Market Research Report

Energy Efficiency within the Pulp and Paper, Water and Wastewater and Irrigation Markets in the Pacific Northwest

prepared by
Ducker Worldwide

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NORTHWEST ENERGY EFFICIENCY ALLIANCE
www.nwalliance.org

529 SW Third Avenue, Suite 600
Portland, Oregon 97204
telephone: 503.827.8416 • 800.411.0834
fax: 503.827.8437

Energy Efficiency within the Pulp & Paper, Water & Wastewater, and Irrigation Markets in the Pacific Northwest

An Examination of Pumps, Fans/Blowers, and Conveyor Equipment

Prepared for:

The Northwest Energy Efficiency Alliance
522 SW Fifth Avenue #410
Portland, OR 97204

Ducker Worldwide
250 Montgomery Street
Suite 1130
San Francisco, CA
94104
(415) 733-0086

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I. EXECUTIVE SUMMARY

This report profiles the pulp and paper, water and wastewater, and irrigation industries in the Pacific Northwest and assesses the opportunity for energy efficiency practices penetration specific to pump, fan/blower, and conveyor system usage and purchase practices within these markets. The report characterizes the value chain, the purchase decision process, and existing practices within these three industries. This report attempts to identify areas of energy inefficiency and provide solutions for each industry.

The industrial motor load for the industries under study reached nearly 18,500 GWh (2,100 aMW). Pumps, fans/blowers, and conveyor systems account for a sizable percentage of energy used in these industries. As a result, improving energy efficiency of this equipment within the pulp and paper, water and wastewater, and irrigation industries would significantly impact energy savings in the Pacific Northwest.

Equipment in these industries are very energy intensive. Pumps account for approximately 10,400 GWh (1,200 aMW) or nearly 20% of the total industrial motor energy use in the Pacific Northwest. Pump inefficiencies are commonplace in these industries. Pump inefficiency tends to be the result of the system rather than the pump design itself. Areas of efficiency savings can be made by:

- Properly sizing pumps for the current system head and capacity. Pump manufacturers and the DOE offer software to properly size pump equipment.
- For application and ensuring that the design of the system itself (size of the pipes and bends in the piping) offsets as much friction related energy loss as possible.
- For applications in which peak flows vary, installing a parallel pump in which the second pump is used as necessary. This may prevent the need to oversize the pump.
- For applications in which load varies, energy savings may be achieved through the replacement of throttle valves with variable speed drives.
- The repair vs. replace should be closely scrutinized for pumps older the 10 years, as they are likely to have dropped dramatically in energy efficiency due to wear.

Fans and blowers in the Pacific Northwest are a major source of energy consumption in the pulp and paper and water and wastewater industries. The installed base of 129,500 fans/blowers in these industries account for 2,144 GWh (245 aMW) electricity consumed. Like pumps, inefficiencies from fan/blower use are the result of improper specification and maintenance rather than the design of the fan itself. Efficiency savings can be achieved through:

- Properly sizing the fan/blower for the application. It may be necessary to talk to the distributor or sales representative to correctly choose the proper impeller size and vane type for the application. Fan/blower manufacturers provide software and tools to size equipment properly.
- Regular maintenance will greatly extend the life and the efficiency of the fan/blower. Maintenance checks should include bearing lubrication, bearing wheel corrosion and tightness of bolts.
- For applications in which motor load varies, the installation of a VSD may greatly increase energy efficiency.

- A critical examination of energy efficiency for fans/blowers older than 10 years. Inefficient older fans should be replaced, as it likely will save money in the long run through operating cost savings.

Conveyor systems are broadly defined as a piece of equipment moving material from one place to another. There are multiple types of conveyor systems used in the pulp and paper and water and wastewater industries for both wet and dry application. The conveyor systems account for 2,122 GWh (242 aMW) of pulp and paper and water and waste water energy consumption in the Pacific Northwest. The conveyor market in these industries is approximately $1 billion in the US (approximately $40,0000,000 in the Pacific Northwest). The structure of the market for conveyor systems varies from the pumps and fans/blowers markets. The conveyor system is a piece of equipment that is essentially the integration of several components (which may include blowers and pumps). Also the types of conveyor systems vary significantly by design and application. As a result the industry is extremely fragment with many smaller players. As a result, this is a difficult market to pursue energy efficiency initiatives. However, there are areas of improvement for the use of conveyor systems. These include:

- Regular maintenance of the conveyor. This entails inspecting the various components (including pumps and blowers) on a regular basis.
- Installation of a VSD may save a substantial amount of energy for those applications in which loads vary significantly.

The three industries under study are prime targets for energy efficiency initiatives due to their consumption of energy in the Pacific Northwest. The industries under study have unique dynamics. As a result, there may be varied success for implemented initiatives across all three industries.

The water and waster industry accounts for 2,100 GWh (240 aMW) motor electricity consumption in the Pacific Northwest. The water and wastewater industry has begun a transition from a city-owned municipality to a growing number of privately run facilities. This industry has recently focused on methods for cost cutting as a result of the pressures associated with the privatization trends. As a result, energy efficiency cost savings may be increasingly attractive to the industry. In addition, the industry is ripe for energy efficiency initiatives as a substantial amount of equipment (84% of pumps and 80% of fans/blowers) are older than 10 years and use significantly more energy than new equipment. Due to its greater energy intensity, the wastewater industry should be a primary target for Alliance initiatives.

The pulp and paper industry is the largest consumer of motor energy in the Pacific Northwest. The industry accounts for 10,084 GWh (1,150 aMW) of motor energy use in the Pacific Northwest with a majority of that energy stemming from pump and fan/blower use. The pulp and paper is characterized by the manufacturing of the commodity, low margin product. As a result, pulp and paper manufacturers tend to look for ways to cut costs. Manufacturers tend to be adopters of new technology and equipment that would lower operating costs, and thus improve margins. Maintenance practices of the pulp and paper industry are much more regular and thorough than the other industries under study, resulting in greater energy efficiency. Perhaps the biggest barrier to energy efficiency is awareness of new technologies and equipment and potential energy cost savings through their implementation.

Irrigation in the Pacific Northwest accounts for 6,278 GWh (717 AMW) and is the second largest industrial consumer of energy in the region. All of the energy consumed is from the use of pumps. The industry is extremely fragmented consisting of multiple pump users including farmers and water suppliers (irrigation districts as well as ditch and canal companies). As a result, irrigation is a difficult industry target for energy efficiency initiatives. However, there is much inefficiency due to the fragmented nature of the industry and the economies of scale working against the investment in new equipment and technology in many cases. For instance, 80% of pumps in this industry are older than 15 years, resulting in tremendous losses in efficiency. On site pump efficiency tests performed by utilities such as Bonneville Power contributed to a significant increase in energy efficiency awareness, but were discontinued in the early 1990s due to budget constraints. As a result, awareness of energy efficiency and operating cost savings as well as knowledge of new technologies has decreased. Energy efficiency initiatives should be targeted at creating awareness of operating cost savings from such practices as properly sizing pumps, replacing older equipment and investment in new technology.

The Pacific Northwest is a difficult region to create awareness concerning the need for energy efficiency due to the low cost of energy. Even in industries that consume a tremendous amount of energy in the region, such as pulp and paper, water and wastewater, and irrigation, there is not a focus on energy efficiency. Initial cost is the primary factor for all three industries in the decision to invest in capital equipment.

Experts in the three industries as well as equipment manufactures indicate that one of the biggest barriers to entry for efficient equipment is awareness of new technology and its benefits. However, opportunities do exist to create awareness, remove barriers, and establish incentives for greater energy efficiency within these industries.

I. I. INTRODUCTION AND METHODOLOGY

The primary objective of this study is to profile the pulp and paper, water and wastewater, and irrigation industries in the Pacific Northwest; Idaho, Montana, Oregon, and Washington. The focus of this study is to understand energy usage and energy efficiency within these industries specifically focusing on pumps, fans/blowers, and conveyor systems. The study provides an overview of the market, including size and segmentation, market drivers, and decision processes with regard to energy usage. This data provided will provide the Northwest Energy Efficiency Alliance (Alliance) with actionable recommendations for market transformation ventures in targeted industries.

The Alliance has selected the targeted industries based on a recent Alliance market assessment finding that indicated eleven industries in the Pacific Northwest accounts for 90% of the motor load.[1] Industrial motor load reached nearly 18,500 GWh (2,100 aMW) for the pulp and paper, irrigation, as well as water and wastewater industries with the pumps, fans/blowers, and conveyor systems accounting for a bulk of these loads.

Study findings are based on market information gathered by Ducker Worldwide (Ducker), including in depth personal and telephone interviews as well as analysis of multiple secondary information sources. Primary research included the following respondent types:

Respondent Type	Number of Interviews
Equipment OEMs	50
Equipment Distributors	20
Engineering & Consulting Firms	10
Plant Managers & Engineers	100
Utilities	10
Government Organizations	10
Trade Associations and Industry Experts	25
Total	**200**

Highly focused and detailed interviews were carried out with key respondents within the pulp and paper, irrigation, and the water and wastewater industries in the Pacific Northwest as well as pump, fan/blower, and conveyor system manufacturers supplying these industries in the Pacific Northwest. These interviews were crucial in determining industry trends as well as industry drivers with respect to energy efficiency product. One source often provided insights into multiple segments of the report.

Market data collected on the number of pumps, fans/blowers, and conveyance systems including sales data on the Pacific Northwest were based on available data from the Census Bureau, earlier Alliance reports within the sectors, Ducker databases, and market estimates based on multiple telephone interviews. These numbers are meant to provide an indication of the market trends,

[1] Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

however are not meant to provide an exact market profile. Further methodology for the sales estimates is provided in Appendix VI.

