is rated at one duty point, which might not be where the pump operates, and that DOE considers only two and four poles. Another manufacturer said the company did not stock or market HI-labeled pumps as it did not see a benefit to doing so. A manufacturers' sales representative started to use the ER label but reported finding its usefulness limited because not enough pumps currently have the label.

3.4 Smart Pump Applications

Cadmus asked manufacturers, manufacturers' sales representatives, and specification engineers which hydronic systems are the most common applications for smart pumps. Manufacturers' sales representatives and specification engineers almost unanimously said smart pumps are primarily used for heating and cooling applications. Manufacturers said smart pumps are slightly more common in heating and water boosting than are chilled water and domestic hot water recirculation applications and that smart pumps are least common in industrial process applications, which often have design characteristics (gallons per minute flow

rate, demand profile) that are better met with external VFDs and unique controls (when necessary) suitable to unique manufacturing needs. Table 7 summarizes these responses.

Table 7. Most Common Applications for Smart Pumps Reported by Market Actors

Market Actor	Domestic Hot Water Recirculation	Heating Systems	Water Boosting	Chilled Water	Process Applications
Manufacturers (n=5)	2	3	4	2	2
Manufacturers' Sales Representatives (n=3)	2	2	2	2	0
Specification Engineers (n=5)	2	2	1	2	0
Total	**6**	**7**	**7**	**6**	**2**

Source: Market actor interview question C8, Which of the following hydronic systems are the most common applications for smart pumps?"

Manufacturers' sales representatives and specification engineers—the market actors with the closest relationship with purchasers and contractors—viewed smart pumps as broadly applicable across all other uses presented, suggesting potential for future market growth initiatives.

When asked to comment on which applications were most conducive to smart pumps, market actors' responses spoke to both circulator pumps up to 5 HP and C&I pumps up to 50 HP:

- Self-sensing pumps are better for projects without a BMS, usually retrofits.
- Self-sensing pumps are also easier to install with a BMS or energy management system (EMS) since there are fewer controls to integrate.
- New construction projects are more likely than retrofits to include variable drives because existing buildings are less likely to have variable drives.
- There are more inquiries about smart pumps for new construction than for retrofits.

Comments about circulator pumps up to 5 HP included these:

- Circulator pumps under 5 HP are appropriate for smart pumps with integrated sensors.
- Constant volume applications are more common for small horsepower pumps, and constant volume applications are less suited to the capabilities of smart pumps.
- The relative price for savings associated with fractional horsepower pumps is higher than for larger smart pumps, therefore upfront cost is more important when deciding to purchase these pumps.

When asked to comment on which applications were most conducive to C&I smart pumps up to 50 HP, market actors' responses included the following:

- Most smart pumps over 5 HP are retrofit installations.
- Since larger horsepower pumps use more energy, efficiency is a more significant consideration in total equipment cost for larger pumps.
- Some market actors recommend external sensors with pumps over 5 HP, rather than self-sensing or internal-sensor pumps.

When asked whether there are complications converting from constant volume systems to variable volume systems that can limit installations, market actors described the system conversion as a minor barrier.

- There are a few specific applications for which constant volume systems are preferred (boilers, chillers, agricultural pumps); these generally operate at the minimum pumping volume required.
- Systems requiring constant volume are more common among pumps that operate at fractional horsepower up to 5 HP
- The conversion is only an issue for retrofits and is usually a "system issue rather than a pump issue."

Of the eight manufacturers and manufacturers' sales representatives asked to estimate the relative share of these types of systems, six estimated that 60% to 90% of new construction installations were variable volume and retrofit pump projects with variable volume ranged from 30% to 60%.

4 Market Actors' Roles, Information, and Product Flow

In 2017, NEEA contracted a preliminary study of the market for efficient C&I pumps and circulator pumps in which they found significant variations in purchasing behavior based on pump size and category.[5] The following year, NEEA developed market actor user profiles[6] describing specific participants in the pump distribution chain and their roles in different pump-use scenarios.

For the current market characterization, Cadmus reviewed the path that information and products flowed through the supply chain to understand each market actor's role, who purchasers worked with, and why they purchased the pumps they chose to install. We asked respondents about the supply chain in general and about new construction and retrofit applications. We identified key points where NEEA could focus its efforts to drive awareness, support purchase decisions, and increase sales of smart pumps.

4.1 Market Actor Roles

Market actors described the pump market in broad terms of distributors and manufacturers' sales representatives working with consultants, engineers, contractors, and end users (facility and building operations managers). The role of each market actor may vary in different scenarios. For example, a contractor, hired to replace a pump, will provide information and recommend pumps to the end users or may simply install the pump that the contractor believes is most appropriate for the application. But if bidding multiple pumps for a new construction project or new process system, that contractor will likely be working from a specification written by a consulting engineer. The contractor will bid the specified pumps or an equal substitution but will not necessarily control the ultimate installation decision because that decision lies with the owner or owner's representative. Each market actor's role is described below as it relates to purchasers as they move through the steps from information gathering to pump purchase.

4.1.1 Market Actors-Information Flow

The information flow for new construction and retrofit applications of efficient pumps begins the same way, with manufacturers and their sales representatives providing the primary sources of information for all others in the sales chain. Increased understanding and acceptance

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[5] Cadeo. *Pumps Market Research-Summary of Findings to Date.* October 2, 2017.

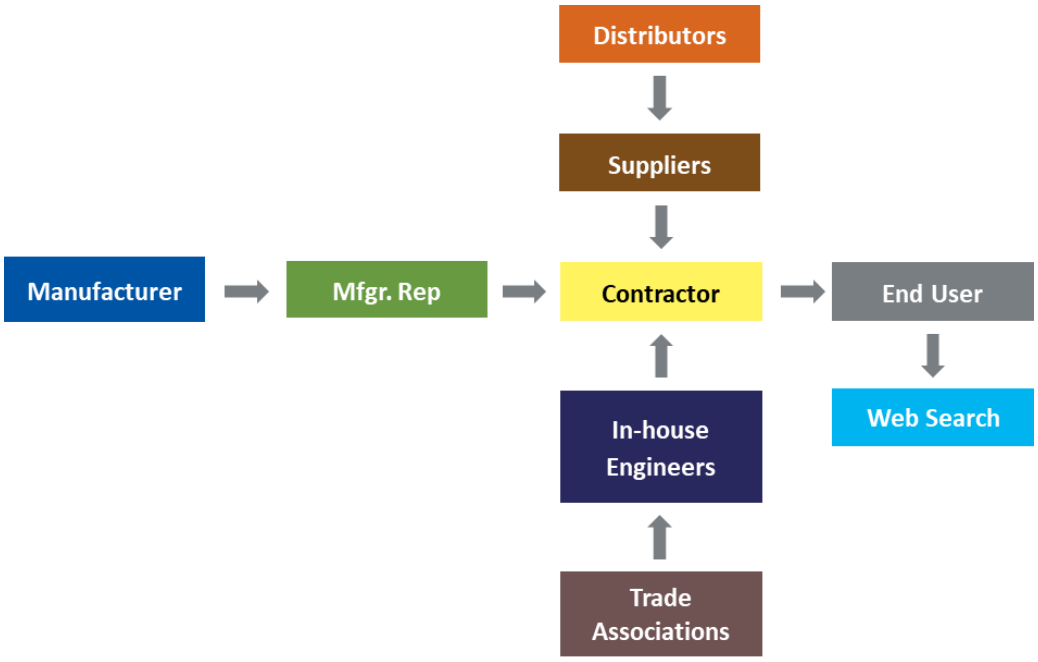
[6] Northwest Energy Efficiency Alliance. *NEEA XMP Pump Market Actor User Profiles-Draft.* PowerPoint presentation dated June 5, 2018.

of smart pumps at this level will flow down through the rest of the supply chain serving both new construction and retrofit projects.

Contractors first look to manufacturers and their sales representatives, then look to engineering staff, suppliers and distributors for information for retrofit and new applications in which they are selecting the pumps. Two contractors also said they turn to the American Society of Plumbing Engineers when researching pump options. As reported above, one manufacturer said many constituents support such trade organizations, so trade organizations are another touchpoint where NEEA could increase support and education about the application and benefits of smart pumps.

End users also first seek information from manufacturers and their sales representatives, and secondly from the internet for both new construction and retrofit projects. End users also said they rely on their contractors for information when purchasing pumps. Figure 1 illustrates the similar information paths and the role contractors play in that flow, both seeking information and extending that information to the end user. Because contractors are another significant market actor in both new construction and retrofit applications, they represent an opportunity where NEEA could accelerate interest in and demand for smart pumps.

Figure 1. Where Contractors and End Users Get Information for New Construction and Retrofit Applications



4.1.2 Market Actors-Product Specification

In some cases, new construction projects may involve an engineering consultant who specifies the pumps. As shown in Figure 2, these specifying engineers work with distributors and

manufacturing representatives (not directly with manufacturers), interact with contractors and, sometimes, with architects. In these scenarios, the specifier will influence the pump selection, but the ultimate decision will typically be made when the contractor bids a project and the owner or owner's representative awards the contract.

Figure 2. Product Specification - New Construction

For retrofit applications (Figure 3), contractors typically recommend pump options to end users, replacing like-with-like. In these scenarios, the contractor is a key decision maker.

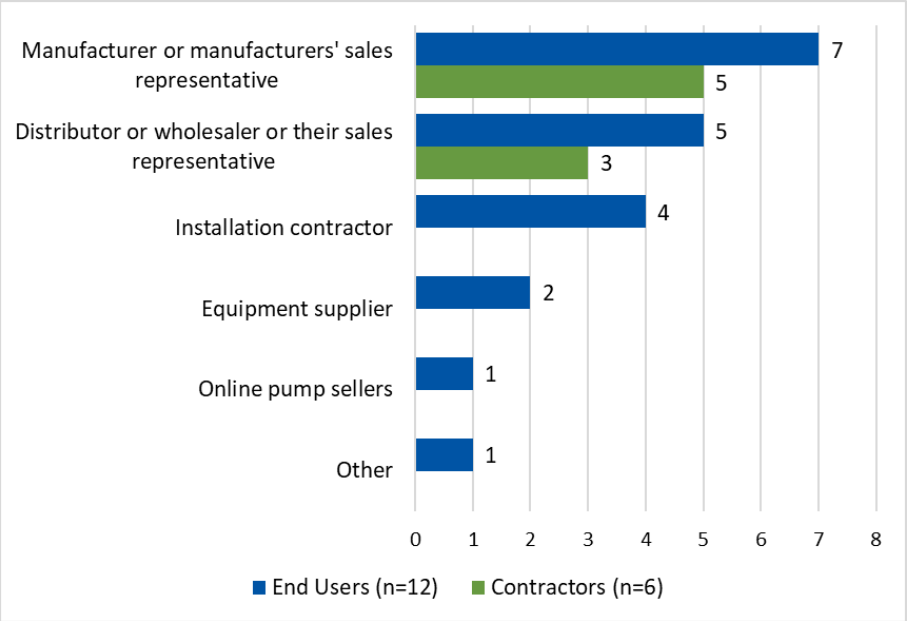
Figure 3. Product Specification-Retrofit Applications

4.1.1 Market Actors-Pump Purchases

Cadmus asked end users and contractors to describe which trade allies they worked with when making a pump purchase. In both new construction (Figure 4) and retrofit applications (Figure 5), end users and contractors both first turned to manufacturers and their sales representatives, then to distributors and wholesalers. End users next turned to installation contractors for assistance, while contractors turned to equipment suppliers.

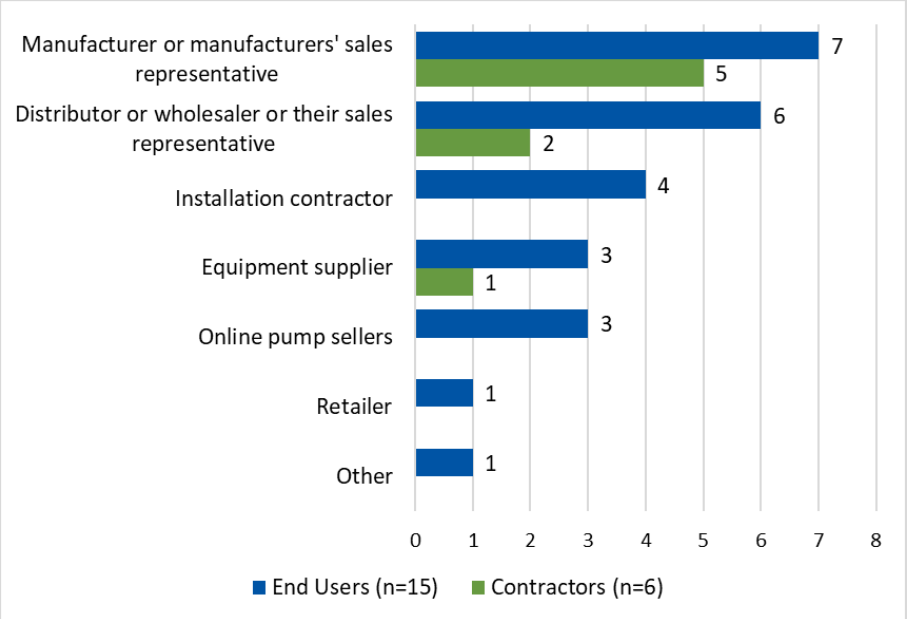
One manufacturers' sales representative reported that "higher horsepower" pumps for C&I projects are usually sold by representatives and rarely through distributors, a finding which supports Cadeo's Pumps Market Research finding from 2017.

Figure 4. Who End Users and Contractors Worked with for Most Recent Clean Water Pump Purchase - New Applications



Source: Survey question B1, "Thinking about the last time you purchased a clean water pump for a new construction application, who did you work with directly for that purchase? Please select all that apply."

Figure 5. Who End Users and Contractors Worked Directly with for Most Recent Clean Water Pump Purchase - Retrofit Applications



Source: Survey question B2, "Thinking about the last time you purchased a clean water pump for a retrofit application, who did you work with directly for that purchase? Please select all that apply."

Online Purchases

End users and contractors often search a distributor's or manufacturer's website for information prior to making a purchase. Of 16 end users, five said they would purchase pumps online, eight would consider it, and three would not buy online. The 13 end users who characterized the pros and cons of purchasing pumps online perceived the benefits to be low price (4 mentions), ease and convenience (3 mentions), and wide selection (1 mention). However, only one end user purchased pumps online. Six end users said lack of support or service or expertise was a reason not to purchase online. Other reasons were compatibility and sizing concerns (5 respondents), difficulty finding a reputable online supplier (2 respondents), or preference of specific vendors (2 respondents).

Contractors were less interested in online pump purchases. Of six contractors, only one would buy pumps online. Four of five contractors cited lack of support or service or expertise, one cited compatibility and sizing concerns, and one cited long shipping times as reasons not to purchase pumps online. One contractor, however, said convenience was a benefit of online purchases.

Summary

Figure 6 provides a summary overview of market actor roles and interactions. The HI, not shown in the table as a market actor, also plays an influential but less direct role in the pump market supply chain through its work developing comprehensive pump standards and as a facilitator for the distribution and exchange of industry knowledge and information among its association of pump industry manufacturers.

Figure 6. Roles of Market Actors Working with Smart Pumps

Manufacturers & Reps	End Users	Contractors	Specifying Engineers
• Key role providing information to all market actors • Inform distribution channel and end users • Often market smart pumps by their application rather than pump characteristics • Hydraulic Institute and Energy Rating Label provide pump efficiency information that manufacturers and reps can promote	Both new construction & retrofit: • Seek information from and work with manufacturers and their reps first • Turn to distributors and wholesalers • Then turn to contractors • Research online and interested in purchasing online (if some concerns addressed) • Large hp C&I more likely direct purchase from manufacturer	• Look to manufacturers, sales reps, suppliers, distributors, and engineering staff for information for new construction and retrofits • Sometimes purchase on behalf of end users • More likely to be involved in retrofits • Less likely to be involved with process applications • Not interested in purchasing pumps online	• More likely to be involved in new construction, but do specify for retrofits • Less likely to be involved with process applications • More likely to be involved with municipal and C&I applications • More likely to work with distributors and manufacturers reps

4.2 Purchase-Making Decision

4.2.1 Purchase Decision-New Construction

Because new construction projects involve a new building or a new process, pumps are one component of a larger project that includes other equipment and upgrades. Thus, the first cost of a pump for new construction may not be the only factor that determines if a smart pump is included. In contrast, contractors selecting pumps for retrofit applications often replace like with like and may not require upgrades or installation of additional equipment besides pumps. New construction projects normally involve outside contractors and engineers, whereas retrofit projects can sometimes be completed by the end user's in-house engineering staff. There tends to be more actors involved in pump specification for new construction projects than retrofits. This is particularly true for C&I pumps up to 50 HP, which are more often purchased from manufacturers and their sales representatives, than for circulator pumps up to 5 HP, which are often bought through wholesalers and suppliers.

4.2.2 Purchase Decision-Existing Facilities

In existing facilities, early failure is the most common reason to purchase pumps, as shown in Figure 7. Pump failure, as opposed to early replacement, is the unplanned termination of pump operation due to equipment malfunction or failure. When a pump needs replacement upon failure, normally the end user or their contractor will contact a manufacturers' sales representative or distributor for a quote on a pump equivalent to the failed pump. This process matches that described in Cadeo's Pumps Market Research memo of 2017, and is similar to the unplanned replacement scenarios described in Opinion Dynamics Corporation's *Commercial High-Performance HVAC Market Characterization* report.[7]

Early replacement involves the planned replacement of pumps prior to pump failure. Opinion Dynamics Corporation's characterization of the market for high-performance HVAC notes that some facilities have a budget cycle for planned capital expenditures including equipment upgrades; such advance planning is more common for facilities that are managed as part of a portfolio of properties rather than free-standing facilities.

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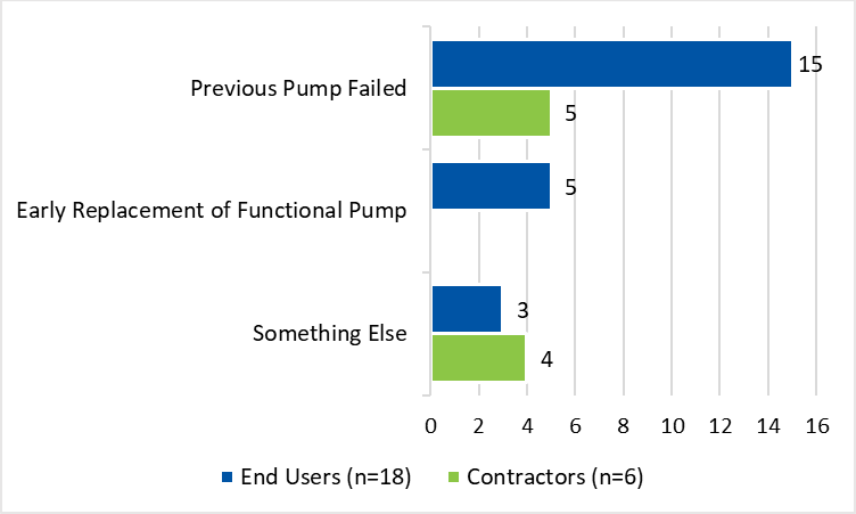
[7] The Opinion Dynamics report characterized the market for high-performance HVAC rather than efficient pumps. The report estimated that 60% of HVAC replacements were unplanned, further broken down into "emergency replacement" upon equipment failure (40% of installations) and "replace it next time it breaks" (system requires maintenance but is reparable; 20% of installations). The other 40% of replacements were planned in advance.
Opinion Dynamics Corporation (McClaren, Focella, and McRae). June 25, 2019. "Commercial High-Performance HVAC Market Characterization." Report for NEEA.

Cadmus' research found that five end users who reported early replacement of pumps cited their motivations for early replacement as improved energy efficiency (four mentions), the previous pumps were nearing the end of their useful life (four mentions), coordinating replacement with production schedules (two mentions), and health and safety concerns (two mentions). Survey results did not indicate major differences between end users who completed early replacements and those who did not.

Figure 7. Triggers for Pump Replacement



Source: Survey question C1, "What typically triggers a pump replacement or purchase?"

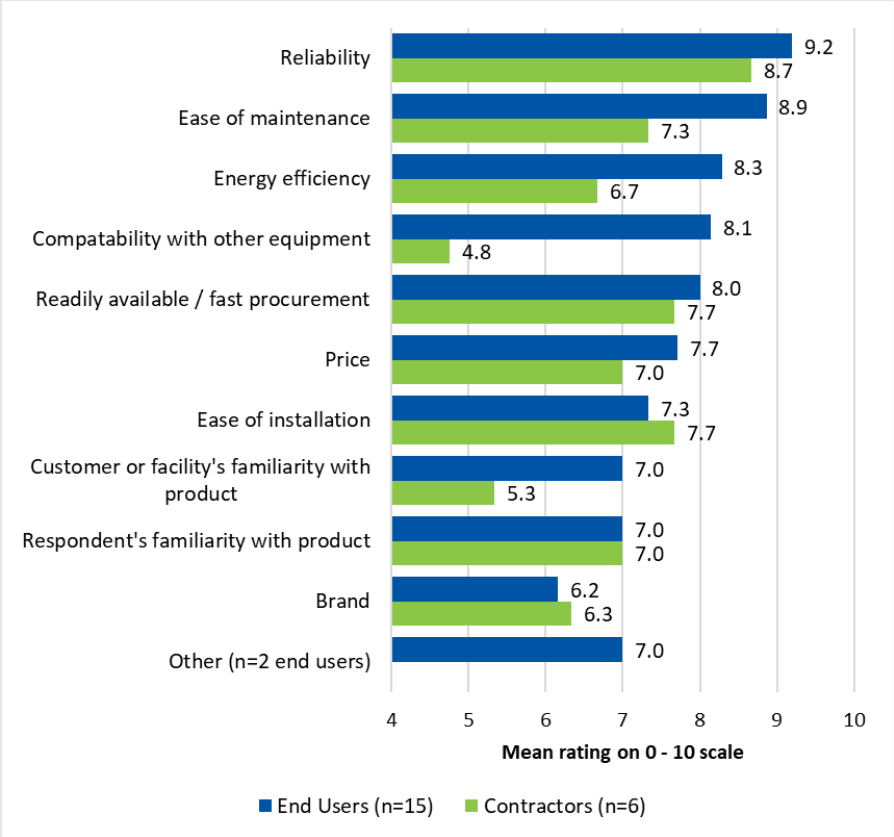
4.2.3 Pump Selection Criteria

On average, surveyed contractors and end users rated reliability (using a scale from 0 to 10) as the most important factor in selecting C&I pumps up to 50 HP and circulator pumps up to 5 HP (Figure 8 and Figure 9). Following reliability, contractors and end users' average ratings of the importance of each factor diverged based on pump size. However, both end users and contractors gave higher average ratings for the importance of compatibility with other equipment for larger pumps than circulator pumps. Contractors also gave higher ratings on average for the importance of energy efficiency for larger pumps (7.7) than for circulator pumps (6.7), while end users rated energy efficiency with about equal importance, on average, for both pump sizes.

Circulator pumps up to 5 HP. When selecting circulator pumps, end users' average next most important factors, after reliability, included ease of maintenance, energy efficiency, and compatibility with other equipment (Figure 8). However, contractors rated these items as less important—particularly compatibility with other equipment (8.1 average rating for end users, but 4.8 average rating for contractors). Price, while rated 7.7 on average by end users and 7.0 on average by contractors, was slightly less important to both purchasers than availability of

product. The only items that contractors rated, on average, equal to or higher than end users' ratings were ease of installation, brand, and familiarity with the product.

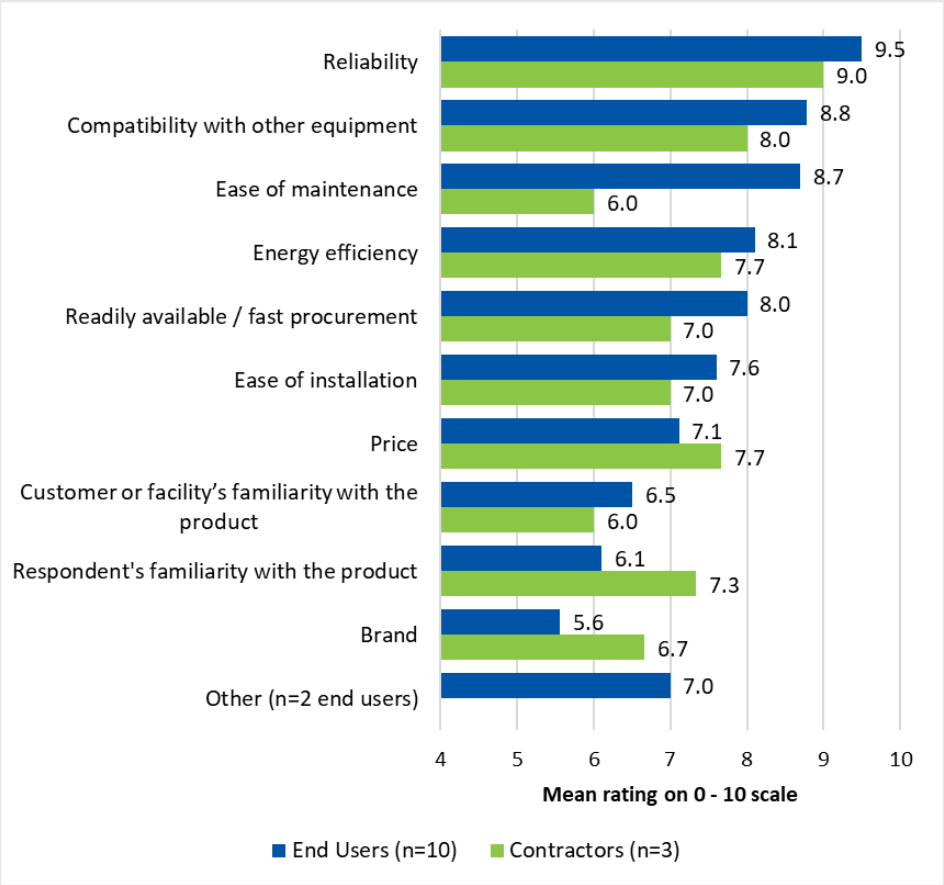
Figure 8. Circulator Pumps up to 5 HP: Importance of Factors in Selection, Recommendation, Specification, or Purchase



Source: Survey question C8, "On a scale of 0 to 10, where 0 means *not important at all*, and 10 means *very important*, please rate the importance of each item in your selection, recommendation, specification, or purchasing of circulator pumps up to 5 HP."

Clean water pumps up to 50 HP. As with circulator pumps, when selecting C&I clean water pumps, end users' average next three most important factors following reliability were ease of maintenance, energy efficiency, and compatibility with other equipment. On average, contractors also rated compatibility highly (8.0), followed closely by energy efficiency and price (both rated 7.7). While contractors again rated brand and familiarity with the product more highly, on average, than end users, they were also somewhat more price sensitive than end users (rating price at 7.7 versus 7.1).

Figure 9. Commercial and Industrial Clean Water Pumps up to 50 HP: Importance of Factors in Selection, Recommendation, Specification, or Purchase



Source: Survey question C10, "On a scale of 0 to 10, where 0 means *not important at all* and 10 means *very important*, please rate the importance of each item in your selection, recommendation, specification, or purchasing commercial and industrial clean water pumps up to 50 HP."

4.3 Choosing Smart Pumps

End users and contractors who had previously specified or installed smart pumps were asked about their reasons for choosing a smart pump option. Seven of nine end users reported smart pumps were more energy efficient. Three end users stated the smart pump was the best fit for the application. Two cited the benefits of requiring less maintenance and having a greater life expectancy.