II. MARKET OVERVIEW

The pulp and paper, water and wastewater, and irrigation industries are large industries in the Pacific Northwest. The motor energy requirement for powering these industrial sites is significant. In 1999, the motor energy requirement reached 18,400 GWh (2,100 aMW). Pumps, fans/blowers and conveyors account for a majority of this motor load.

Industrial Motor Energy Usage by Application

Industry	Pumps	Fans/ Blowers	Conveyor Systems	Other
Pulp & Paper	35%	20%	20%	25%
Water & Wastewater	45%	10%	5%	40%
Irrigation	100%	0%	0%	0%

The Pacific Northwest has two unique dynamics effecting energy efficiency: relatively low electricity rates and the popularity of green politics characterizing the region. The Pacific Northwest's low electricity rates help to attract new industry into the region. However, the low rates can also serve as a disincentive to becoming more energy efficient. Lower electricity rates translate to longer payback periods for energy efficient equipment. Long payback periods are typically a major disincentive for equipment purchases by end users in each of the three industries under study. On the other hand, the green movement is immensely popular in the Pacific Northwest. As a result, industries and the region's residents are more aware of the importance of energy efficiency. Both these characteristics provide a unique dichotomy of industry's attitude toward energy efficiency.

Each of the three industries under study has unique attributes that characterize either the attitude toward energy efficiency initiatives or the level of effectiveness in trying to implement such initiatives. The pulp and paper industry is comprised of a small number of large companies, and this smaller number of leverage points would make it easier for the Alliance to implement an energy efficiency program. However, some of the major companies indicated that energy efficiency initiatives may have limited returns. This is due to the fact that the pulp and paper industry is manufacturing a commodity product and is already driven to research and implement energy efficient equipment and technologies in order to be competitive. The irrigation industry is a strong target for energy efficiency as many of the pumps are relatively old and less energy efficient, and the end users are less cognizant of the benefits of energy efficiency. However, this market may prove to be a difficult target for the Alliance due to its fragmented nature, lack of uniform systems, and maintenance and purchasing characteristics. The water and wastewater industry is a strong candidate for energy efficiency initiatives. The water and wastewater industry is consolidated and would be ideally suited for an Alliance program. At present, the industry is less inclined to purchase state of the art, energy efficient equipment. Most municipalities are constrained to order equipment from the lowest bidder and are therefore concerned with first cost. While this practice makes the industry suited for an educational program on the necessity to relate equipment purchase cost to operating costs and payback period, there may be industry standards that will be a barrier to such a program. Each of the three industries under study has some areas to improve their energy efficiency, however the key to rectifying these areas of inefficiency is to translate energy efficiency to the bottom line.

III. EQUIPMENT SUMMARY

A. *Pumps*

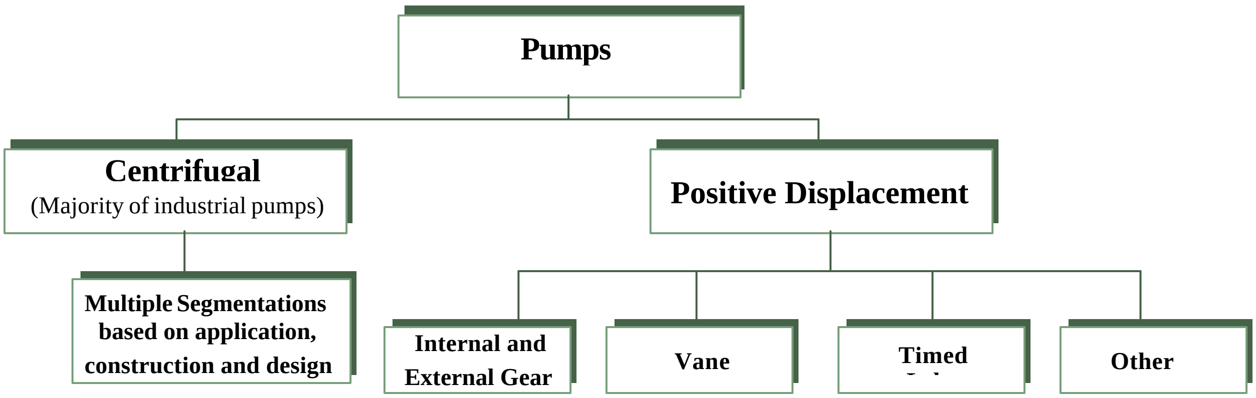
Respondent Type	Number of Interviews
Pump OEMs	25
Pump Distributors	10
Engineering & Consulting Firms	10
Plant Managers & Engineers	100
Utilities	5
Government Organizations	3
Trade Associations and Industry Experts	10
Total	**160**

Of the equipment under study, pumps consume a bulk of the energy use in the pulp and paper, water and wastewater, and irrigation industries. Pumps account for approximately 10,400 GWh annually (1,187 aMW). In 1999, 29,500 pumps were sold to the pulp and paper, water and wastewater as well as the irrigation industries in the Pacific Northwest. The tremendous energy requirements as well as the strong pump sales in the industries under study indicates the necessity to ensure this product is as energy efficient as possible.

Pump manufacturers as well as those responsible for the specification and maintenance of pumps in each of the three industries indicate that the pumps currently used in the market are efficient. Inefficient pumps are the result of oversizing the equipment in order to accommodate unforeseen demand increases and poor maintenance due to lack of emphasis or funding allotted for pump care. Pump manufacturers provide in their catalogues a guideline for sizing pumps and efficiency charts as well as software applications to help those specifying pumps in the industries select the proper pump and pump size for the applications.

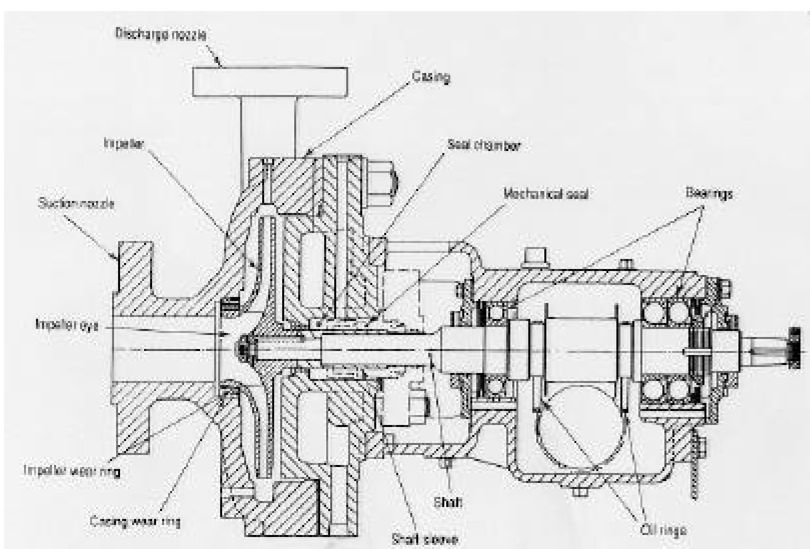
1. Types of Pumps

Pump Segmentation



197,000 pumps installed in pulp & paper, water & wastewater and irrigation industries in the PNW

There are essentially two basic types of pumps: positive displacement pumps and centrifugal pumps. Positive displacement pumps require mechanical energy to move liquid. These pumps are limited to low volume applications. Positive displacement pumps are used when the fluid being pumped is extremely viscous or abrasive.



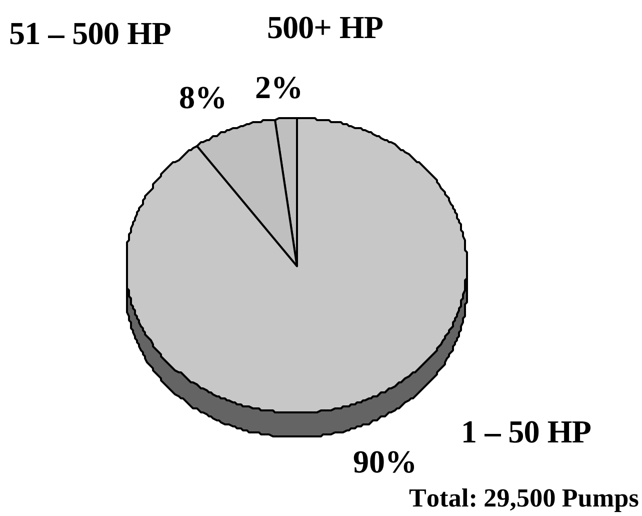
(Source: Purdue University http://abe.www.ecn.purdue.edu/~agen 555/Caramel/pumps.html)

The centrifugal pump (pictured above) is the second type of pump used. These pumps are capable of conveying large volumes of fluid, and as a result, make up a large majority of the pumps in the pulp and paper, water and wastewater, and irrigation industries. Centrifugal pumps rely on kinetic energy to pump liquid rather than mechanical energy. These pumps are best suited for low pressure applications. Centrifugal pumps can withstand not only large volumes of clear liquid, but also fluids that are dirty and abrasive, as well as fluids with a high solid content.

Two aspects of the pump design affect the efficiency: the volute (the curved funnel within the pump casing through which water flows) and the impeller (the curved blade within pump casing which pushes water through the volute). A pump with a simple volute is the more efficient pump. However, less complex volutes have a small capacity allowance and may have high radial loads. The type of liquid being pumped dictates the impeller design. A closed impeller design is the most efficient design. However, the closed impeller design is limited to fluids free of any solids. The less efficient, open impeller design is required for pumping fluids with solids. Most pumps in the irrigation industry have applications suited for the closed impeller design. The pulp and paper as well as the water and wastewater industries have a majority of applications, which require the open impeller design.

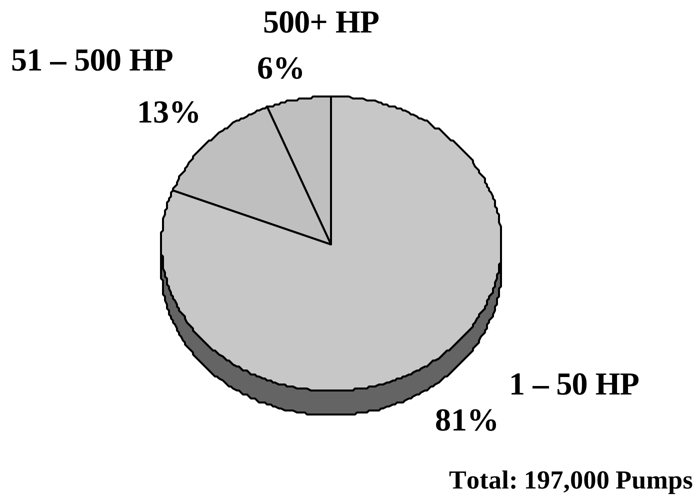
2. Pump Sizes

1999 Pumps (HP) Sold by Size in the PNW

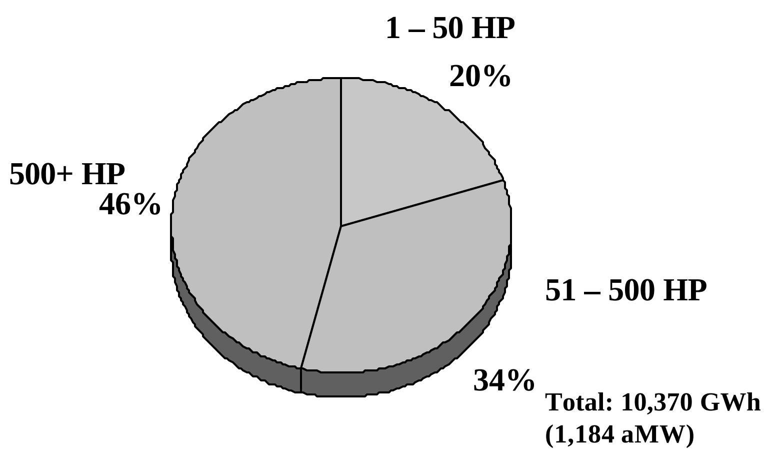


A majority of the pumps for the various applications in the three industries under study require smaller horsepower. Pumps that are 1-50 HP make up 90% of pumps sold each year to the three industries in the Pacific Northwest. Those pumps that are 51-500 HP comprise approximately 8% of the market. The massive 500+ HP pumps account for 2% of the pumps sold to the three industries in the Pacific Northwest. One reason for the abundant number of 1-50 HP pumps sold is the shorter lifetime than their larger counterparts.

1999 Pumps (HP) Installed Base by Size in the PNW



1999 Energy Consumed by Pumps (HP) in the PNW



Pumps greater than 500 HP account for only 6% of pumps installed in the Pacific Northwest, but nearly half of the pump motor load required by the three industries under study. On the other hand, 1-50 HP pumps represent 80% of the installed pump base in the three industries, but account for only 20% of energy consumed by pumps.

The market for used pumps in the three industries under study is almost nonexistent. The equipment specifiers within the pulp and paper, water and wastewater, and irrigation industries predominately specify new pumps.

3. <u>Pump Materials</u>

Pumps for applications within the three industries under study typically have a stainless steel impeller with cast iron, mild steel, stainless steel or titanium volute. Stainless steel and titanium casings are more expensive than cast iron or mild steel, but highly resistant to abrasive and corrosive liquids. Because of the lower cost, cast iron is usually used for applications in which the fluid being pumped is a non-corrosive substance such as water for irrigation. In the water and wastewater industry most pumps are cast iron. Less than 5% of pumps supplied to the water and wastewater industry are stainless steel or titanium. The pulp and paper industry requires most of its pumps to be stainless steel or titanium due to the highly corrosive bleaching process. Brown paper mills, which do not require a bleaching process, typically specified the less expensive mild steel or cast iron pump casings. However, cracking problems caused by the other abrasive and corrosive liquids involved in pulp and paper processing have led many new plants to specify stainless steel pump casings.

4. <u>Pump Evolution</u>

The design of the pump is fairly mature and has remained unchanged for decades. Changes to the pump's hydraulic design and construction are not expected in the foreseeable future. Most pump OEMs have invested in some R&D efforts toward development of new materials. New material development is aimed at making a material that is less expensive and more able to withstand highly corrosive materials than stainless steel. This resistance would lower maintenance requirements and increase durability and lifetime of the pump. There is almost no R&D specifically devoted to improving pump efficiency.

Some new pump designs have been introduced that are being specified in the pulp and paper industry. However, their impact on energy efficiency in minimal. Sealless pump designs have been introduced in the chemical industry and have been used in the chemical bleaching process in the pulp and paper industry. The sealless design decreases the amount of liquid leakage. Due to the requirement of a magnet drive, the pump consumes more energy. However, the decrease of liquid loss and the elimination of the need to cool down liquid entering the pump offset this inefficiency.

Another pump recently introduced in the pulp and paper industry is the medium consistency pump for the transport of slurry. By removing air through a vacuum, the pump can transport 12% consistency rather than the typical 6% consistency. Although the pump requires more energy per gallon, the pump's total energy consumption is equivalent because it is essentially moving twice the volume in the same amount of time. Medium consistency pumps are increasingly being specified bleach chemical mixing and recycling applications within the pulp and paper industries.

5. Codes Regulating Pumps

Several guidelines and standards regulate the pump industry. American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), and the Hydraulic Institute have contributed to the major pump standards and guidelines affecting pumps for the various applications within the pulp and paper, water and wastewater as well as the irrigation industry. The ASME code regulates vessel pressure and piping. The ANSI standards regulate size and flow rate of pumps. The Hydraulic Institute's overview and standards provide definitions and segmentations of pumps as well as recommendations on application specifications for pump types in order to provide optimal performance and efficiency. Currently, codes dictating minimum efficiency do not exist. Pump OEMs and end users often discuss minimum motor efficiency standards on pumps when referring to pump efficiency.

6. Major Pump Manufacturers

Although typically pump manufacturers specialize in one or two industry, most of the large pump manufacturers produce and supply pumps to a number of industries including pulp and paper, water and wastewater, as well as irrigation. Most pump manufacturers are national companies and have extensive local sales representatives.

Manufacturer	Industries Under Study Served
Ahlstrom	Pulp & paper
ITT Goulds/Flyt	Pulp & paper, water & waste, irrigation
Gormann Rupp	Pulp & paper, water & waste
Pentair Pump Group	Water & waste, irrigation
KSB	Pulp & paper, water & waste
PACO	Pulp & paper, water & waste, irrigation
Jacuzzi	Water & waste, irrigation
Barnes	Water & waste
Grundfos	Water & waste, irrigation
Ingersoll Dresser	Pulp & paper, water & waste, irrigation
Cornell	Water & waste, irrigation
Peerless	Irrigation
Sta-Rite	Water & waste, irrigation

The pump manufacturers listed in the table above (Ahlstrom, ITT Goulds/Flygt, Gorman Rupp, Pentair Pump Group, KSB, PACO, Jacuzzi, Barnes, Grundfos, Ingersoll Dresser, Cornell, Peerless, Sta-Rite) include the major manufacturers supplying the pulp and paper, water and wastewater and irrigation industries in the Pacific Northwest. These manufacturers represent more than 80% of the US market in the water and wastewater, pulp and paper, and irrigation industries.

The major manufacturers of pumps in the pulp and paper industry include Ahlstrom and ITT Goulds. Gorman-Rupp, KSB, PACO and Ingersoll-Rand pumps also supply pumps to the industry, although their core market is in other industrial sectors.

There are several large manufacturers with a line of pumps for the water and wastewater industry. Within the water and wastewater industries, major pump manufacturers include Gormann-Rupp, Pentair Pump Group, KSB, PACO, Jacuzzi, ITT Flygt and ITT Goulds.

The pump market for irrigation is comprised of several manufacturers. The major manufacturers within the irrigation industry include PACO, Pentair Pump Group, Ingersoll-Dresser, Goulds, Mueller, Cornell, Peerless, and Sta-Rite Industries.

Ahlstrom (pulp and paper)

Ahlstrom is Finnish company that manufactures paper and equipment used in pulp and paper manufacturing, including pumps. The Swiss company, Sulzer Pumps recently acquired the pump division, which has presence in the pulp and paper industry in the Pacific Northwest primarily through its aftermarket parts and repair business. Sulzer will continue production of the Ahlstrom pump line. Ahlstrom's pump line for the pulp and paper industries include general process pumps, medium consistency pumps and specialty pumps.

Gormann-Rupp (water and wastewater, pulp and paper)

Gormann-Rupp, based in Mansfield, OH, manufactures pumps for the water and wastewater industries as well as the construction, petroleum, and other industries including pulp and paper and food processing.

Pentair Pump Group (water and wastewater, irrigation)

Pentair Pump Group is a company consisting of several brands devoted to various applications. Each of the brands has a separate manufacturing location, most of which are based in the Midwest. Pentair pump brands supplying to the water and wastewater industry include Aurora Pump, Fairbanks Morse, Hydromatic, Myers, Layne & Bowler, and Verti-Line.

KSB (water and wastewater, pulp and paper)

KSB, headquartered in Frankenthal, Germany manufactures pumps and valves for several heavy industrial sectors including the wastewater industry. KSB does have pumps suited for pulp and paper applications.

PACO Pump (water and wastewater, irrigation, pulp and paper)

PACO Pump, based in Brookshire, TX, manufacturers pumps for a wider range of applications than most pump manufacturers. PACO has established the reputation of being a leading supplier for water and wastewater applications. PACO also is a sizable product line devoted to the irrigation industry as well as a smaller line of pumps suitable for the pulp and paper market.