No single reason for specifying or installing smart pumps dominated for the five contractors. Two stated the smart pump was the most efficient option, two stated it was the best fit for the application, and two mentioned the benefits of easier integration with control systems.

End users and contractors who had not previously specified or installed smart pumps for retrofit applications were asked why they did not. The most common reason was that pumps are replaced with a similar pump (e.g., a single speed pump with a single speed pump). One

respondent said, "Usually we use direct OEM [original equipment manufacturer] replacement."[8]

Other reasons smart pumps were not chosen for retrofit applications were lack of opportunity, cost of the equipment, and a preference for a customized rather than packaged pump system. For example, one respondent said, "We will typically design our own system with a VFD and pressure switches for efficiency."

Similarly, end users and contractors who had not previously specified or installed smart pumps for new applications cited a lack of opportunity (e.g., no new construction or applicable new applications). One stated that the contractor specified the pump. One contractor perceived smart pumps as expensive and more complex than the projects require. End users and contractors preferred customized systems. One respondent said, "Typically, we want consistency of variable speed drives throughout the project. We therefore choose to marry the drives up ourselves. Also, we have controls people on board who will handle the various modes of operation."

Three respondents expressed concerns about the magnets in the ECM leading to erosion (ferrous buildup) and potentially compromising reliability or leading to maintenance. One suggested educating users "that fatigue due to magnet deterioration in ECMs is not common and how to avoid it."

4.4 Benefits and Value Propositions

NEEA noted that smart pumps provide unique benefits not shared by non-smart pumps. They self-optimize to meet user requirements, adapt to changes in the building without needing to be reprogrammed, reduce installation costs and complexity, and encourage long-lasting performance of the VFD controls, by reducing the likelihood that a wall-mounted VFD will become ineffective. For the contractor or end user, smart pumps are easy to install and set up, offer reliability, and have a better ROI compared to pumps that are not smart.[9]

Through the interviews with market actors, Cadmus explored market actors' perceptions of the benefits and value proposition of smart pumps. Respondents reported that many of their

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[8] Direct OEM always exists, or an updated replacement model is available. Some manufacturers provide direct model equivalencies to other manufacturer models within their specification literature. For example, a Grundfos model XYZ is a direct replacement for Taco model XYZ. Grundfos dedicates 16 pages of model reference tables for competitor models in its UP pump series data booklet. Grundfos. "UP Series: Circulator pumps 60 Hz." https://www.ecomfort.com/manuals/UPGuide.pdf

[9] Various discussions between NEEA and Cadmus.

customers have limited understanding of the benefits of smart pumps. In cases where energy efficiency is prioritized, end users usually ask for the "highest efficiency option" rather than making a specific request for smart pumps. Respondents said the value propositions that typically drive customers to purchase smart pumps include these:

- Energy savings and integration with control functions (self-sensing pumps, variable speed, integration with EMS/BMS)
- Lower installation costs because there is less wiring and fewer controls to install
- Ease in setup with an intuitive control interface
- Improved maintenance (using the EMS/BMS connectivity to know when a pump is malfunctioning)

Market actors cited the following benefits of self-sensing pumps:

- Operate at higher efficiency and reliability levels
- Reduce run times stemming from more efficient operation
- Easily integrate with EMS/BMS
- Able to self-regulate without EMS/BMS

One respondent stated that realizing the full benefits of smart pumps requires an interface that informs maintenance staff of tasks to be completed (i.e., there needs to be a way to easily interpret data from the pump). Others highlighted the pumps' ease of installation, set up, use, and maintenance—in addition to energy efficiency—as the differentiating features for smart pumps. Three of the five specification engineers and all three manufacturers' sales representatives mentioned saving on installation costs because not as many supporting controls, sensors, valves, and wiring are needed with smart pumps.

Smart pumps provide the user with control strategy options, but the integrated programming code is not visible and cannot be modified or troubleshooted if a problem arises. Some purchasers resist choosing smart pumps as some pump components or programming are "black box" and proprietary. Two of the five specification engineers said end users preferred systems with components that can be more easily adjusted and replaced. One of the three manufacturer's sales representative suggested that drives in packaged systems are sometimes inferior to drives that can be installed separately.

4.5 Recognized Manufacturers and Distributors

All interviewed market actors were asked which manufacturers offer smart pumps. Respondents mentioned Grundfos (and subsidiary brands such as Paco), Bell and Gossett (a subsidiary of Xylem), Taco, and Armstrong as the major manufacturers of smart pumps. One also mentioned German pump manufacturer Wilo. Respondents differed on their perceptions

of which manufacturers were the most dominant in the smart pump space, and all four of the major manufacturers were perceived as leaders in the field.

Market actors reported that key distributors of circulator pumps include Ferguson (mentioned most frequently as a major distributor), Hijoka, CHC Hydro, Gritton and Associates, Keller Supply, Pacific Plumbing Supply, Consolidated Supply, Columbia Hydronics, Proctor Sales. C&I pump distributors include Columbia Hydronics, Johnson Barrow, Hurley (Grundfos), CHC Hydro, Mechanical Sales, and Proctor Sales. Cadmus did not collect data to characterize the geographic focus or size of these companies.

Purchasers reported that equipment suppliers include ABB Group, Cascade Machine & Electric, Davis & Shirtliff, Flynt & Walling, Grainger, Motion Industries, Bering Engineering, Hurley Engineering, Thomas & Associates, Knorr Systems, Lincoln Aquatics, and Pacific Coast Well & Pump. Cadmus did not collect data to characterize the geographic focus or size of these companies.

Contractors reported that equipment suppliers include Columbia Hydronics, Cole Industrial, Johnson-Barrow, Liberty, Grundfos, and “local distributors.” Cadmus did not collect data to characterize the geographic focus or size of these companies.

5 Logic Model and Barriers Research

NEEA developed a program theory and logic model for its XMP Initiative. As NEEA implements the Initiative's activities, it is testing the program theory as represented in the logic model, assessing hypothesized barriers for each of the market actors, and seeking to understand which barriers are the most intransigent, along with the best way to mitigate the barriers. Additionally, NEEA wishes to identify the salient leverage points that could further the Initiative.

Cadmus designed its research to examine barriers, activities that address them, and anticipated outcomes identified in NEEA's logic model. The barriers research is summarized below.

Section *5.1 Supply- and Demand-Side Barriers Assessment* discusses the supply- and demand-side barriers identified through primary research. We asked pump purchaser survey respondents to rate the top five barriers they encounter when selecting and purchasing smart pumps. The most common barriers are summarized in Table 8 and Table 9. Each table notes whether the barriers mentioned by market actors were shown in NEEA's logic model. Cadmus also asked market actors to describe barriers that could hinder the adoption of smart pumps and where in the supply chain they occur. We also asked about specific items from a list of potential barriers when interviewees did not mention these barriers unprompted. Findings of this barriers research are summarized in Table 10 and Table 11.

Section *5.2 Barriers Assessment* discusses findings from Cadmus' barriers assessments. First, Cadmus applies its findings in relation to NEEA's current logic model. Second, we discuss the research-identified barriers in addition to those in NEEA's current logic model. We summarize the implications of the findings of the barriers assessments in Section *5 Logic Model and Barriers Research*.

5.1 Supply- and Demand-Side Barriers Assessment

Cadmus asked pump purchasers to identify their top five perceived barriers to the selection or purchase of smart pumps. The most frequent responses from 15 end users who answered this question are listed in Table 8. No single barrier dominated for this group, but most mentioned upfront equipment cost and converting constant volume to variable volume systems.

Table 8. Most Frequent Barriers to Selection and Purchase of Smart Pumps Perceived by 15 End Users

Barriers	Number of Mentions	Logic Model Barrier	Included in NEEA's Logic Model
Upfront cost of equipment	8	Demand-side inertia	Pump buyer/specifier select on low first cost with minimal calculations
Lack of information about energy-saving benefits of smart pumps	6	Supply-side inertia	Distributor stocking and marketing practices do not promote or see strategic value of efficient pumps and systems
		Demand-side inertia	Pump buyer/specifier select on low first cost with minimal calculations
		Demand-side inertia	Pump buyer lack of awareness on how to identify efficient pump systems
Facility has other priorities for capital investments	6	Demand-side inertia	Pump buyer/specifier select on low first cost with minimal calculations
Difficulty converting constant volume systems to variable volume systems	8	Not Included	--
Controls, reliability, and maintenance concerns	6	Not Included	--
Lack of staff experience or training on use and maintenance of smart pumps	6	Not Included	--

Shown in Table 9, five of the six contractors surveyed mentioned concerns about controls, reliability, and maintenance as top barriers. Four mentioned the upfront cost of the equipment.

Table 9. Most Frequent Barriers to Selection and Purchase of Smart Pumps Perceived by Six Contractors

Barriers	Number of Mentions	Logic Model Barrier	Included in NEEA's Logic Model
Upfront cost of equipment	4	Demand-side inertia	Pump buyer/specifier select on low first cost with minimal calculations
Lack of information about energy-saving benefits of smart pumps	2	Supply-side inertia	Distributor stocking and marketing practices do not promote or see strategic value of efficient pumps and systems
		Demand-side inertia	Pump buyer/specifier select on low first cost with minimal calculations
		Demand-side inertia	Pump buyer lack of awareness on how to identify efficient pump systems
Controls, reliability, and maintenance concerns	5	Not Included	--
Not compatible with previously installed systems	3	Not Included	--
Lack of experience or training on installation of smart pumps	2	Not Included	--

In Table 10 (Supply-Side Barriers) and Table 11 (Demand-Side Barriers), we summarize the supply-side and demand-side barriers discussed across all interviews and surveys. The Barrier column lists the categories described by respondents. Under each of the next column headings

for market actors (Manufacturer, Manufacturers' Sales Rep., etc.) is a detailed description of the barrier described by the market actor listed in the table column headings. Market actors comment about their perception of barriers as it applies to themselves and to other market actors.

Additional tables, Table C-1 and Table C-2 in *Appendix C,* summarize comments about the barriers ascribed to the market actors by the respondents, both when the respondents described themselves and when describing other actors. The tables in *Appendix C* do not show which market actors made the comments.

Table 10. Supply-Side Barriers Associated with each Market Actor and Purchaser Role

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors
Suppliers unfamiliar with smart pump options	Manufacturers and distributors do not provide purchasers with data for ROI calculations (Interview F1)		Can be difficult to get pump specs from manufacturers and distributors (Interview F1)	Perceived lack of benefits from smart pump features, perception that smart pumps are complicated to install (Survey D11, D12)
Suppliers offer alternative solutions to smart pumps	Contractors focus on providing solutions and systems rather than individual pieces of equipment; packaged systems are not as readily available as adding a VFD to a non-smart pump (Interview B4, C6)	A packaged system with substandard VFD is inferior to installing the VFD separately; contractors look for low price solutions, particularly for retrofits, and smart pumps are usually not the lowest price; stocking pumps of every possible voltage is impractical, which limits availability of smart pumps for unplanned replacement (Interview B4, B6, F1)	Contractors may claim greater savings for non-smart pumps because they are not including all of the cost benefits of smart pumps (including installing fewer controls); contractors can bring down costs by specifying lower efficiency pumps that meet end user requirements; smart pumps compete with other pump control strategies (customized approaches); pumping systems can involve bids from multiple trades with differing priorities (Interview C18, E2, F1)	Prefer a customized system design to a packaged system, or a familiar system to learning about new equipment (Survey D11, D12)
Suppliers do not agree on a common definition of smart pumps as a packaged system with integrated controls	Some manufacturers do not differentiate between "smart pumps" and "high efficiency pumps"; most do not use the term "smart pumps" (Interview B1, B2)	Some representatives do not differentiate between "smart pumps" and "high efficiency pumps"; most do not use the term "smart pumps" (Interview B1, B2)	Most engineers refer to smart pumps as "pumps with ECM" or "pumps with VFD" (Interview B1, B2)	Most contractors and end users use the term "high efficiency pump" rather than "smart pump" (Survey D5)

Table 11. Demand-Side Barriers Associated with each Market Actor and Purchaser Role

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors	End Users
New smart pumps may not be the best fit with purchasers' energy efficiency goals		End users ask for the "highest efficiency option" and rely on contractors to select the best option (Interview B4)	Maximizing energy savings from upgrades is not always a priority for end users (Interview C13, F1)	Energy efficiency is less of a priority for contractors than end users (Survey C8, C10)	Limited awareness of the energy-saving benefits of smart pumps (Survey F1)
Purchasers have limited awareness of non-energy benefits of smart pumps	Commercial end users are less familiar with smart pumps (Interview B4)		Purchasers have limited awareness of non-energy benefits of smart pumps (Interview F1)	Limited awareness of non-energy benefits of smart pumps (Survey E1)	Limited awareness of non-energy benefits of smart pumps (Survey E1)
New smart pumps are not the best fit with requirements of the purchasers' application	Smart pump savings in energy usage and maintenance (down time) are dependent on the pump application (Interview D2)		Pumps 5 HP and below can run at constant volume and do not require variable flow smart pumps (Interview C12)	Limited awareness of appropriate applications for smart pumps (Survey E1)	Prefer a customized system design to a packaged system (Survey D11, D12)
New smart pumps may not integrate with purchasers' existing systems	Smart pump installation may require new pipes and related equipment; end users are concerned about integrating smart pumps with BMS (Interview B6)	Smart pump installation may require new pipes and related equipment; smart pumps are more beneficial for buildings without BMS because they are self-sensing (Interview B6)		End user system requirements are not compatible with smart pumps (Survey F2)	Concerns about converting constant volume system to variable volume and compatibility with existing equipment (Survey F1)
Purchasers lack the infrastructure (e.g., trained staff) required to take advantage of smart pump benefits	End users and their maintenance staff may not have the time or training to utilize smart pumps to their full potential (Interview B6)	End users may not have the staff or equipment to monitor pump systems (not aware of how current pump operates or how a smart pump would be different); end users may not allow monitoring of equipment over the Internet, may not be comfortable with or capable of using "smart" technology (Interview B6, F1)	End users and maintenance contractors may not be comfortable with packaged systems, they may not have staff time and expertise to take advantage of smart pumps (Interview B6)	Taking advantage of smart pump benefits would require additional infrastructure (Survey E1)	Taking advantage of smart pump benefits would require additional infrastructure (Survey E1)

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors	End Users
Equipment cost is a barrier	Until demand is greater, packaged systems will be more expensive due to economies of scale (interview B6, F1)	Until demand is greater, packaged systems will be more expensive due to economies of scale; contractors look for low price solutions, particularly for retrofits (Interview B4, B6, F1)	Smart pumps are more expensive due to including ECM; contractors may not be aware that higher cost of smart pumps can be offset by savings from the system requiring fewer controls (Interview C18, F1)	Higher cost of smart pumps relative to other pumps (Survey E1, F2)	Higher cost of smart pumps relative to other pumps (Survey E1, F1)
Capital investment priorities are a barrier	End users will prioritize upgrades that have the most energy-saving potential, which may not be pumps (Interview F1)	Without incentives or an "energy champion", engineers and contractors are unlikely to specify more expensive pumps for retrofit projects (Interview F1)			Limited capital investment budgets and competing priorities (Survey F1)
Purchasers have payback requirements (ROI)	End users need to see payback on their investment within a reasonable period; ROI can be difficult to calculate for new technologies; circulator pumps may generate less energy savings relative to upfront cost; manufacturers and distributors do not provide purchasers with data for ROI calculations (Interview B6, F1)	Contractors look for low price solutions, particularly for retrofits (Interview B4)	Contractors may claim greater savings for non-smart pumps because they are not including all the cost benefits of smart pumps, or are not aware of the energy savings of smart pumps (Interview F1)		
Purchasers' requirements for reliability and maintenance	Pumps without ECM have a longer life expectancy; contractors have concerns about ferrous build up from magnets (Interview B6, F1)	End users and contractors lack training and experience on the use and maintenance of smart pumps; concerns about ferrous build up from magnets (Interview F1)	Concerns about ferrous build up from magnets; maintenance savings are greater for larger horsepower pumps (Interview B6, D1)	Need to minimize repair costs and downtime for customers. (Survey F1)	Concerns about controls, reliability and maintenance and staff's lack of experience and training on smart pumps (Survey F1)

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors	End Users
Smart pumps are proprietary systems		A packaged system with substandard VFD is inferior to installing the VFD separately (Interview B6)	Proprietary controls may not be easily adjustable by the end user; non-proprietary systems are easier to maintain and to integrate with BMS (Interview D2, F1)		
Lack of experience and training on installation of smart pumps	Smart pumps require more set up during installation; contractors may lack knowledge on installation requirements; installations may take longer to complete (Interview D2, F1)	Smart pump installation may require additional contractors for control systems (Interview F1)		Prefer a familiar system to learning about new equipment. Perceive smart pumps are complicated to install (Survey D11, D12)	

5.2 Barriers Assessment

This section of the report summarizes Cadmus' research findings as they inform NEEA's logic model. Additional discussions of the implications of barriers research for the logic model is included in Section *5.2 Barriers Assessment*, including suggestions for a limited number of modifications and updates to the logic model.

5.2.1 Logic Model Barriers Assessment

Cadmus compared its research results describing market actor roles and profiles of smart pump users to NEEA's detailed and thorough User Profile PowerPoint. The Profile commented on users' "unfamiliarity with the equipment." Cadmus' research respondents identified reliability, expressed concerns about controls and the "black box" of packaged systems, commented about the deterioration of and buildup of ferrous materials from rare earth magnets, and discussed lack of opportunity to install smart pump. Respondents also mentioned some concern about constant flow and variable flow systems. These comments could be categorized under "unfamiliarity with the equipment."

Cadmus' review of NEEA's XMP Initiative logic model found that it is detailed and well thought out. Primary research confirmed the barriers NEEA listed.

Supply-Side Inertia

Barriers creating supply-side inertia shown in NEEA's logic model include the following:

- Distributor stocking and marketing do not promote or see strategic value of efficient pumps and systems
- Distributors are not interested in a lengthy incentive process
- Lack of full category data of pumps sold through distribution

Promoting strategic value of efficient pumps and systems. While manufacturers appear to be familiar with smart pumps, there is not a single, cohesive definition used to market smart pumps and build familiarity across supply- and demand-side market actors. Some manufacturers recommend custom systems rather than off-the-shelf smart pumps. Manufacturers may prefer selling customized systems to keeping multiple voltages and configurations of packaged pump systems in stock. Additionally, suppliers recommend familiar customized systems over packaged systems where smart pumps could work in both retrofit and new applications, and they replaced like for like or used OEM replacements for retrofit applications. Some supply-side market actors perceive the pumps to be costly or that their clients are cost-conscious so propose alternatives to smart pumps. They also perceive that data are not provided to purchasers to compute ROI. Market actors noted a lack of familiarity and experience installing smart pumps and their controls. Taken together, these factors (and others discussed elsewhere in this report)

demonstrate suppliers may not fully understand the strategic value, applications, and opportunities for smart pumps, which ultimately leads to a lack of awareness of and marketing for smart pumps.

Incentive structures and processes. NEEA hypothesized that distributors are not interested in a long or drawn-out incentive process, hence the incentive payment structure could be a supply-side barrier. To address this potential barrier, this Initiative plans to offer midstream incentives to distributors who could in turn pass the incentives to buyers at point of sale. Midstream programs can be designed for efficient incentive payment from NEEA or utilities to distributors. Cadmus did not speak directly to distributors to ascertain their interest in midstream incentives for smart pumps. Our experience with other commercial midstream programs and interviews with participating distributors supports NEEA's hypothesis that distributors will be more amenable to a streamlined process.

While Cadmus' surveys and interviews for this research did not delve deeply into incentive structures, manufacturers commented on the important role incentives play. One manufacturer stated, "NEEA and utility incentives are a critical piece for market adoption of smart pumps." Another stated, "Rebates have to be consistent, long term, and dependable so that it becomes part of a contractor's business. Pay distributors and wholesalers to work through the paperwork, [do not require] mail-in rebates." Another manufacturer estimated that the majority of their high efficiency pump sales occur in four states with aggressive incentive programs. One manufacturer suggested that incentives for retrofits should be prioritized over new construction.

Lack of pump data sold through distributors. NEEA's logic model suggests that lacking complete data about this category of pumps could hinder breaking supply-side inertia and slow adoption of this technology. Lacking a robust compilation of sales data for this category of pumps contributes to difficulty estimating the market size and estimating trends in sales, technology adoption and market penetration, and gauging market response to the Initiative. The inability to identify applicable pumps of interest and educate the market about the full category of smart pumps could potentially slow market response.

Demand-Side Inertia

In its logic model, NEEA hypothesized barriers to demand-side inertia included:

- Pump buyers and specifiers select on low first cost and simplified payback calculations
- Pump buyer lack of awareness of how to identify efficient pump systems
- Pump buyers may not be interested in lengthy incentive processes
- Split incentives challenge the purchasing process

Low first cost and minimal calculations. Cadmus' research confirmed that pump buyers and specifiers consider equipment cost and ROI in their purchase decisions. Manufacturers' sales representatives and specifiers perceived contractors might look for low price solutions or might not know that higher cost smart pumps could be offset by savings resulting from fewer controls. While contractors perceive their customers are cost-conscious, which may lead them to offer alternatives, end users noted that reliability—not price—was the most important factor in decisions to purchase pumps. Research confirmed buyers have limited awareness of energy saving and non-energy benefits of smart pumps. Educating all market actors about the costs, values, and benefits of smart pumps is needed to promote smart pump installations. Including the benefits such as reliability—minimized repair costs and equipment downtime—along with other smart pump values and benefits could be included in ROI calculations. Cost-based market resistance to smart pumps by some purchasers and contractors may be reduced if they can easily identify which applications will be cost-effective and consider the comparatively lower installation and reduced maintenance costs, that is, the life-cycle costs.

Lack of awareness. Manufacturers' representatives noted that end users may request the "highest efficiency" option or solutions when replacing a pump system because they lack information to identify smart pump systems. End users have limited awareness of the energy-saving benefits and the non-energy benefits of smart pumps. Manufacturers noted that, while commercial end users are less familiar with smart pumps, contractors are also unfamiliar with smart pumps, have limited knowledge of appropriate applications for smart pumps, and perceive they are complicated to install. Using consistent language to describe the characteristics of smart pumps, offering a catalog of smart pumps, and utilizing energy rating labels and other tools to broadly educate consumers about smart pumps and their applications will reduce barriers and help to facilitate market adoption.

Incentive structures and processes. While this research did not examine preferences for incentive structures and processes, one specifying engineer suggested that *"*Incentives for these pumps would make them easier to find. It could be similar to an online catalog with performance specs across manufacturers." This comment also supports the hypothesis that buyers do not know how to identify smart pumps and that a catalog of smart pumps and the HI ER label will be useful information for consumers.

Split incentives. NEEA's logic model hypothesizes that split incentives may be a demand-side barrier by challenging the purchasing process. That is, when one entity pays for capital improvements and another pays for energy, capital improvements that increase efficiency may not be prioritized. Cadmus' interview respondents did not mention split incentives.

Leverage Opportunities

NEEA's logic model notes that the XMP Initiative has an opportunity to take advantage of the rule-making of DOE, the Regional Technical Forum, and the HI ER label. For example, the HI's work in establishing the HI Energy Rating labeling database and efforts to build recognition and increase use are ongoing. This is important, as survey respondents noted the HI ER label is being used by some manufacturers and end users and has potential for distinguishing high efficiency pumps (possibly qualifying for incentives). However, none of the contractors and specifying engineers interviewed currently use the label, possibly because contractors require detailed pump specifications to identify applicable pumps. End users were more likely than contractors to use the labels to inform their purchase decisions.

5.2.2 Research-Identified Barriers Assessment

Through its primary research, Cadmus identified supply-side and demand-side barriers in addition to those shown in NEEA's logic model. We suggest adding items to the existing logic model. The research-identified barriers are shown in Table 10 and Table 11 and in the companion tables in *Appendix C*. Section *5.2.3 Implications for the Logic Model* below discusses suggested modifications to NEEA's logic model in more detail.

Supply-Side Inertia. Research-identified supply-side barriers include lack of familiarity, experience, or opportunity limits the smart pump market; preference for familiar and customized pump solutions limits consideration of smart pumps as an option; lack of a simple common definition or description of smart pumps limits marketability. Table 10 demonstrates the need for education and expanding dialogue among market actors. For example, manufacturers perceived that purchasers are not provided with data needed for ROI calculations, contractors don't perceive the benefits of smart pump features and feel they are difficult to install, and specification engineers find it difficult to get pump specifications from manufacturers and distributors. Offering familiar systems rather than packaged smart pumps occurs for many reasons, noted by each of the supply-side market actors. Noted above, the lack of a cohesive definition limits the ability to market smart pumps and build familiarity across supply- and demand-side market actors.

Demand-Side Inertia. Research-identified demand-side barriers include limited awareness and understanding of non-energy benefits and life-cycle costs reduces adoption; installers' and end users' lack of training, experience, and infrastructure (such as management systems and available staff) limits opportunities to take advantage of smart pump benefits; uncertainties about smart pump reliability, maintenance and the "black box" and proprietary nature of packaged systems limits adoption. Table 11 provides examples of each of these barriers.

5.2.3 Implications for the Logic Model

Using insights discussed throughout this report, Cadmus identified additional barriers and modifications that could be made to NEEA's logic model. We annotated NEEA's XMP Initiative logic model to indicate additional text for existing boxes and new boxes, shown in Figure 10. The **letter inside each box** corresponds to discussion outlined below.

A **solid red triangle** in the upper right corner of an activities or outputs text box indicates an important leverage point where NEEA may put additional attention to move the market, as identified in this research. Supported by this research and comments from respondents, Cadmus identified four particularly salient activities which NEEA could leverage in its activities to transform the market for smart pumps. These include: developing strong relationships, developing and delivering training and awareness campaigns, developing a strong marketing toolkit including an ROI calculator, and, establishing the savings validation and verification methods and tools.

Red arrows between boxes indicate additional relationships between items.

Box A. Supply-Side Inertia. Cadmus identified additional supply-side barriers, noted in Table 10 and C-1, and suggests adding these to the supply-side inertia box. These include lack of familiarity, experience, or opportunity limits the smart pump market; preference for familiar and customized pump solutions limits consideration of smart pumps as an option; lack of a simple common definition or description of smart pumps limits marketability.

Box B. Demand-Side Inertia. Cadmus identified additional demand-side barriers, noted in Table 11 and C-2, and suggests adding these to the demand-side inertia box. These include limited awareness and understanding of non-energy benefits and life-cycle costs reduces adoption; installers' and end users' lack of training, experience, and infrastructure (such as management systems and available staff) limits opportunities to take advantage of smart pump benefits; uncertainties about smart pump reliability, maintenance and the "black box" and proprietary nature of packaged systems limits adoption.

NEEA's Role: Activities and Outputs. Cadmus' research supports the logic model activities and outputs shown under NEEA's Role. In addition to those listed, we offer the following, labeled as Box C, D, and E, and suggest edits to Box F. We added arrows from Box G and I.

Box C. Activities. Because market actors are familiar with smart pumps, but have limited experience with them, they questioned smart pump reliability and ease of maintenance. This is an area where NEEA can demonstrate these factors. We suggest adding an activity: "Conduct research to validate and demonstrate reliability and ease of maintenance." The arrow from Box B drops to Box C.

Box D. Activities. Market actors seek alternatives to smart pumps because they have limited experience and familiarity with specific applications where smart pumps are appropriate. Several manufacturers and their sales representatives stated that they market pumps by their application rather than characteristics of the pump. We suggest adding an activity to demonstrate applications: "Conduct case studies that demonstrate smart pump applications. Provide incentives to business for participation in the case study." An arrow from Box B drops to Box D. An arrow from Box D drops to Box H.