Jacuzzi (water and wastewater, irrigation)

Jacuzzi, a worldwide manufacturer of whirlpools, baths, showers, pool equipment, and pumps, with its pump manufacturing locations based in Little Rock, AR and Ontario, Canada. Jacuzzi's pumps are suited for water and wastewater or well as pool and spa applications.

Barnes (wastewater)

Barnes manufactures primarily large submersible pumps for wastewater applications.

ITT Flygt and Goulds Divisions (water and wastewater, irrigation, and pulp and paper)

ITT's Flygt division manufactures pumps for the wastewater industry. Its N-Pump line is its premium line touting energy efficiency. The N-Pump line has an altered hydraulic end and a self-cleaning open impeller with a relief groove in the volute. This design alteration increases pump efficiency and resistance to clogs. ITT Flygt designs its own motors for its pumps. Both its energy efficient flagship product line and its manufacturing of the motor are an anomaly in the industry.

ITT Goulds has pump lines in all three industries, however the most extensive product line and industry presence is within the pulp and paper industry. ITT Goulds has a similar product line for the pulp and paper industry as Ahlstrom with general process pump, medium consistency pump and specialty pump lines. ITT Goulds maintains it has set strategic initiatives and has begun incentivizing its sales force to sell VSD drives on pumps. ITT Goulds also has a significant presence in the market for pumps in water and wastewater as well as irrigation. ITT is a leader in terms of manufacturing and promoting its energy efficient pumps.

Grundfos (irrigation, wastewater)

Grundfos Pumps, a major player in the irrigation pump market, has begun to command a greater presence in the wastewater market through its acquisition of Sarlin Pumps, a Finnish company that is a leading manufacturer of wastewater pumps.

Ingersoll-Dresser (irrigation, water and wastewater, pulp and paper)

Ingersoll-Dresser is the second largest manufacturer of pumps. Ingersoll-Dresser is made up of several brands including Ingersoll-Dresser, Jeumont-Schneider Pumps, Pacific, Pleuger, Scienco, and Worthington. Ingersoll-Dresser also has presence in the water and wastewater and the pulp and paper industries, however the Pacific and Worthington brands are synonymous with the irrigation pump market. Ingersoll Dresser is in the process of being purchased by Flow Serve, an industrial flow management materials supplier based in Dallas, TX. Flow Serve's market base has been within the chemical and petroleum industries. This acquisition is meant to help Flow Serve gain entry into other markets including irrigation, water and wastewater, and pulp and paper.

Cornell Pump (irrigation, wastewater)

Cornell Pump, headquartered in Portland, OR, has significant name recognition in the Pacific Northwest. Although Cornell does have some pumps suited for food and wastewater applications, the company has a significant presence in the irrigation market and other applications requiring clear water pumping. Cornell Pump has a new Y Series pump line devoted to the agriculture and irrigation market.

Peerless Pump (irrigation)

Peerless Pump is a subsidiary of Sterling Fluid Systems, a fluid system manufacturer and service provider in pumps, valves, vacuum technology, engineered systems and water treatment.

Sta-Rite Industries (irrigation, water and wastewater)

Sta-Rite Industries headquartered in Delaven, WI, manufactures pumps as well as pool and spa equipment. Through its Sta-Rite and Berkeley pump brands, Sta-Rite offers a significant product line of pumps for the water and wastewater as well as the irrigation industries.

Distributors of pumps supplying to industries in the Pacific Northwest include Argo, Pump Industry, Mitchell Lewis & Staver, KN Industrial, GPM and Smith & Koch.

7. Trends in the Industry

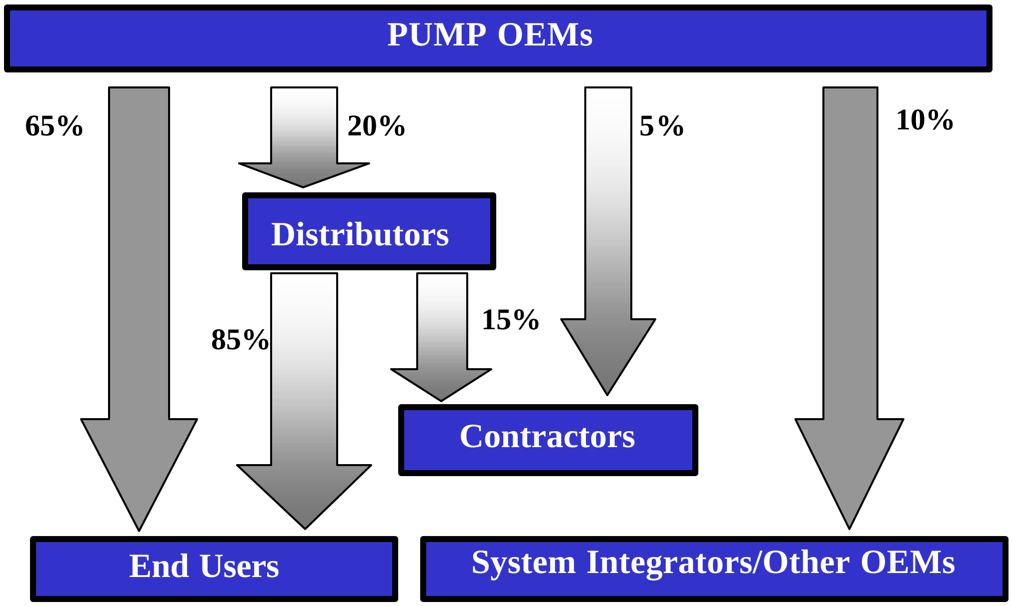
The demand for pumps in these industries has remained relatively constant. The industry has remained fairly steady with regard to sales and prices. The manufacturers' shipment of industrial pumps in 1998 was $2.9 billion, a 7% increase in sales dollars from the previous year. [2] Whereas, sales dollars have been increasing, unit sales for pumps have had a slower growth rate (less than 4% per year).

Consolidation in recent years has made the pump industry less fragmented with a handful of large players in the commercial/industrial pump market. The dominance of large, international and national pump manufacturers is more conducive to an R&D and product refinement focus. This product improvement potential may indirectly effect energy efficiency.

[2] *Pumps and Compressors: Current Industrial Reports 1998*. US Census Bureau.

8. Distribution of Pumps

PRODUCT FLOW



Pumps are distributed to the pulp and paper, water and wastewater, and the irrigation industries in the Pacific Northwest primarily through pump OEMs (Original Equipment Manufacturers) and regional OEM affiliated suppliers. The remaining pumps are purchased from pump OEMs and supplied to end users by industrial distributors and engineering contractors.

9. Drivers in the Purchase Decision Process

Although pump manufacturers concede that customers do have some concerns regarding energy efficiency, manufacturers perceive that initial cost is the primary driver in the decision making process for end users and contractors. Even those cases in which the end user is aware of operating efficiencies and payback period, manufacturers still perceive initial cost to be the most important consideration for purchase. This is especially true of the smaller, less expensive pumps with shorter lifetimes. Operating costs and other variables become increasingly important as the size and expected lifetime of the pump increases.

Each of the three industries is aware of operating efficiencies and takes payback period into account. The payback period is a product of the initial investment, the price of electricity in the region, and the time of usage. Some facilities simply take the lowest bidder and do not calculate payback period. In some cases, the relative expense and expected life of the piece of equipment being purchased may be negligible and calculating payback period may not be considered of value. Nonetheless, payback period is generally expected to be about 2 ½ years for large capital expenditures. This is the timeframe most plant and facility accountants consider appropriate for investing in a higher price piece of equipment and will amortize the equipment in the accounting books within this time frame.

10. Pump Maintenance

Maintenance and replacement decisions vary depending on the industry, the company and the facility practices. However, there are generally accepted practices for motor replacement and rewind decisions. The decision to replace or rewind pump motors is based primarily on the motor size. End users will typically replace motors that are less than 20 HP. For 20-100 HP motors, the motor is not typically rewound unless it is a specialty motor. Motors greater than 100 HP typically are rewound if they are not older than 15 years. A larger motor is typically rewound once over the course of a 15 year period. Less than 5% of the motors in a given facility are rewound in a given year.

Pump experts believe that rewinding motors typically decreases motor efficiency by 2% and can decrease its efficiency by up to 20%. Experts indicate that motors exposed to excessive heat, previously rewound, or older than 20 years should be replaced. In addition, motors should be replaced if the cost of rewinding the motor is greater the 65% of the cost of a new VSD drive with a motor.

11. Energy Efficiency Improvements for Pumps

Overall efficiency of the pump is expressed by the "wire to water" ratio:

Overall Efficiency (%) = (GPM x TDH x 100)/ (Input HP x 3690)

GPM: Gallons per minute pumped
TDH: Total dynamic head in feet created by pump. TDH incorporates the sum of pressure, lift and system friction losses.
Input HP: Power delivered to the motor
3690: constant required to convert units into hp

The efficiency of the pump does vary by type, model and manufacturer. However, good pump efficiency is considered to range from 75-85%. However, when the pump is actually placed in systems with bends, leaks and other conditions that effect overall efficiency, it is likely that the efficiency rating will be lower than the pump efficiency range that is provided given optimal conditions. Pump systems with a 65% efficiency rating is considered acceptable, and systems below 55% should be candidates for repairs and replacements.[3]

[3] *Energy-Efficient Irrigation Practices Handbook: Irrigation Technology in the 90's*. IDWR Energy Division, University of Idaho, Local Utility.