Box E. Activities. Market actors require an easy way to determine whether their application, for the specified horsepower, is a cost-effective investment. NEEA is beginning to develop a calculator tool to demonstrate smart pump cost-effectiveness, life-cycle costs, and ROI. This will be a useful tool to identify applications where smart pumps are appropriate. We suggest adding an activity: "Develop a tool to demonstrate smart pump cost-effectiveness." An arrow from Box B drops to Box E. An arrow from Box E drops to Box I.

Box F. Activities. We found that all market actors along the supply chain could benefit from education and training about various aspects of smart pumps. Education will raise understanding, increase trust, and show the benefits of smart pumps. We suggest editing the existing text in the first sentence to state: "Deliver education, training and awareness campaign for all supply chain market actors. Leverage OEM, distribution, & sales training opportunities." (There are no changes to the second sentence.)

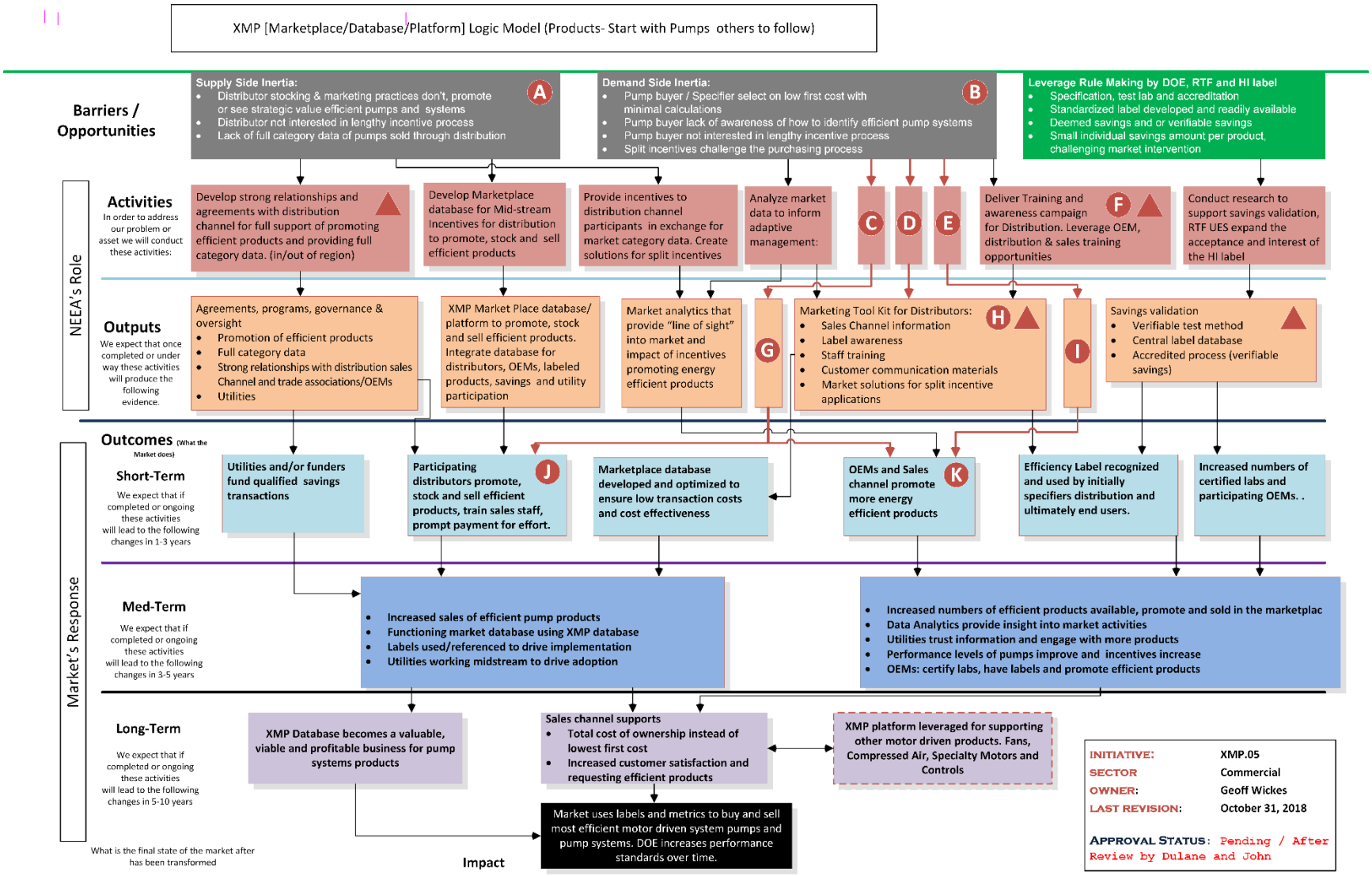
Box G. Outputs. The new arrow from the new Box C drops to new Box G, showing the output from research activity in Box C. Add text to Box G: "Reliability and ease of maintenance verified and documented." A new arrow from Box G drops to Outcomes Box J and to Box K.

Box H. Outputs. The new arrow from the new Box D drops to existing Box H. Add to the existing text: "Case studies demonstrate smart pump applications."

Box I Outputs. The new arrow from the new Box E drops to new Box I. Add text: "Cost calculator developed that demonstrates ROI, life-cycle costs, cost-effectiveness of proposed application." A new arrow from Box I drops to Outcomes Box K.

Market Response: short-term, medium-term and long-term outcomes. Cadmus' research supports the logic model short-term, medium-term and long-term outcomes associated with Market Response. Cadmus finds the market response outcomes are reasonable. We suggest that new arrows drop from new Boxes G and I to Boxes J and K in short-term outcomes.

Figure 10. Recommendations for Logic Model Updates



6 Conclusions

This study focused on commercial and industrial (C&I) applications for clean water pumps up to 50 HP and circulator pumps in commercial applications from fractional to 5 HP. The study assessed market perceptions of energy-efficient smart pump systems, examined the roles of supply and demand side market actors, reviewed the XMP Initiative's logic model, and identified market barriers.

This section provides research conclusions. Overall, the research found varying perceptions among market actors about the characteristics that define energy efficient smart pumps. The market transformation barriers surrounding the emerging market for smart pump solutions identified in this research are addressable through the XMP Initiative's activities.

Increasing Market Awareness

NEEA has an opportunity to shape the discussion around smart pumps to promote certain characteristics in ways that engage and resonate with market actors, builds familiarity with smart pumps, and increases awareness of high-efficiency smart pump solutions.

- Although supply-side market actors were aware of smart pumps, having no common definition of smart pumps creates communication and marketing barriers. Lack of information and experience with smart pumps occurs throughout the supply chain and can result in lost opportunities to promote, recommend, and select smart pumps. Findings point to the need to build communication between and among the market actors and to offer training about smart pumps, their characteristics, applications, benefits, and costs. Training and education provided to each type of market actor could build familiarity and increase experience with smart pump options, encourage the various market actors to work together, and encourage supply-side market actors to recommend or specify this option.

Mitigating Barriers to Market Transformation

Challenges facing market growth for smart pumps are addressable with supply and demand side intervention activities, such as training, education, and by providing marketing guidelines and tools.

- Smart pumps are not being fully marketed or considered as a viable solution for several reasons, including a lack of familiarity with smart pump applications, the perception that smart pumps are costly, and limited experience or opportunity to install smart pumps. Education, information, and awareness campaigns could build familiarity and market awareness, helping to mitigate market barriers.

- It does not appear that market actors are trying to avoid smart pumps, rather that it is easier for specifiers and installers to stay with what they know. Since purchasers often request the "most energy-efficient" pump solution from contractors, it is important that contractors and pump suppliers fully understand the benefits and applications, and are comfortable recommending and installing smart pumps.
- Training and education guidelines could help to familiarize specifiers, contractors, installers, and end users about smart pump options and applications, and could help to address cost perceptions and inform consumers about benefits. Marketing guidelines and case studies of real applications could be useful marketing tools to educate specifiers, installation contractors, and end users alike.
- Additional tools are needed to help market actors easily identify which smart pump applications will be cost-effective. One possible tool is a cost calculator that examines specific applications, life-cycle costs, and ROI. NEEA's cost calculator, which is under development, will be a useful tool for both supply- and demand-side market actors to address cost perceptions.
- Incentives could reduce first cost, and address cost-based market resistance to smart pumps by some purchasers and contractors.

Supporting Market Actor Roles

Findings suggest there is potential for growth in smart pump sales. Market intervention activities can be tailored to the various market actors, particularly in their roles in replacement (planned and emergency) and new projects or new construction.

- Smart pumps can be found in the market to varying degrees, ranging from 10% of sales to 100% of sales. Manufacturers and their sales representatives are two key market actors in both new construction and retrofit pump market scenarios who directly impact sales. Increasing their understanding, acceptance, and promotion of smart pumps will flow down through the rest of the supply and demand chains.
- Intervention efforts should be tailored to market actors involved in new construction and those in the retrofit markets, with an understanding of the market actors, their relationships, and factors impacting purchase decisions within each scenario.
- The Hydraulic Institute Energy Rating (HI ER) used by some market actors has potential for distinguishing high efficiency pumps (possibly qualifying for incentives). HI ER could fill the need for industry wide use of energy efficiency labeling and cataloging to identify smart pump solutions. Continuing to work with HI, increasing the number of HI ER labeled pumps, and expanding recognition of the label could lead to wider acceptance and use of the labels to inform purchase decisions.

- Market drivers include external factors such as changing building codes, increasing efficiency standards, and state policies with targets to reduce emissions, which will play a large role in accelerating market adoption of smart pumps. Trade associations can provide external support promoting guidelines for more efficient pumps. The Initiative recognizes and leverages these external factors as they affect all supply and demand side market actors, and new construction, retrofit, and replacement pump system solutions.

7 Appendices

Appendix A. References

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Appendix B. Survey Approach

Survey Frequency

Cadmus conducted online and telephone surveys with potential pump purchasers (end users and contractors). All potential survey respondents received three invitations to the online survey, and Cadmus made a small number of outbound phone calls to potential respondents who did not respond to email invitations. When respondents were not qualified to take the survey, they were asked for the contact information for another person who might be better suited to take the survey; seven additional contacts were generated this way.

Targeting

To target end users and contractors with experience and knowledge about hydronic pumps, Cadmus assembled contact lists from internal sources (CBSA, IFSA, and MSMA), sources provided by NEEA, and outreach to United Association of Plumbers Union Local 290. Some of this contact information had been collected for previous research efforts related to pump technology. These efforts yielded 106 potential end users and 66 contractors potentially involved with pump technology. Cadmus purchased additional records from the Dunhill International List Company. The Dunhill contacts were filtered for facility managers and operators to target end users, and, mechanical engineering firms to target contractors. However, we could not filter the Dunhill lists for facilities or contractors who had experience with pumps. Table B-1 lists the job titles, SIC codes, industry types, and list source of the end users and contractors contacted for this study.

Table B-1. Extended Motor Products Pump Purchaser: End User and Contractor Contacts

Respondent	Job Title	SIC Code	Industry Type	List Source
End User	Manager, Engineering Tubular Products Group	5051	Metal Service Centers and Offices	IFSA
End User	Owner	3812	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems and Instruments	IFSA
End User	Director of Engineering	7011	Hotels and Motels	CBSA
End User	Energy and Utilities Manager	1499	Miscellaneous Nonmetallic Minerals, except Fuels	MSMA
End User	Maintenance and Operation Supervisor	8211	Elementary and Secondary Schools	CBSA
End User	Facilities	8011	Clinics	Dunhill
End User	Facilities	9121	Government Offices-City, Village & TWP	Dunhill
End User	Facilities	4225	Warehouses	Dunhill
End User	Site Manager	5063	Electric Equipment and Supplies-Wholesale	Dunhill
End User	Facilities	5941	Sporting Goods-Retail	Dunhill
End User	Facilities	2084	Wineries (MFRS)	Dunhill
End User	Facilities	2037	Frozen Fruit, Fruit Juices/Vegs (MFRS)	Dunhill
End User	Facilities	7948	Race Tracks	Dunhill

Respondent	Job Title	SIC Code	Industry Type	List Source
End User	Maintenance Manager	1522	General Contractors-Residential Buildings, other than Single-Family	MSMA
End User	Facilities	9221	Police Departments	Dunhill
End User	Plant Manager	8711	Engineering Services	MSMA
End User	Facilities	9111	City Government-Executive Offices	Dunhill
End User	Facilities	4941	Water Treatment Management Plant	Dunhill
Contractor	Manager	1711	Mechanical Contractors	Dunhill
Contractor	Manager	1711	Mechanical Contractors	Dunhill
Contractor	Executive	1711	Mechanical Contractors	Dunhill
Contractor	Owner	1711	Plumbing, Heating and Air-Conditioning	Contractor
Contractor	Region Manager	5078	Refrigeration Equipment and Supplies	Contractor
Contractor	Engineering/Technical	1711	Mechanical Contractors	Dunhill

Sample Attrition

Table B-2 lists the number of records acquired by Cadmus for fielding the survey, their sources, and the disposition of each record. Separate results are presented for end users and contractors, although both were invited to take the same survey. From the sample of 3,718 end users, 87% were contactable (net of incomplete records, bounced emails, and respondents clicking the opt-out link in the invitation). For contractors, 85% of 525 records could be contacted. Among all end users and contractors contacted, fewer than 2% clicked the survey link in the invitation (63 out of 3,674). Only 35% of end users and 55% of contractors who clicked the link completed a valid survey, resulting in valid survey response rates of 0.5% for end users and 1.1% for contractors.

Table B-2. Extended Motor Products Pump Purchaser: End User and Contractor Online Survey Attrition

Description of Outcomes	End Users: Number of Records	Contractors: Number of Records
Lists compiled from NEEA and Cadmus sources	107	66
Lists purchased from Dunhill	3,604	459
Additional referrals from survey contacts	7	0
Survey Population (number of records)	**3,718**	**525**
Email was missing, incomplete, invalid, or duplicate	56	5
Survey Sample Frame (email invitations sent)	**3,662**	**520**
Email was returned (bounce back)	358	60
Refusal (clicked opt-out link)	77	13
Total receiving invitation to take survey	**3,227**	**447**
Responded to Invitation (clicked survey link)	**52**	**11**
Not eligible (not experienced with pump purchase or installation)	22	3
Incomplete survey (did not answer enough questions for inclusion in analysis)	12	2
Completed Surveys (including 3 partially complete)	**18**	**6**
Valid Completion Rate (valid surveys divided by responded)	**35%**	**55%**
Total Valid Response Rate (valid surveys divided by population)	**0.5%**	**1.1%**

Appendix C. Additional Findings from Barriers Research

Section *5.1* Supply- and Demand-Side Barriers in the main text discusses supply-side and demand-side barriers identified in surveys and interviews and show the comments of each respondent group. Tables in Section *5.1 Supply- and Demand-Side Barriers Assessment* show which market actor made the comments.

Table C-1 and Table C-2 in this appendix are companion tables to Table 10 and Table 11. Unlike Table 10 and Table 11, tables in this appendix do not show which market actors made the comments. These tables summarize comments about the barriers ascribed to the market actors by the interview and survey respondents, both when the respondents described themselves and when describing other actors. For example, when specifying engineers reported that **contractors** rarely consider energy savings when recommending pumps, this barrier is listed under **contractors**.

Table C-1. Supply-Side Barriers Associated with each Market Actor and Purchaser Role

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors
Suppliers unfamiliar with smart pump options.				Installation and/or controls contractors are not familiar or have limited experience or opportunity with smart pump options. Some prefer familiar customized systems over packaged systems.
Suppliers offer alternative solutions to smart pumps.	Some manufacturers recommend custom systems rather than off-the-shelf smart pumps. Manufacturers may prefer selling customized systems to keeping multiple voltages and configurations of packaged pump systems in stock.	Some representatives recommend familiar alternatives to smart pumps where smart pumps could work, often customized systems with external controls.	Some engineers recommend familiar customized systems over packaged systems to smart pumps where smart pumps could work.	Some contractors recommend familiar systems where smart pumps could work, and are concerned about controls, reliability, maintenance, cost and compatibility.
Suppliers do not agree on a common definition of smart pumps as a packaged system with integrated controls.	Some suppliers sell systems with the characteristics of smart pumps, but they do not call them smart pumps. "High efficiency" and "smart pumps" are not mutually exclusive.	Some representatives prefer or use other terms, such as "integrated pump systems" or "sensorless pumps" or "high efficiency."	Specifying engineers used other terms, such as "ECM pumps" or "pump with VFD." (While not the same equipment, both can increase pump efficiency.)	Some call smart pumps "high efficiency" pumps, "eco-pumps" or "pumps with integral speed drive."

Table C-2. Demand-Side Barriers Associated with each Market Actor and Purchaser Role

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors	End Users
New smart pumps may not be the best fit with purchasers' energy efficiency goals.	Not all manufacturers provide detailed information about energy savings.	Representatives do not present a value proposition to customers (e.g., accurate and detailed energy savings). Representatives do not make savings data accessible.	Smart pumps are not the most efficient option for purchasers' applications. Energy savings for the proposed application cannot be quantified and/or savings data cannot be found.	Smart pumps are not the most efficient options for purchasers' applications. Energy savings cannot be quantified and/or savings data cannot be found for the proposed application.	End users ask for the "highest efficiency option" and rely on contractors to select the best option. Lower cost of energy makes efficiency a lower priority.
Purchasers have limited awareness of non-energy benefits of smart pumps.		Representatives do not present the value proposition to describe benefits besides energy savings, such as ease of installation and maintenance.	Specifying engineers may have limited awareness of smart pump benefits such as lower installation costs.	Contractors aware of smart pump benefits but may not market ease of setup or reduced maintenance.	End users have limited awareness or familiarity with smart pumps, and their benefits, often requesting the "most efficient."
New smart pumps are not the best fit with requirements of the purchasers' application.			Options other than smart pumps may be, or may be perceived as, more applicable for purchasers' end uses. The engineer specifies a non-smart pump.	Options other than smart pumps may be, or may be perceived as, more applicable for purchasers' end uses. Contractor specifies a non-smart pump.	Systems requiring constant flow do not need a variable-flow smart pump, and a smart pump is not appropriate.
New smart pumps may not integrate with purchasers' existing systems.			End-user system requirements are not compatible with smart pumps.	End-user system requirements are not compatible with smart pumps.	Requirements of facility control (BMS, EMS) or other systems (e.g., piping, valves, process) mean that smart pumps cannot be integrated or cannot be integrated cost-effectively. May also include security protocols that prevent facility data from going off site (stored on a cloud or the Internet).

Barrier	Manufacturers	Manufacturers' Sales Rep.	Specification Engineers	Contractors	End Users
Purchasers lack the infrastructure required to take advantage of smart pump benefits.					End user lacks staff or systems to take full advantage of smart pump benefits.
Equipment cost is a barrier.	Until demand is greater, packaged systems will be more expensive due to economies of scale.	Customers' budgets influence purchase decisions.	Customer's budget influences purchase decisions.	Customer's budget influences purchase decisions. Contractors can bring down project costs by specifying less efficient alternatives that meet end users' requirements.	Higher equipment costs posed an issue with retrofits, where competing capital investments were a top barrier for end users.
Purchasers have payback requirements (ROI).			Need to demonstrate that the project and specific smart pump application meets payback requirements. Must be able to calculate ROI and meet customers' criteria.	Need to demonstrate that the project meets payback requirements. Must be able to calculate ROI and it must meet customers' criteria.	Smart pump does not meet end users' ROI criteria, or ROI cannot be calculated. ROI is a more important consideration for C&I pumps than circulators as potential energy savings are lower for smaller pumps.
Purchasers' requirements for reliability and maintenance.				Need to minimize repair costs and downtime for customers. Contractors need to be comfortable with maintenance of smart pumps.	Concerns about repair costs and maintenance downtime for smart pumps.
Smart pumps are proprietary systems.			Some engineers prefer external sensors, controls, and drives to proprietary components of integrated systems.	Some contractors are concerned about difficulties maintaining proprietary components.	
Lack of experience and training on installation of smart pumps.				Contractors have limited opportunities to install and do not recommend smart pumps due to lack of installation experience or integration with BMS may require additional contractors.	

Appendix D. Market Actor Interview Guide

CADMUS

NEEA 2019 XMP Market Characterization Market Actor Interview

Interview Overview: This in-depth interview is conducted as a conversation. This interview/conversation guide provides the questions the interviewer will ask, however the interviewer will follow the flow of the conversation rather than try to ask questions precisely in this order or wording.

This interview will be directed to manufacturers, manufacturers' sales representatives, distributors and specifiers of efficient pumps, as well as a representative of the Hydraulic Institute. Data collected through the interview will be used to assess the market, future smart pump growth, identify barriers to smart pump adoption, and map the key influence points in the supply chain.

Researchable Questions	Question Number
Assess NEEA/Cadmus definition of smart pumps	B1-B3,
Estimate NW market size for circulator pumps up to 5 hp, and commercial/industrial pumps up to 50 hp	C3, C5-C7,
Estimate the presence of smart pumps in the market and the market size	B4, C1, C2, C4, C8, C11, C13-C17,
Forecast smart pump market growth (over 20 years if possible)	D1-D9
Characterize pump distribution and identify key distributors	E1-E3
Assess supply side and demand side barriers to smart pump adoption	B5-B6, C9-C10, C12, C18, F1
Characterize market actor roles (to be used to map the supply chain for pump purchases)	A1-A3,

Table 1. Target Completes by Audience

Stakeholder Group	Target Completes
Manufacturers and Sales Reps	5
Hydraulic Institute Representative	1
Specification Engineers	4 Commercial and 2 Industrial
Distributors	Up to 5

General Instructions

- Interviewer instructions are in green **[LIKE THIS]**
- Programming instruction and skip patterns are in red **[LIKE THIS]**

A. Introduction and Market Actor Roles

[EVERYONE]

Thank you for agreeing to speak with me about the NW market for smart pumps, I appreciate your time. NEEA contracted with Cadmus to characterize the market for smart pumps in the Northwest (defined as OR, WA, ID, MT, UT) and help them identify opportunities to accelerate market adoption of efficient

motor-driven products. For our interview, we are focusing on circulator pumps up to 5 hp, and commercial/industrial pumps up to 50 hp.

May we have your permission to record this conversation? We often reference these recordings to refresh our memories as we write up our report.

A1. Before we begin, would you please briefly describe your role at **[INSERT COMPANY]** and the company's role in the NW pumps market?

A2. What is the territory served by your company?

A3. What other supply chain market actors for clean water pumps do you work with directly and in what role?

B. Market Awareness

[ASK EVERYONE]

For this interview, we would like to ask you about pumps with specific characteristics. We will call these "smart pumps" but you might know them by another name. " Smart pumps" are designed to minimize the use of energy in operation, that is, to be highly energy efficient. Typically, they are a packaged pump unit consisting of a pump, variable speed drive, internal sensor, and pre-programmed controls. Smart pumps have multiple control modes, can operate on constant flow or variable flow systems, and do not require integration to an external sensor or building management system.

B1. Prior to this interview, had you heard of pumps with these characteristics?

B2. Had you heard the term *smart pump*?

1. **[IF YES]** Is this a term used in your business for a pump that has the above-mentioned characteristics?
   (1) How does your business define smart pumps?
   (2) Have you heard the term smart pump associated with the pump description that I just provided?
   (3) How do you differentiate between high-efficiency pumps and smart pumps?

B3. Have you seen or heard a common definition for smart pumps used and understood among pump manufacturers, distributors, pump specifiers, and purchasers?

1. **[IF YES]** What is that definition?
2. **[IF NO]** Have you heard different definitions across these businesses? What definitions or characteristics have you heard for smart pumps?

B4. Do your customers ask you specifically about highly energy efficient pumps, what we have identified as smart pumps?
   1. Who are your typical customers for smart pumps? **[PROBE BUSINESS SECTOR, NEW CONSTRUCTION, RETROFIT]**
   2. What information do customers typically ask for regarding smart pumps? **[PROBE HOW WELL THE MARKET UNDERSTANDS SMART PUMPS]**

B5. What do you think are the **major benefits** that result from installing and using smart pumps? **[CONFIRM WHICH DEFINITION THEY ARE THINKING ABOUT WHEN THEY RESPOND TO THIS QUESTION. FOCUS THEM ON OUR SMART PUMP DEFINITION]**

B6. What are the **major drawbacks** of smart pumps? **[CONFIRM WHICH DEFINITION THEY ARE THINKING ABOUT WHEN THEY RESPOND TO THIS QUESTION. FOCUS THEM ON OUR SMART PUMP DEFINITION]**

C. Market Size and Presence of Smart Pumps

I'd like to ask you about the market for pumps, and specifically smart pumps in the NW.

[ASK MANUFACTURERS/SALES REPS/DISTRIBUTORS C1-C10]

C1. Do you market or stock **smart pumps** for commercial and industrial applications, that you differentiate from other high-efficiency pumps?
   1. Yes – Market
   2. Yes – Stock
   3. Neither market nor stock
   4. **[IF YES]** How do you label or differentiate smart pumps from other high-efficiency pumps to your customers?

C2. Please describe the way you categorize your pump offerings. For example, on your website or in your catalog, how would a customer search for a pump? (Probe, by application, price, size, application, other?)

[INTERVIEWER: FOR C3-C4 IF THE PERCENTAGE FOR SMART PUMPS SOLD OR INSTALLED IS VERY SMALL/NON-EXISTANT, OR RELATIVELY SIZEABLE, ASK INTERVIEWEE TO ELABORATE ON WHY THAT IS? PROBE WHAT ARE THE IMPLICATIONS FOR THEIR BUSINESS AND THE MARKET FOR SMART PUMPS]

C3. Approximately what percentage of **all your pump sales** are:
   1. Circulator pumps up to 5 hp
   2. Commercial/industrial pumps up to 50 hp

C4. Approximately what percentage of all your pump sales are **smart pumps**:
   1. Circulator pumps up to 5 hp
   2. Commercial/industrial pumps up to 50 hp

C5. Approximately what percentage of **all your pump sales are replacing existing pumps**?
1. Circulator pumps up to 5 hp
2. Commercial/industrial pumps up to 50 hp

C6. For **new construction**, what percentage of **all pumps sold** are installed on:
1. Constant volume systems
2. Variable flow systems

C7. For **existing systems**, what percentage of **all pumps sold** are installed on:
1. Constant volume systems
2. Variable flow systems

C8. Which of the following hydronic systems are the most common applications for smart pumps?
1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems

C9. Are you familiar with the Hydraulic Institute Energy Rating Label? **[IF NEEDED, PROVIDE DEFINITION]**

C10. Do you market or stock smart pumps bearing the Hydraulic Institute Energy Rating Label?
1. Do you see benefits from that?
2. What are the benefits?
3. How influential is this label in your pump selection?
4. Are there other sources of information about pump efficiency that you rely on? Which?

[ASK SPECIFICATION ENGINEERS C11 - C18]

C11. Can you describe a project where you specified or installed a smart pump? **[PROBE IF NOT MENTIONED]**
1. Don't specify smart pumps **[ASK C12]**
2. What was the application?
3. Was this for a replacement retrofit application or a new pump application in an existing facility?
4. Was this for new construction?
5. Was this application similar to other times you specified a smart pump or was there something particularly unique about this application? **[IF DIFFERENT, HOW SO?]**

C12. If you don't specify smart pumps, why not? **[PROBE IF NOT MENTIONED]**

1. If lack of knowledge, what would help?
2. If cost, what would help?
3. If design decisions, what specific factors and what would help alleviate those issues?
4. If poor historical performance, what would help?
5. Other (specify)

C13. **[ASK IF C11 > 1]** What factors influenced your decision to specify smart pumps over a non-smart pump in the project you just described?