To run at maximum efficiency, those specifying the pump must consider the piping system as well as the required flow rate when selecting the proper pump and pump size. Software and pump efficiency curves exist to aid in the selection of the proper pump for a given application. These aids provide the specifier with the Best Efficiency Point (BEP), the highest efficiency attainable for the capacity at the maximum impeller diameter performance curve. Specific speed, hydrodynamic size, headrise to shut off, and correction of viscosity are based on the calculated BEP. Most end users in the three industries under study try to attain pump operation within 80-110% of the BEP.

Several ways to attain greater pump efficiency have been identified:

- First, ensure that the pump is not oversized. Pumps should be sized based on system head and capacity expectations. It is usually less expensive to add pumping capacity as requirements increase rather than paying higher operating costs

- Second, design systems requiring lower total head requirements. This may be achieved by lowering friction losses as a result of using larger pipes. In some applications, a change in pipe material may be feasible and would reduce friction loss. For instance, the use of an epoxy-coated steel or plastic pipe can reduce friction loss by about 40% in many cases

- Third, use two or more pumps in parallel to improve efficiency. One pump can operate during periods of low demand, and additional pumps can be operated in parallel during peak periods. Efficiency is achieved by eliminating the need to throttle a larger pump during times of low demand

- Fourth, in applications in which the load varies, the use of Variable Speed Drive Motors should be used to replace throttling valves (*see section III. D. 2.* ***Use of VSDs*** *for further information*)

- Fifth, maintenance is crucial to pump efficiency as wear can lower the pump's efficiency. Maintenance includes the lubrication and/or replacement of bearings as well as ensuring that the impeller and volute is smooth and have not suffered from cavitation. A maintenance routine should be established in each facility

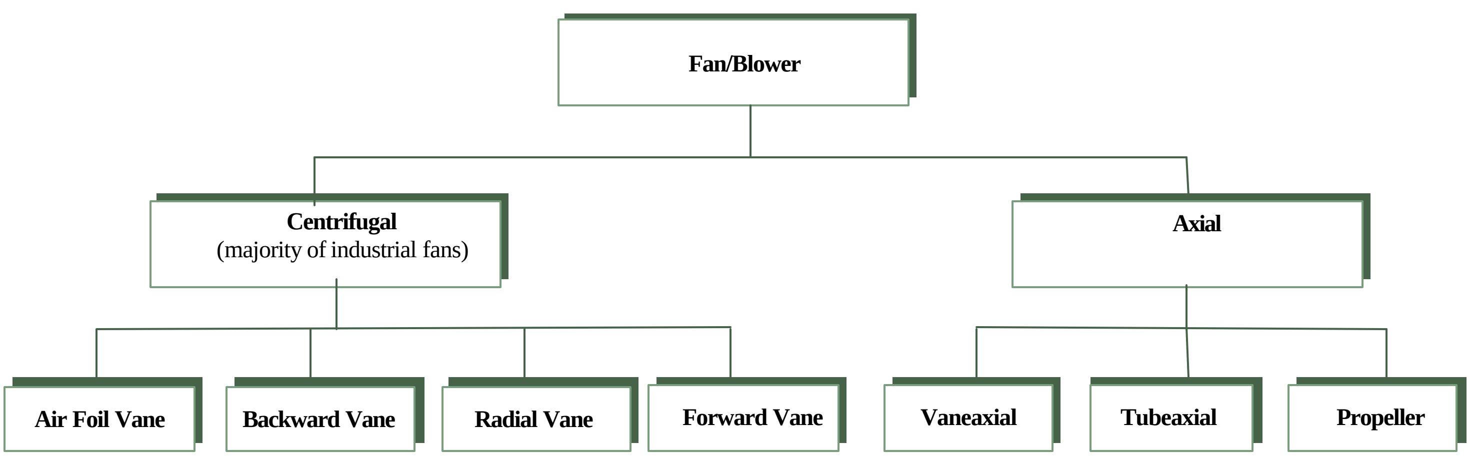
B. *Fans and Blowers*

Respondent Type	Number of Interviews
Fan/Blower OEMs	20
Fan/Blower Distributors	5
Engineering & Consulting Firms	10
Plant Managers & Engineers	100
Utilities	5
Government Organizations	5
Trade Associations and Industry Experts	5
Total	**150**

Fans and blowers are a major source of energy use in the pulp and paper as well as the water and wastewater industries. Most fan and blower manufacturers maintain that the fans and blowers specified in both industries are already energy efficient. Manufacturers indicate that problems with inefficiency are the result of not specifying the equipment properly or not using VSDs and other higher efficiency motors when possible. Like the pump manufacturers, fan and blower manufacturers provide performance curves, which depict the relationship between desired pressure and flow rate as well as provide the fan's efficiency and power requirements.

1. Types of Fans and Blowers

Fan/Blower Segmentation



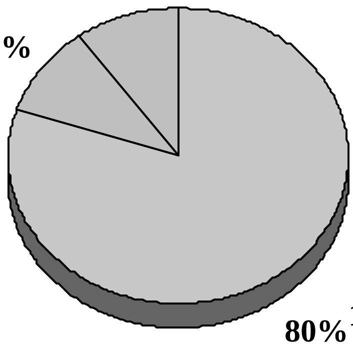
129,500 fan/blowers installed in the pulp & paper and water & wastewater industries in the PNW

Fans are designed to move air through a system. A blower is essentially a fan that produces static pressures greater than 30- in. w.g. at a low airflow. Fans and blowers are used throughout industrial facility applications including the cooling of facilities and equipment, dilution ventilation, and process ventilation. There are essentially two basic types of fans and blowers: axial fans and centrifugal fans. Axial fans provide high air flow and low static pressure. Axial fans move air parallel to the rotational axis. Axial fans can be further segmented into three main categories based on their impellers: vaneaxial, tubeaxial, and propeller. Axial fans are used when space constraints exist. Centrifugal fans provide higher static pressure and lower air flow than axial fans. Centrifugal fans take in air at the center and push the air outward in a radial direction. Centrifugal fans can be further segmented into four major impeller types: air foil vane, backward vane, forward vane, and radial vane. The airfoil vane type is suited for the high speed movement of clean air. The air foil vane fans are the most energy efficient. The backward or backward inclined vane is similar to the airfoil, but is 2-3% less efficient. However, the backward vane fans are more durable and easier to maintain than the airfoil vanes. The radial vane fans are the least energy efficient, but they must be used in applications requiring high static pressure. The production of higher static pressure results in higher energy consumption of the axial fan. Higher static pressure is necessary to move air with solid content. The pulp and paper as well as the water and wastewater industries typically specify the centrifugal fans for most applications unless space constraints require the specification of axial fans.

2. Fan and Blower Sizes

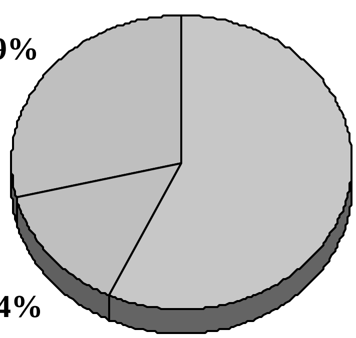
The sizes of fans and blowers can be described in several ways including HP of the motor, diameter of the fan vanes, the cubic feet per minute (CFM) of blowing capacity, and static pressure. Sizing the fan and blower is application specific with factors including pressure required, power required, and density of the air. The diameter of the fan vanes range from 6 to 96 inches. The CFM ranges between 5,000 to 100,000 CFM. Finally, static pressure is another way to measure fans and blowers. The static pressure can range from 2-50 in. w.g. The motor HP ranges from 10-300 HP. Most fans and blowers within the pulp and paper as well as the water and waste industries have less than 50 HP motors.

1999 Fans/Blowers (HP) Sold by Size in the PNW

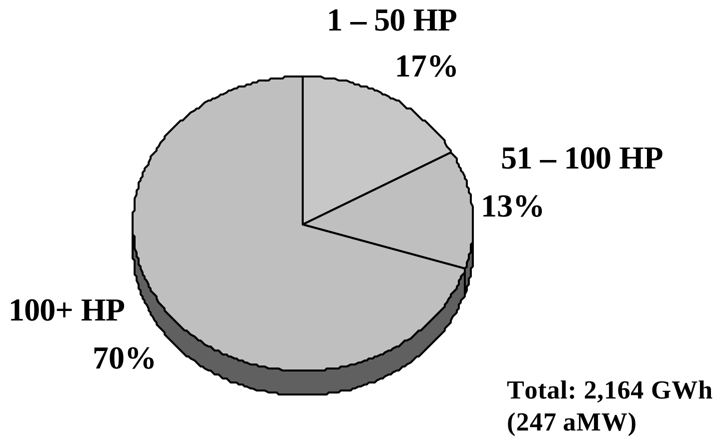


Most fans and blowers serving the industries under study are less than 50 horsepower. The 1-50 HP fans and blowers make up 80% of fans and blowers sold each year to the three industries in the Pacific Northwest. Those fans and blowers that are 51-100 HP comprise approximately 10% of the market. The massive 100+ HP fans and blowers account for 10% of the fans and blowers sold to the two industries in the Pacific Northwest.

1999 Fans (HP) Installed Base by Size in the PNW



1999 Energy Consumed by Fans (HP) in the PNW



Although there are fewer larger HP fan and blower units in the water and wastewater and pulp and paper industries, these larger HP units consume a greater portion of the energy than the more numerous, smaller HP fans and blowers. Fans and blowers greater than 100 HP account for 29% of units installed in the industries under study Pacific Northwest, but 70% of the fan and blower motor load required by the three industries under study. On the other hand, 1-50 HP fans and blowers represent 57% of the installed base in the three industries, but account for only 17% of energy consumed by fans and blowers.

3. Fan and Blower Materials

Fans and blowers specified in the industries under study are typically made of three main types of materials: stainless steel, fabricated steel, and aluminum. The aluminum fans and blowers can withstand temperatures up to 250° F. It is the cheapest of the three materials and is ideal for moving dry, clean air. The fabricated steel is slightly more expensive than aluminum but can handle a wider range of temperatures (up to 750° F). Stainless steel, the most expensive of the materials, is suited for extreme temperatures (up to 1000° F) as well as highly corrosive and moist applications. In addition to these three basic material types, some heavy-duty applications require vane shafts made of Teflon. Fiberglass reinforced fans and blowers are another alternative to the coated fans for high moisture and corrosive environments. Coated fans can become chipped during shipping, handling and maintenance, thereby minimizing their resistance capabilities. Fiberglass reinforced fans are typically slightly less expensive than coated or stainless steel fans. However, fiberglass fans and blowers are heavier and more bulky than the stainless steel or coated fans and blowers. As a result, the fiberglass fans and blowers are less energy efficient.

4. Fan and Blower Evolution

The design of the fans and blowers has not significantly changed in recent decades. There are no changes to the fan and blower design and construction expected in the near future. Like pump manufacturers, several fan and blower manufacturers indicated that some work is being done on the development of new materials. However, this work is being done to find a less expensive, corrosion resistant material for fans and blowers that would reduce maintenance and increase the life of the fan. Although the emphasis of the research is on finding a less costly material, the energy efficiency of the product may be positively impacted if the material is less dense and heavy.

5. Codes Regulating Fans and Blowers

Many codes regulating fans and blowers exist. Many of these codes pertain specifically to the motor, which typically is integrated by the fan and blower manufacturer. The fan must also meet fire and spark resistance standards. Standards for fans and blowers are set by American National Standards Institute (ANSI)/Air Movement and Control Association (AMCA) or ISO. The 1997 ISO 5801 contains the AMCA Standard 210 most recently revised in 1999. The AMCA section 211 is an industry-sponsored guideline, which provides certified performance ratings on air performance for standard fans. Fans meeting this standard are tested in an ideal setting in which the air flowing through the fan is clean and unobstructed. This standard does not replicate true industrial conditions found in the pulp and paper and the water and wastewater industries. These systems typically have airflow obstructions, poorly located dampers, sharp turns and other aspects that decrease true fan efficiency. Whereas standard centrifugal fans are rated between 50-60% efficient, their installed rating is typically only 30-40% efficient.

6. Major Fan and Blower Manufacturers

Several national fan and blower manufacturers supply to the three industries under study. Several niches exist within the fan and blower market. For instance, one manufacturer may produce fans below 125 HP. Other manufacturers produce fans for heavy duty applications. Still others produce very specific fans targeted at one industry or application. Large fan and blower manufacturers supplying to the pulp and paper, water and wastewater and irrigation industries include Howden Fan Company, Greenheck Fan Corporation, New York Blower Company, ACME Engineering, Chicago Blower, Cincinnati Fan and Ventilator Company, Penn Ventilator and Twin City Fan Company. All of these fan and blower manufacturers produce products for the industrial as well as the commercial industries.

Manufacturer	Industrial Fan Sales (Ttl. Mkt.: $550 M)	Industries Under Study Served
Howden	$100 M	Pulp & Paper, Waste & Water
Twin City Blower	$75 M	Pulp & Paper, Waste & Water
New York Blower	$63 M	Pulp & Paper, Waste & Water
Loren Cook	$45 M	Pulp & Paper, Waste & Water
Chicago Blower	$42 M	Pulp & Paper, Waste & Water
ACME	$40 M	Pulp & Paper, Waste & Water
Greenheck	$35 M	Pulp & Paper, Waste & Water
Penn Ventilator	$33 M	Pulp & Paper, Waste & Water
Cincinnati Fan	$23 M	Pulp & Paper, Waste & Water

Howden Fan Company

Howden is considered the industry leader in heavy industrial fans. Howden has a wide array of products and a stable market share in North America and Europe in the water and wastewater, pulp and paper as well as other heavy industries. Its acquisition of New Philadelphia fan has increased the company's focus on the axial fan business.

Twin City Fan & Blower

Through its acquisition of Clarage, Twin City has placed greater emphasis on equipment for heavy industry such as wastewater and pulp and paper. Twin City manufactures centrifugal fans and high-pressure fans going into these industries.

Greenheck Fan Corporation

Greenheck Fan Corporation is considered the industry leader in terms of new product development. Greenbeck's niche market is in the lighter industrial applications.

Penn Ventilator

Penn's acquisition of Barry Blower, a manufacturer that specialized in industrial fans, has solidified Penn's presence in the industrial market place.

New York Blower Company

New York Blower Company manufactures material handling fans, stainless steel fans, pressure blowers, high temperature fans and axial fans for primarily heavy industry including the water and waste as well as pulp and paper industries.

ACME Engineering

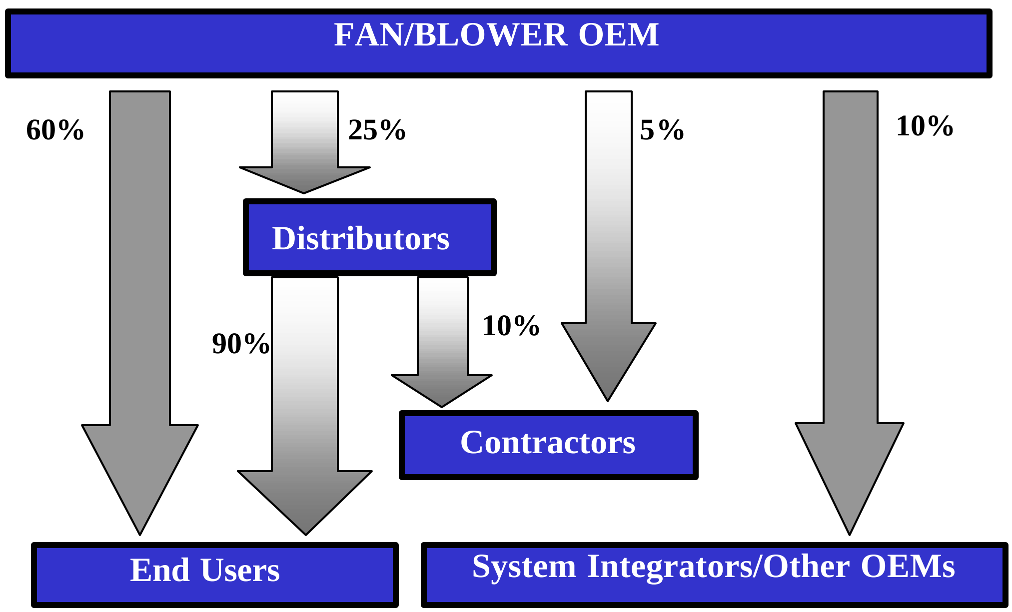
ACME Engineering serves both the commercial and industrial sectors, with an additional focus on the agricultural segment.

Cincinnati Fan & Ventilator Company

Cincinnati Fan & Ventilator Company focuses on the industrial market, manufacturing small heavy gauge industrial fans and ventilators up to 36.5".

7. Distribution of Fans and Blowers

PRODUCT FLOW



Fans and Blowers are distributed to the pulp and paper and the water and wastewater in the Pacific Northwest primarily through fan and blower OEMs and regional OEM affiliated suppliers. The remaining fans and blowers are purchased from fan and blower OEMs and supplied to end users through industrial distributors including HVAC distributors as well as contractors.

8. Drivers in the Purchase Decision Process

End users and contractors in the pulp and paper and the water and wastewater industries take into account several factors when purchasing fans and blowers. Initial cost is the primary driver in the decision process. This emphasis on first cost is especially true of smaller fans and blowers, fans with shorter life spans, and fans in applications that are non-corrosive and less expensive material is acceptable. Operating cost is a factor. End users often include expected equipment maintenance costs with energy consumption when considering operating costs. Brand name and product familiarity is a factor when purchasing fans and blowers as brand name may be an indicator of product reliability and maintenance requirements. Finally, convenience is a factor in the purchase decision as some end users are willing to absorb a slight premium for an earlier delivery date. Energy efficiency is a secondary concern in the purchase of fans and blowers.

9. Fan and Blower Maintenance

As with pumps, maintenance and replacement decisions for fans and blowers vary depending on the industry, the company and the facility practices. Fan and blower OEMs maintain that a regular maintenance is the key to extending the fan's life and making the piece of equipment as efficient as possible. The frequency of the maintenance depends on the harshness of the application and environment. Maintenance checks should include the lubrication of bearings, ensuring the tightness of setscrews and bolts, ensuring the wheel-to-inlet cone clearance when replacing either the wheel or the cone, ensuring the V-belt drive is aligned and has the proper tension, checking for worn shaft seals, and checking the fan's wheel for corrosion or buildup that may cause harmonics or bearing wear. Most end users do a majority of the maintenance routine regularly.

Problems with the fan or blower over the course of its lifetime typically involve excessive vibration, noise, poor performance and early parts failure. Fan imbalance, loose bolts and bearing, wear and tear and material on the wheel of the fan may be the cause of excessive vibration. Excessive noise is often due to loose belt drives and improper location of fan intake system. Performance problems are often due to poor system design and installation. Poor maintenance, misaligned bearings, excessive speed are often the cause for early parts failure. In order to ensure a reasonable life and efficiency, manufacturers stress the importance of proper maintenance.

10. Energy Efficiency Improvements for Fans and Blowers

Fans and blowers are considered by both the manufacturers and end users to be already energy efficient. Friction caused by the pushing of materials through the fan or blower is oftentimes inevitable in industrial applications. Finding a way to reduce the equipment's friction was one example of a means to increasing energy efficiency. However, lowering friction would require a breakthrough in product design or material development, which is not currently a focus for manufacturers.