C14. Are these factors the same for new construction and for retrofit applications?

C15. Which of the following hydronic systems do you most often specify for smart pumps in new construction?

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (record type)

C16. Which of the following hydronic systems do you most often specify for smart pumps in retrofit applications?

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (record type)

C17. Smart pumps have multiple control modes. These include constant flow control, constant pressure control, BAS input, or variable flow control. Which control mode do you most often specify for each of the following systems?

1. Primary heating systems
2. Secondary heating systems
3. Chilled water systems
4. Water boosting
5. Domestic hot water recirculation
6. Process systems
7. Other (record type)

C18. Where smart pumps have been installed, how have they performed compared to a traditional pump system? **[OPEN ENDED. PROBE THE FOLLOWING IF NOT MENTIONED]**

1. Have you found that system balancing is simplified?
2. How have costs compared?
3. Have you found any additional maintenance is necessary?
4. Have your customers generally been satisfied with smart pumps?
5. Do building operators need additional training on smart pump operation?
6. Would you recommend smart pumps again? Why or why not?

D. Market Growth for Smart Pumps

[ASK EVERYONE D1-D2]

D1. Do you see the market for smart pumps increasing, decreasing or remaining the same over the next 5 years, 10 years, 20 years? **[ASK THIS QUESTION FOR EACH TIME PERIOD TO CAPTURE ANY GROWTH OR LEVELING OUT. PROBE WHY FOR EACH TIME PERIOD, WHAT ARE THE KEY INFLUENCERS, WHAT IS CURRENTLY MOVING THE MARKET, BLOCKING THE MARKET, AND WHAT IS NEEDED TO MOVE THE MARKET FURTHER?]**

1. 5 years
2. 10 years
3. 20 years

D2. What product features and differentiation will be influential in driving the market adoption of smart pumps?

[ASK HYDRAULIC INSTITUTE REP D3-D9]

D3. We understand the aim of the Hydraulic Institute's PEI label is to promote a common understating about a pump's energy efficiency. Can you tell us about how you envision the PEI label will contribute to the market adoption of smart pumps in particular?

D4. How do you (does the Hydraulic Institute) differentiate a smart pump from an energy-efficient pump?

D5. Do you rate a smart pump as more efficient than an energy-efficient pump?

D6. What has been the response from manufacturers and distributors to the Hydraulic Institute Energy Rating Program and the PEI label?

D7. We conducted surveys with smart pump specifiers and purchasers. **[QUESTIONS TO BE DEVELOPED FROM SURVEY RESPONSES, TO GET HI REP RESPONSE TO FINDINGS]**

D8. Are there points in the supply chain that you think could be leveraged to help move the market adoption of smart pumps?

D9. What do you think NEEA, in particular, could do to help move the market adoption of smart pumps?

E. Distribution Chain

[ASK MANUFACTURERS, SALES REPS AND DISTRIBUTORS]

E1. Please describe the supply chain flow by which your product reaches the end user. **[PROBE: IF THE PRODUCT FLOW HAS MULTIPLE PATHS, ASK WHICH PATH HAS GREATER VOLUME? (EXAMPLE, IF PUMPS CAN BE PURCHASED DIRECTLY FROM MANUFACTURERS VS. DISTRIBUTORS, WHAT IS THE RATIO OF THE SALES VOLUME?]**

E2. By sales volume, of companies supplying the Northwest, who are the largest…

1. Manufacturers of:
   (1) Circulator pumps up to 5 hp
      (a) All pumps
      (b) Smart pumps
   (2) Commercial/industrial pumps up to 50 hp
      (a) All pumps
      (b) Smart pumps
2. Distributors/Wholesalers of
   (1) Circulator pumps up to 5 hp
      (a) All pumps
      (b) Smart pumps
   (2) Commercial/industrial pumps up to 50 hp
      (a) All pumps
      (b) Smart pumps
3. Suppliers of
   (1) Circulator pumps up to 5 hp
      (a) All pumps
      (b) Smart pumps
   (2) Commercial/industrial pumps up to 50 hp
      (a) All pumps
      (b) Smart pumps

[ASK EVERYONE]

E3. At what point in the supply chain do you see the greatest opportunity to influence market adoption of smart pumps?

F. Market Barriers

[ASK EVERYONE]

We are almost finished. I appreciate all your time. The last topic I'd like to discuss is about market barriers that could hinder the adoption of smart pumps. Please tell me about the barriers you see and

where it is in the supply chain. For example, the barrier could be with the distributor or specifying engineer. Then I'd like to know how large you think the barrier is, how difficult it might be to overcome, and how important it is to address soon. I'd also like to hear any ideas you have about how the barrier could be overcome or addressed.

F1. Let's get started. What market barriers or challenges come to mind which could hinder the adoption of smart pump? **[FIRST DISCUSS EACH ITEM MENTIONED WITHOUT PROMPTING. THEN GO BACK AND PROMPT TO DISCUSS EACH ITEM NOT MENTIONED]**

Let's discuss barriers to the adoption of smart pumps, and where you think the barriers occur in the supply chain	**Mentioned, no prompt** Y/N	**Where is the barrier?** Manufacturer (M), Distributor (D), Supplier (S), Specifying Engineer (SE), Retailer (R), Purchaser/demand side (P) (add other mentioned)	**How large and how difficult do you think this challenge is to overcome? Why?** Large/difficult; moderate large/easy; small/difficult; small/easy;
Example: Upfront cost of the equipment	*Y*	*Supplier*	*Large/difficult. Suppliers want to make a profit*
Upfront cost of the equipment			
Converting constant volume systems to variable volume systems			
Controls, reliability, and maintenance			
Providing client specific information about the energy-saving benefits of smart pumps			
Lack of awareness about the non-energy benefits of smart pumps			
Supply chain actor or end user lack of experience/training on the use and maintenance of smart pumps			
Compatibility with previously-installed systems			
Longer timeline for installation			
Lack of available equipment in stock/stocking practices			
Limited applications for smart pumps			

F1. Continued

How do you think these barriers can be mitigated to encourage the adoption of smart pumps?	Mentioned, no prompt Y/N	How can it be overcome?	Who/what firm is the best to take action to mitigate this challenge?
Example: Upfront cost of the equipment	*Y*	*Reduce first cost; educate about energy benefits*	*Utility or supplier incentives; utility & trade associations provide information to buyer about energy benefits and return on investment*
Upfront cost of the equipment			
Converting constant volume systems to variable volume systems			
Controls, reliability, and maintenance			
Providing client specific information about the energy-saving benefits of smart pumps			
Lack of awareness about the non-energy benefits of smart pumps			
Supply chain actor or end user lack of experience/training on the use and maintenance of smart pumps			
Compatibility with previously-installed systems			
Longer timeline for installation			
Lack of available equipment in stock/stocking practices			
Limited applications for smart pumps			

This completes the interview. We appreciate your participation and thank you so much for your time. Have a good [evening/day].

Appendix E. Purchaser Survey Instrument

CADMUS

NEEA 2019 XMP Market Characterization: Purchaser (End User/Contractor) Survey

Survey Overview: This brief online survey will be directed to purchasers of efficient pumps, primarily facility managers and building operators, and contractors who influence purchasers in their selection of efficient pumps. Data collected through the survey will be used to assess the market, future smart pump growth, identify barriers to smart pump adoption, and map the key actors and influence points in the supply chain. NEEA will provide a list of contractors along with their email addresses to Cadmus for inclusion in the survey. Cadmus will pull a sample of facility managers and building operators from our contacts for MSMA & IFSA in the Northwest, as well as our CBSA work and data purchased from Dunhill International. NEEA will contact their list of contractors in advance to introduce the study and ask for their participation in the online survey.

Research Objectives	Corresponding Question Numbers
Assess NEEA/Cadmus definition of smart pumps	D4-D5
Estimate NW market size for circulator pumps up to 5 hp, and commercial/industrial pumps up to 50 hp	D1-D3
Estimate the presence of smart pumps in the market and the market size	D2-D3, D6-D10
Forecast smart pump market growth (over 20 years if possible)	E1-E2
Characterize pump distribution and identify key distributors	C1- C6
Assess supply side and demand side barriers to smart pump adoption	B1-B2, C7-C12, D11-D12, F1-F2
Characterize market actor roles (to be used to map the supply chain for pump purchases)	A1-A4

Target Audience: facility managers/building operators/contractors

Expected number of completions: 100 facility managers/building operators, TBD contractors

Estimated timeline for fielding: April-May 2019

Variables to be Pulled into Survey

- Email
- FirstName
- LastName

General Instructions

- Programming instruction and skip patterns are in red **[LIKE THIS]**

Email Invitation

To: [EMAIL]
From: Northwest Energy Efficiency Alliance (NEEA)

Subject: NW market for smart pumps

Dear [FIRSTNAME AND LASTNAME],

NEEA is conducting a study about the market for pumps in the Northwest. Your experience and insight into this market will contribute valuable information and we appreciate you taking a few minutes to complete this survey. Your input is very important to us! It will be kept confidential and only used for research purposes. **The survey will take 10 minutes to complete. As our thanks for completing the survey, we will enter you into a drawing for a $200 Amazon gift card.**

Click the link below to take the survey:

[auto-generated link]

Or you may copy and paste the URL below into your internet browser: [auto-generated URL]

If you have any questions about this research, or any difficulties taking the survey, please contact David Ladd at The Cadmus Group, the national research firm conducting this survey on our behalf. You can reach David at 872.888.6255 or David.Ladd@cadmusgroup.com.

Thank you in advance for sharing your knowledge and your time

Steve Phoutrides
Project Manager
NEEA

Reminder Invitation

To: [EMAIL]
From: Northwest Energy Efficiency Alliance

Subject: Don't forget to be part of NEEA's market study of pumps in the NW

Dear [FIRSTNAME AND LASTNAME],

We recently invited you to participate in our market study about pumps in the NW. We would still like to hear from you. Your input is very important to us, will be kept confidential, and only used for our research. **Please take 10 minutes today to complete the survey**. As our thanks for completing the survey, we will we will enter you into a drawing for a $200 Amazon gift card.

Click the link below to take the survey:

[auto-generated link]

Or you may copy and paste the URL below into your internet browser: [auto-generated URL]

If you have any questions about this research, or any difficulties taking the survey, please contact David Ladd at The Cadmus Group, the national research firm conducting this survey on our behalf. You can reach David at 872.888.6255 or David.Ladd@cadmusgroup.com.

Thank you in advance for sharing your knowledge and your time.

Steve Phoutrides
Project Manager
NEEA

A. Roles and Responsibilities

[CLIENT-APPROVED LOGO TO APPEAR ON START SCREEN]

Welcome! Thank you for participating in this survey to better understand the market for pumps in the Pacific Northwest. This should take about 10 minutes to complete. Your responses will remain confidential and will only be used for research purposes. Be sure to enter your name and email at the end of the survey to be entered a drawing for one of two $200 Amazon gift cards.

A1. Please select which best describes your business role:
1. Facility Manager
2. Building Operator
3. Contractor
4. Other, please specify: **[TEXT BOX]**

A2. Are you involved in selecting, recommending, specifying or purchasing clean water pumps?
1. Yes, **circulator pumps up to 5 hp**
2. Yes, **commercial and industrial clean water pumps up to 50 hp**
3. Yes, both types of pumps above
4. No **[SKIP TO A4]**

A3. **[ASK IF A2 = 1, 2 OR 3]** For each role listed below, please select whether you are involved in new construction, retrofit, both applications, or neither. **[PROGRAM AS DROP-DOWN MENU TABLE]**

	New Construction	Retrofit Applications	Both	Neither
Selecting pumps				
Recommending pumps				
Specifying pumps				
Purchasing pumps				

A4. **[ASK IF A2=4 OR A3=NEITHER FOR ALL SELECTIONS]** Please provide the name and contact information of the person at your facility who is involved in selecting, recommending, specifying or purchasing clean water pumps. **[THANK & TERMINATE AFTER FILLING OUT FORM]**

[TEXT BOX FORM]

First and last name: **[FIRST AND LAST NAME]**

Email: [EMAIL]

Phone: [PHONE]

[THANK AND TERMINATE]: This survey is intended for those who are involved in selecting, recommending, specifying, or purchasing pumps for facilities, so we have no additional questions for you. Thank you for your time.

B. Market Awareness

NEEA is very interested in learning more about where you obtain information about the clean water pumps and where you purchase pumps.