A major cause for inefficiency is improper specification of the fan type. For instance, some end users will specify a less expensive axial fan for applications requiring high static pressure, thereby lowering the efficiency. Improper specification of the impeller diameter and the vane type is another source of inefficiency. Although fan and blower manufacturers provide general guidelines in the catalogues, end users would benefit from greater assistance with regard to proper equipment selection. End users must be made aware of operating efficiencies and cost savings for the proper specification of fans and blowers.

Finally, VSDs may be a good candidate for the improvement of energy efficiency on fans and blowers. This is due to the varying demands often associated and fan and blower applications. At present, the VSD motor penetration is 10-15% of motors on fans and blowers in the industries under study. VSD specification for fans and blowers are expected to increase especially for fans with motors greater than 100 HP as awareness about the benefits of the technology increases.

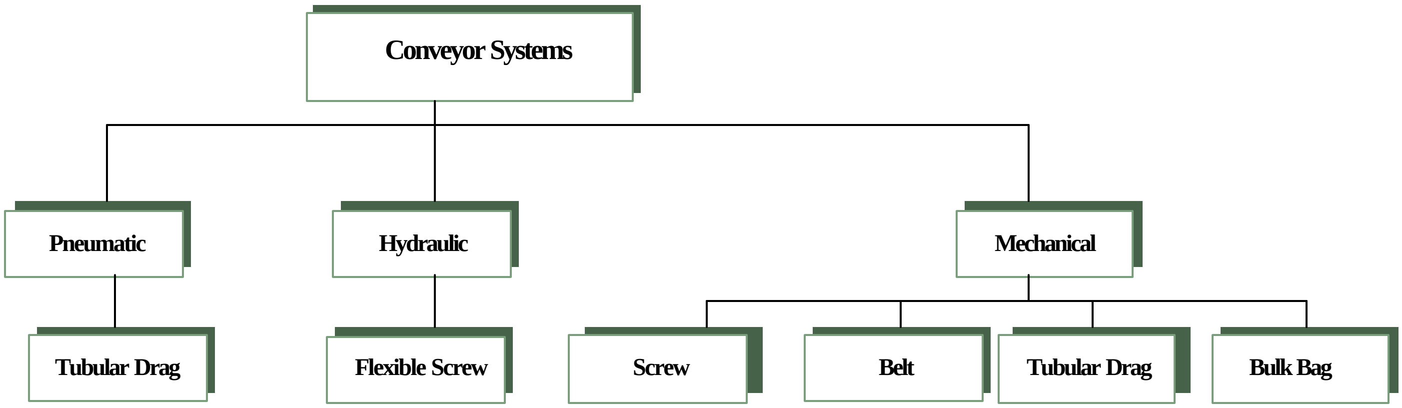
C. ***Conveyor Systems***

Respondent Type	Number of Interviews
Conveyor System Manufacturers	5
Fan/Blower Distributors	10
Engineering & Consulting Firms	3
Plant Managers & Engineers	100
Utilities	0
Government Organizations	0
Trade Associations and Industry Experts	2
Total	**120**

Conveyor systems account for a sizable amount of energy consumption in the pulp and paper and the water and wastewater industries. The conveyor system market differs significantly from the pump as well as the fans and blower markets. Unlike pumps and fans, the conveyor system market is essentially the integration of several different components into a system custom made for an industrial application. Conveyor system can be defined as a system that moves an object or fluid from one location to another. As a result of this broad definition, conveyor systems can refer to a wide array of equipment. Typically conveyor system integrators specialize in a specific industry. The market for conveyor systems in the pulp and paper and the water and wastewater is estimated to be $1 billion.

1. Types of Conveyor Systems

Conveyor System Segmentation



An array of equipment systems can be defined as conveyor systems since a conveyor system essentially is a system that moves products through the facility. However, there are three basic types of conveyor systems being used in the industries under study: mechanical, pneumatic, and hydraulic. Within the mechanical system, there is the tubular drag, screw, belt, and bulk bag unloader systems. The hydraulic conveyor system consists of a flexible screw. Finally, the pneumatic conveyor system consists of a tubular drag system. The tubular drag conveyor transports finely divided, free flowing material regardless if the material is wet or dry. The flexible screw conveyor transports powders, crystals, flakes and granules. The belt conveyor systems transport solids on a moving belt.

There are some fundamental components that typically make up a conveyor system. These components include:

- Framework
- Motor
- Safety Device
- Rollers
- Belt End
- Chain Transfer
- Pushers
- Photo Eye Controllers (transmits flow information to the program which controls the speed of the motor)
- Drive Cabinet (hold the program controlling the motor)

The pulp and paper as well as the water and wastewater industries require conveyor systems for a variety of applications. The pulp and paper industry primarily utilizes the pneumatic and belt conveyor systems. The pneumatic conveyor system is used for sawdust and wood chip removal and conveyor. The belt conveyor moves solids through the plant such as the lumber into the mills. Some applications within a pulp and paper plant may require a bulk bag unloader or a screw system. The water and wastewater facilities typically require a flexible screw, hydraulic conveyor systems for transportation of solids and sludge through the facility.

2. <u>Conveyor System Sizes</u>

Conveyor systems are custom made for each application. As a result, sizes vary by industry, application and facility. Most pulp and paper utilize belt driven conveyor systems are 72”-84” wide. Conveyor systems in water and wastewater treatment plants weigh up to 20 tons. As a rule, conveyor systems require one drive for every 75 feet of length.

3. <u>Conveyor System Materials</u>

Conveyor systems are made of a variety of materials depending on the application. Within the pulp and paper industry 90% of conveyor systems are made of carbon steel. The remaining 10% of these systems is made of stainless steel. In the water and wastewater industries, half of the conveyor systems of comprised of carbon steel. The other half of the systems is stainless steel.

4. <u>Conveyor System Evolution</u>

The design of conveyor systems for the most part has remained unchanged since the invention of the steam engine. The development of sensors has improved flow control in the hydraulic conveyor systems. Significant changes are not expected in the near future. Conveyor system manufacturers are essentially component integrators, and therefore dependent of manufacturers of blowers, motors and other components for the improvement of energy efficiency.

5. <u>Codes Regulating Conveyor Systems</u>

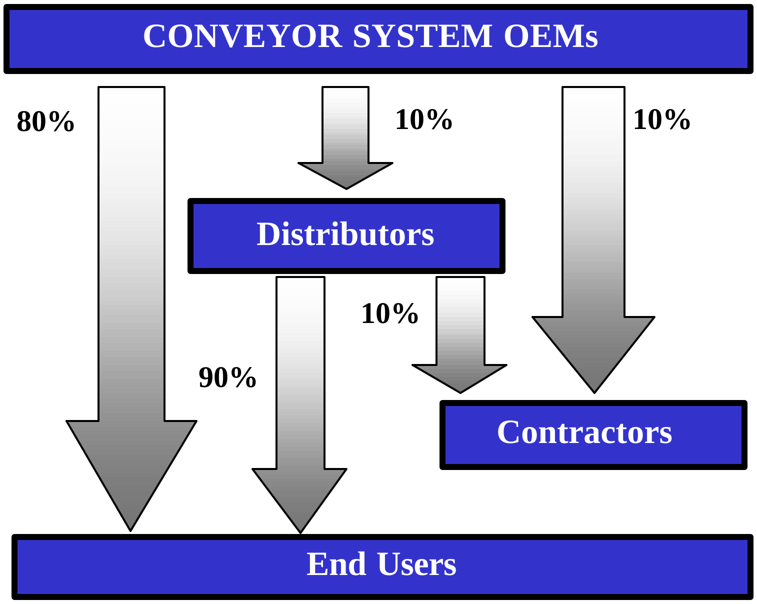
Codes do not regulate conveyor systems. Instead codes exist regulating the components within the conveyor system. The Conveyor Equipment Manufacturing Association (CEMA) has set design criteria and industry standards. The American Institute of Steel Construction (AISC) also provides some standard and fabrication practices. However, standards directly addressing the energy efficiency of the system do not exist.

6. <u>Conveyor System Companies</u>

Most of the conveyor system integrators are national companies. They typically supply the conveyor system as well as its components. Conveyor system integrators typically specialize in pneumatic, hydraulic or mechanical conveyor systems. Conveyor systems recognized in the three industries include Chicago Conveyor Corp (pneumatic), Hapman (flexible screw, tubular, and pneumatic), FMC Energy Systems (belt and screw), Martin (tubular drag and screw), and Transco (screw and belt). However, there are several smaller job shops that integrate conveyor system parts and supply to the pulp and paper and water and wastewater industries.

7. Distribution of Conveyor Systems

PRODUCT FLOW



Conveyor systems are distributed to the pulp and paper and the water and wastewater in the Pacific Northwest primarily through conveyor system integrators. These integrators primarily distribute their products on a national scale, however many focus on one or two industries. The remaining conveyor systems are supplied to end users predominately through contractors.

8. Drivers in the Purchase Decision Process

Cost is a primary driver in the purchase decision process for the conveyor systems. Service is also an important factor. The life a conveyor is up to 20 years. Over the course of the system's lifetime, components must be replaced. A pulp and paper plant typically buys between $100,000 and $200,000 worth of conveyor system equipment a year. End users place emphasis on the service provision by the company supplying the conveyor system and ultimately the replacement components.

9. Energy Efficiency Improvements for Conveyor Systems

Integrators and end users maintain that the conveyor systems are sufficiently energy efficient. Maintenance is considered to be critical to the system's energy efficiency. In addition to regular maintenance, blowers must be resurfaced or replaced every 3 to 5 years. The motor efficiency is another source of the system's efficiency. If the system's energy demands have peaks and flows, a VSD motor would be suitable. At present, the penetration of VSDs is less than 10%. Penetration is expected to grow at a slower rate than pumps and fans and blowers in part due to a relatively low level of industry consolidation and organization.