B1. **[ASK IF A3 = NEW CONSTRUCTION FOR ANY]** Thinking about the last time you selected, recommended, specified or purchased a clean water pump for a **new construction** application**,** which of the following did you **rely on for information** about energy-efficient pumps? Select all that apply. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM (OTHER)]**

1. Manufacturer or manufacturer's sales representative
2. Distributor/wholesaler or distributor/wholesaler's sales representative
3. Equipment supplier (please specify the supplier:) **[TEXT BOX]**
4. Contractors
5. Internet search
6. Pump labeling or packaging
7. In-house engineering staff
8. Third-party engineers or architects
9. Hydraulic Institute
10. Industry or trade organizations (please specify the organization) **[TEXT BOX]**
11. Other (please specify) **[TEXT BOX]**

B2. **[ASK IF A3 = RETROFIT FOR ANY]** Thinking about the last time you selected, recommended, specified or purchased a clean water pump for a **retrofit** application**,** which of the following did you **rely on for information** about energy-efficient pumps? Select all that apply. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM (OTHER)]**

1. Manufacturer or manufacturer's sales representative
2. Distributor/wholesaler or distributor/wholesaler's sales representative
3. Equipment supplier (please specify the supplier:) **[TEXT BOX]**
4. Contractors
5. Internet search
6. Pump labeling or packaging
7. In-house engineering staff
8. Third-party engineers or architects
9. Hydraulic Institute
10. Industry or trade organizations (please specify the organization) **[TEXT BOX]**
11. Other (please specify) **[TEXT BOX]**

C. Distribution Chain

C1. **[ASK EVERYONE]** What typically triggers a pump replacement or purchase? **[ALLOW MULTIPLE RESPONSE]**

1. Previous pump failed
2. Early replacement of functional pump
3. Something else, please specify: **[TEXT BOX]**

C2. **[ASK IF C1= 2 EARLY REPLACEMENT]** What typically motivates early replacement of a pump? Select all that apply. **[ALLOW MULTIPLE RESPONSE, RANDOMIZE ORDER EXCEPT FOR LAST ITEM (OTHER)]**

1. Energy Efficiency
2. Health and safety concerns
3. Coordinating with production schedules
4. Nearing the end of the anticipated useful life of existing pump
5. Something else, please specify: **[TEXT BOX]**

C3. **[ASK IF (A3 = PURCHASED) AND (A3=NEW CONSTRUCTION OR BOTH)]** Thinking about the last time you purchased a clean water pump for a **new construction** application, who did you **work with directly** for that purchase? Please select all that apply. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM (OTHER)]**

1. Manufacturer or manufacturer's sales representative
2. Distributor or wholesaler or their sales representative
3. Equipment supplier (please specify the supplier) **[TEXT BOX]**
4. Retailer (please specify) **[TEXT BOX]**
5. Installation contractor
6. Online pump sellers
7. Other (please specify) **[TEXT BOX]**

C4. **[ASK IF (A3 = PURCHASED) AND (A3 = RETROFIT OR BOTH)]** Thinking about the last time you purchased a clean water pump for a **retrofit** application, who did you **work with directly** for that purchase? Please select all that apply. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM (OTHER)]**

1. Manufacturer or manufacturer's sales representative
2. Distributor or wholesaler or their sales representative
3. Equipment supplier (please specify the supplier) **[TEXT BOX]**
4. Retailer (please specify) **[TEXT BOX]**
5. Installation contractor
6. Online pump sellers
7. Other (please specify) **[TEXT BOX]**

C5. **[ASK IF C3 OR C4 = 6, ONLINE PUMP SELLERS]** You mentioned that you purchased pumps online. From whom did you purchase the pumps online?

1. Manufacturer (please specify the manufacturer) **[TEXT BOX]**
2. Distributor or wholesaler (please specify the distributor or wholesaler) **[TEXT BOX]**
3. Equipment Supplier (please specify the supplier) **[TEXT BOX]**
4. Retailer (please specify) **[TEXT BOX]**
5. Other (please specify) **[TEXT BOX]**

C6. **[ASK EVERYONE]** It is becoming easier to buy products online. Do you see yourself buying clean water pumps online in the next year?

1. Yes
2. No
3. Maybe

C7. **[ASK EVERYONE]** Please share your thoughts about the pros and cons of buying clean water pumps online. **[TEXT BOX]**

Next, we would like to know about the importance of various features and benefits in your selection or purchase. First, we will ask about circulator pumps up to 5 hp, then we will ask about commercial and industrial clean water pumps up to 50 hp.

C8. **[ASK IF A2= A2.1 OR A2.3 BOTH]** On a scale of zero to 10 where zero means not important at all, and 10 means very important, please rate the importance of each item in your selection, recommendation, specification or purchasing of **circulator pumps up to 5 hp. [RANDOMIZE ORDER EXCEPT FOR FIRST ITEM (1. DON'T SPECIFY OR PURCHASE) AND THE LAST ITEM (OTHER)]**

1. Brand **[SLIDER FROM 1 TO 10]**
2. Price **[SLIDER FROM 1 TO 10]**
3. Your familiarity with the product **[SLIDER FROM 1 TO 10]**
4. Your customer's or facility's familiarity with the product **[SLIDER FROM 1 TO 10]**
5. Ease of installation **[SLIDER FROM 1 TO 10]**
6. Ease of maintenance **[SLIDER FROM 1 TO 10]**

7. Compatibility with other equipment **[SLIDER FROM 1 TO 10]**
8. Reliability **[SLIDER FROM 1 TO 10]**
9. Energy efficiency **[SLIDER FROM 1 TO 10]**
10. Readily available / fast procurement **[SLIDER FROM 1 TO 10]**
11. Something else (please specify) **[TEXT BOX] [SLIDER FROM 1 TO 10]**

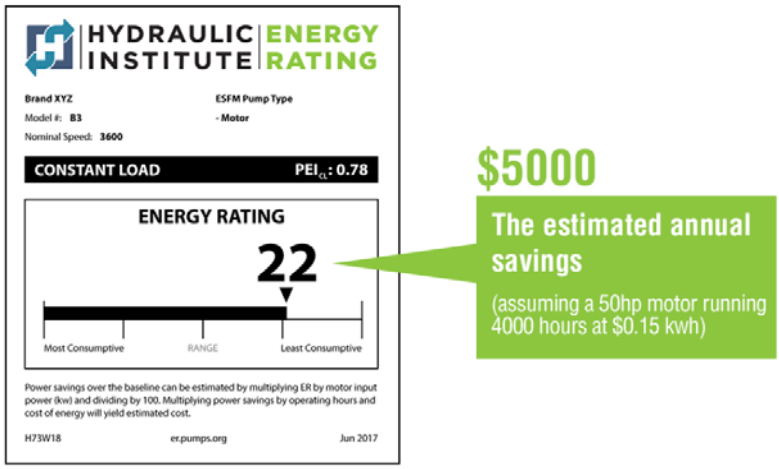
C9. **[ASK IF A2= A2.3 BOTH]** You said you also select, recommend, specify or purchase **commercial and industrial clean water pumps up to 50 hp.** Is the importance of the factors you just rated for circulator pumps up to 5hp, the same for **commercial and industrial clean water pumps up to 50 hp**, or are they different? **[SHOW ONLY ITEMS SELETED IN C8]**

1. The importance of these factors is the same for both types of pumps
2. The importance of these factors is different for these two types of pumps

C10. **[ASK IF A2= A2.2 AND A2.3 BOTH IS NOT CHECKED / OR A2= A2.3 BOTH AND C9 = 2 DIFFERENT]** On a scale of zero to 10 where zero means not important at all, and 10 means very important, please rate the importance of each item in your selection, recommendation, specification or purchasing **commercial and industrial clean water pumps up to 50 hp.** **[RANDOMIZE ORDER EXCEPT FOR FIRST ITEM (1. DON'T SPECIFY OR PURCHASE) AND THE LAST ITEM (OTHER)]**

1. Brand **[RADIO BUTTON]**
2. Price **[SLIDER FROM 1 TO 10]**
3. Your familiarity with the product **[SLIDER FROM 1 TO 10]**
4. Your customer's or facility's familiarity with the product **[SLIDER FROM 1 TO 10]**
5. Ease of installation **[SLIDER FROM 1 TO 10]**
6. Ease of maintenance **[SLIDER FROM 1 TO 10]**
7. Compatibility with other equipment **[SLIDER FROM 1 TO 10]**
8. Reliability **[SLIDER FROM 1 TO 10]**
9. Energy efficiency **[SLIDER FROM 1 TO 10]**
10. Readily available / fast procurement **[SLIDER FROM 1 TO 10]**
11. Something else (please specify) **[TEXT BOX] [SLIDER FROM 1 TO 10]**

C11. Prior to this survey, had you heard of or seen pumps carrying the Hydraulic Institute energy rating label (example shown below)? **[INSERT GRAPHIC BELOW]**



1. Yes
2. No

C12. **[ASK IF C11 = YES]** Do you use the Hydraulic Institute energy rating label?

1. Yes, to compare pump performance
2. Yes, for something else **(please specify) [TEXT BOX]**
3. No

D. Market Size and Presence of Smart Pumps

D1. **[ASK IF A2= A2.3 BOTH]** Thinking about all the pumps you specify or install in any application, what would you say are the percentage that are:

1. Circulator pumps up to 5 hp **[SLIDER FROM 0% TO 100%]**
2. Commercial/industrial pumps up to 50 hp **[SLIDER FROM 0% TO 100%]**

D2. **[ASK IF D1.1 > ZERO OR A2=1 CIRCULATOR PUMPS UP TO 5 HP]** Please select the applications for which you have specified or installed circulator pumps up to 5 hp (select all that apply):

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (please specify) **[TEXT BOX]**

D3. **[ASK IF D1.2 > ZERO OR A2=2 C/I PUMPS UP TO 5O HP]** Please select the applications for which you have specified or installed commercial/industrial pumps up to 50 hp (select all that apply):

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (please specify) **[TEXT BOX]**

In the next section, we would like to ask you about pumps with specific characteristics. For this survey, we will call these "smart pumps" but you might know them by another name. "Smart pumps" are designed to minimize the use of energy in operation, that is, to be highly energy efficient. Typically, they are a packaged pump unit consisting of a pump, variable speed drive, internal sensor, and pre-programmed controls. These pumps have multiple control modes, can operate on constant flow or variable flow systems, and do not require integration to an external sensor or building management system.

D4. Prior to this survey, had you heard of pumps with these characteristics?

1. Yes, with all these characteristics
2. Yes, but with only some of these characteristics
3. No

D5. **[IF D4 = 1 OR 2 (YES)]** What have you heard these called?

1. Smart Pumps
2. High-Efficiency Pumps
3. Something else (please specify) **[TEXT BOX]**

D6. **[IF A1=3]** Using the definition of smart pumps above, do you currently specify or install smart pumps in retrofit or new applications? Select all that apply. **[RANDOMIZE ORDER]**

1. Yes, for retrofit applications
2. Yes, for new applications
3. No, do not currently specify or install smart pumps **[CANNOT BE SELECTED WITH ITEMS ABOVE]**

D7. **[IF A1=1, 2 OR 4]** Using the definition of smart pumps above, has your organization installed any smart pumps in retrofit or new applications? Select all that apply. **[RANDOMIZE ORDER]**

1. Yes, for retrofit applications
2. Yes, for new applications
3. No, have not installed smart pumps **[CANNOT BE SELECTED WITH ITEMS ABOVE]**

D8. **[ASK IF D6 OR D7 = YES, RETROFIT]** Please select the retrofit applications in which you specify or install smart pumps.

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (please specify) **[TEXT BOX]**

D9. **[ASK IF D6 OR D7 = YES, NEW]** Please select the new applications in which you specify or install smart pumps.

1. Heating systems
2. Chilled water systems
3. Water boosting
4. Domestic hot water recirculation
5. Process systems
6. Other (please specify) **[TEXT BOX]**

D10. **[ASK IF D6 OR D7 = EITHER "YES" RESPONSE]** When you specify or install a smart pump instead of a pump that is "not smart" what are the reasons you would choose the smart pump option? **[TEXT BOX]**

D11. **[ASK IF "YES, RETROFIT" IS NOT SELECTED IN D6 OR D7]** Why don't you specify or install smart pumps in retrofit applications? **[TEXT BOX]**

D12. **[ASK IF "YES, NEW" IS NOT SELECTED IN D6 OR D7]** Why don't you specify or install smart pumps in new applications? **[TEXT BOX]**

E. Market Growth for Smart Pumps

E1. What is required for you to specify or purchase smart pumps in the future? Select all that apply. **[RANDOMIZE ORDER FOR RESPONSE CHOICES 1-7]**

1. Additional information on the energy-saving benefits of smart pumps
2. Additional information on the non-energy benefits of smart pumps
3. Additional information about the applications for smart pumps
4. Lower upfront cost
5. Evidence that smart pumps are operationally reliable
6. Additional equipment or infrastructure to take full advantage of smart pump features
7. More readily available / faster procurement
8. I currently have no applications for smart pumps **[CANNOT BE SELECTED WITH ITEMS ABOVE]**
9. Other (please specify) **[TEXT BOX]**

98. Don't know

E2. Thinking about the items you just selected, which do you consider mandatory to drive your decision to purchase? Select all that apply **[SHOW ONLY ITEMS SELETED IN E1]**

F. Market Barriers

F1. **[IF A1= 1, 2, OR 4]** We would like to learn more about barriers to the selection or purchase of smart pumps. Please rank the top 5 in terms of difficulty in overcoming the barrier, where 1 is the most challenging of the top 5, and 5 is the least challenging of the top 5. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM OTHER] [LIMIT SELSECTION TO 5 RESPONSES]**

1. Upfront cost of the equipment
2. Not compatible with previously-installed systems
3. Difficulty converting constant volume systems to variable volume systems
4. Controls, reliability, and maintenance concerns
5. Lack of information about the energy-saving benefits of smart pumps
6. Lack of information about the non-energy benefits of smart pumps
7. Lack of staff experience or training on the use and maintenance of smart pumps
8. Facility has other priorities for capital investments
9. Longer installation times than traditional pumps
10. Lack of available smart pump equipment in stock
11. No applications for smart pumps
12. Other barriers (please specify) **[TEXT BOX]**

F2. **[IF A1=3]** We would like to learn more about barriers to selection or specification of smart pumps. Please rank the top 5 in terms of difficulty in overcoming the barrier, where 1 is the most challenging of the top 5, and 5 is the least challenging of the top 5. **[RANDOMIZE ORDER EXCEPT FOR LAST ITEM OTHER] [LIMIT SELSECTION TO 5 RESPONSES]**

1. Upfront cost of the equipment
2. Profit margin on equipment
3. Not compatible with previously-installed systems
4. Difficulty converting constant volume systems to variable volume systems
5. Controls, reliability, and maintenance concerns
6. Lack of information about the energy-saving benefits of smart pumps
7. Lack of information about the non-energy benefits of smart pumps
8. Lack of experience or training on the installation of smart pumps
9. Lack of available smart pump equipment in stock
10. Longer installation times than traditional pumps
11. Other barriers, please specify: **[TEXT BOX]**

G. Closing

G1. Thank you! Those are all the questions we have today. We appreciate your time and feedback! We will enter your name into our drawing for the $200 Amazon gift card. Please provide your name and email address, so we may contact you should you be the winner.

1. First Name: **[FIRST NAME]**
2. Last Name: **[LAST NAME]**
3. Email: **[EMAIL ADDRESS]**

G2. I am unable to accept a gift card, please do not enter me in the drawing.

End of Survey Message

Those are all the questions we have. Thank you for participating in this survey.