D. Motors and Drives

The motor and drive market in the Pacific Northwest is similar to the national market. Motor and drive manufacturers distribute their products to original equipment manufacturers (OEMs), distributors, irrigators, and end users including pulp and paper, water and wastewater facilities as well as irrigators. Distributors account for the largest proportion of sales. Most distributors are small, local operations offering motor rewind services and additional parts. These distributors typically push the lowest cost and most readily available equipment, rather than the most energy efficient equipment. Due to the dominance of large corporations and the level of consolidation, some manufacturers in the pulp and paper industry such as Weyerhauser will have a direct purchase contract with motor manufacturers rather than going through a distributor.[4]

1. Motor Manufacturers

Motor manufacturers supplying to pump, fan/blower and conveyor system OEMs as well as to end users and distributors include USEM, Siemens, GE, Baldor, Lincoln, Leeson and Magnetech, Reliance and Toshiba. Although these motor manufacturers are similar in terms of product offering, they vary by emphasis on price and quality or efficiency. Lincoln, Leeson and Magnetech market their motors through emphasis on low prices. USEM, Baldor, Reliance and GE have substantial product lines and place emphasis on the mid range quality and price motors. These four companies represent approximately 40% of the motor market in the United States. Toshiba and Siemens stand out due to the emphasis on the high quality motors.[5] Major drive manufacturers supplying to the industries and equipment OEMs include Seimens, ABB, and Rockwell Automation's Reliance and Allen Bradley.

The three industries have different motor purchase behavior. The irrigation industry tends to be very conservative with regard to motor purchase decisions. The industry is more apt toward motor rebuild rather than purchasing a new motor. If utility rebates are offered, irrigators will purchase premium efficiency motors.

The pulp and paper industry was one of the earliest adopters of premium efficiency motors. This is due to the industry's concentration on energy efficiency in order to save money in this commodity market. The replacement of DC motors with packaged AC motors and drives has been an industry trend over the past decade.

2. Use of Variable Speed Drives

Applications with variable loads likely will increase efficiency by installing a variable speed drive motor (VSDs). Variable speed drive motors increase the life of the equipment, require less maintenance, in

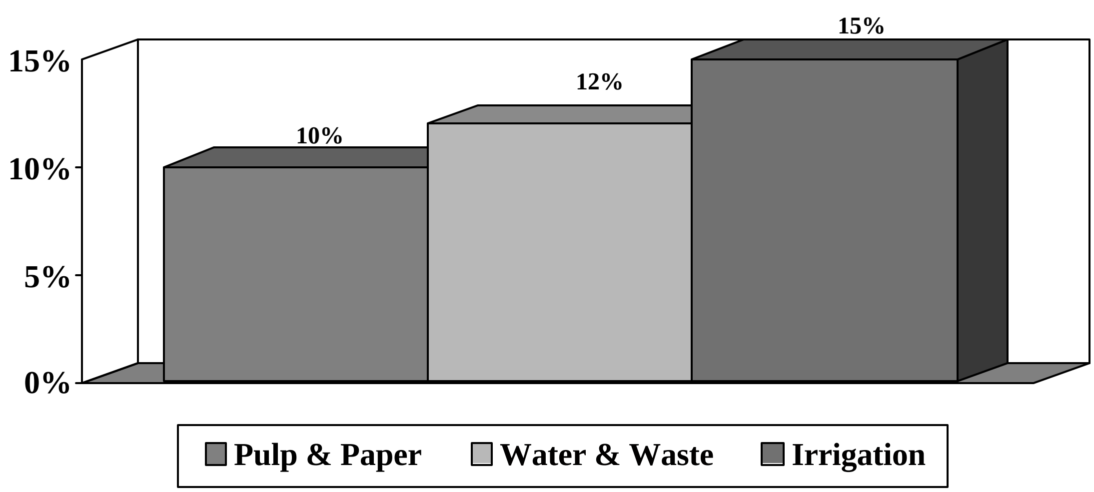
[4] Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

[5] *Ibid.*

addition to saving energy. Acting like a reduced voltage starter by reducing the amount of current, VSDs run at the necessary speed for the flow rate desired.

There are three types of VSD motors. The application and environment determine the type of VSD that should be used. The VSDs include a voltage source inverter, current sound inverter, and pulse width modulation. The voltage source inverter is capable of handling a wide speed range, has a simple design, and controls multiple motors from a single source. The voltage source inverter's drawbacks include the lower power factor at lower speeds and harmonics. The current source inverter is considered reliable and cost effective. It is suited for large motors greater than 200 HP. The current source inverter suffers from decreasing power factors at low speed and is not suited for the operation of multiple motors. Finally, the pulse width modulation has a constant power factor and is capable of handling a wide speed range. It has open circuit protection and is considered highly efficient. The pulse width modulation suffers from noise problems and design complexity. Specifiers will examine their equipment and application needs to determine which of the three types of VSD is best suited for the application.

1999 Percent Penetration of VSD's
Installed on Pump, Fan/Blower and Conveyance Systems



In the Pacific Northwest, VSDs on pump applications are penetrating the three industries under study. The use of VSDs in the pulp and paper industry is approximately 10% of all pump motors. In water and wastewater, VSDs represent 12% of motors on pumps. Approximately 15% percent of pump motors are VSD's in the irrigation industry. The use of VSDs is more frequent especially true in systems with highly variable demands. Irrigation canals, for instance, have only a 5% VSD penetration, whereas farms have nearly 25% penetration due to the varying flow requirements. Estimates indicate that VSD's are expected to reach a penetration rate of nearly 50% by 2004 as awareness of the technology and its benefits becomes more recognized.

The use of a VSD can result in significant energy savings in the industries under study. VSDs can reduce equipment pumps, fans and blowers energy requirements to nearly half. For instance, a pump with a 25 HP motor that is in operation 23 hours a day (2 hours at full speed, 8 hours at 75% speed, 8 hours at 67% speed, and 5 hours at 50% speed) can reduce its energy costs by 45%.[6] This could equate to a $2700 annual saving at $.05 kWh. The overall savings do vary by equipment size, motor load characteristics and friction.

A typical installed drive for a 25 HP motor is approximately $11,000, thereby making the payback period in the above example just about 4 years. The payback period for the investment in a VSD is typically one to three years. However, due to the lower electricity costs in the Pacific Northwest ($.02-.07 per kWh), payback periods in this region are slightly above the national level.

Variable speed drives are most often integrated into new equipment. Integrated VSD and motor systems are known as Smart Motors and typically the way in which VSDs are introduced into new systems. VSDs can be ordered separately from the motor and are often ordered in those cases in which the application already exists. VSDs can be applied to the entire range of HP motors. Current penetration of VSD motors is higher in the in the smaller HP motors. However, the trend is toward VSDs in larger HP motors. They are becoming increasingly popular with 20-50 HP motors.

The major barrier to entry for VSD technology is the initial cost. Equipment purchase decisions are based primarily on first cost. Some specifiers are unaware of exact operating cost savings, and therefore the initial cost is the major factor in the decision. End users indicate that if they were made more aware of the benefits of these motors and the application candidates for these motors, they would be more likely to specify the VSDs. General contractors and engineering consultants tend to be even more cost sensitive. Unless the end user specifies a VSD motor, the contractor will typically order the less expensive, non-specialty motor. Efforts should be targeted at creating end user awareness about the specific benefits of VSD.

E. ***Equipment Overview***

The equipment under study, pumps, fans/blowers, and conveyor systems, have existed and been refined for over several decades. Manufacturers, end users as well as contractors maintain that the equipment itself is as efficient as possible for each application. Only

[6] "Efficiency Strategies-Variable Frequency Drives" Energy-Water Connection, California Energy Commission (http://www.energy.ca.gov/water/tech/vfds.html)

marginal opportunities for energy efficiency exist for improvement of equipment design. Hence, it is necessary for the Alliance to target the systems as a whole.

The occurrence of inefficiency is the result of improper specification of the motor as well as improper selection of the equipment with respect to size and application. For instance, a pump or fan may be oversized in order to account for greater demands that may be required in the future. While this practice may increase operating costs and lower efficiency, it may prevent end users from having to incur the upfront cost of replacing or purchasing additional equipment to accommodate greater demand. These sources of inefficiency can be improved through education and increased awareness for all those involved in the decision making process: the specifier within each industry, the distributor, the equipment OEM as well as the engineering consultants if they are involved. By creating awareness, the Alliance would incentivize the end users to improve their specification, purchase decision, and equipment maintenance because it translates to the bottom line.

F. ***Industry Summary***

The pulp and paper, water and wastewater and irrigation industries have different dynamics from one another. The pulp and paper industry is defined by the production of a commodity product. Therefore, the pulp and paper industry is compelled to find ways to cut costs as even minimal savings could equate to a major advantage over a competitor. The water and wastewater industry is primarily made up of municipal organizations. Like many other government organizations, the treatment facilities order equipment by taking bids from several companies offering contracts to the lowest bidder. As a result, most facilities are primarily concerned with first cost. The irrigation industry is a fragmented industry made up of local and federal governments, private ditch and canal companies and individual farmers. In addition, the systems for distributing water vary significantly based on the source of the water, the environment, and the end use demands. The purchase decision for pumps within this industry varies significantly among these market actors as well as the system make up. All three industries are primarily driven by first cost. Energy efficiency is a secondary consideration due to lack of awareness or cost constraints.

G. Water and Wastewater

Respondent Type	Number of Interviews
Equipment Manufacturers	40
Equipment Distributors	10
Engineering & Consulting Firms	5
Plant Managers & Engineers	50
Utilities	5
Government Organizations	3
Trade Associations and Industry Experts	7
Total	**120**

The water and wastewater industry accounts for a significant portion of the Pacific Northwest's industrial motor load. In 1998, the industry account 2,100 GWh (240 aMW) in the Pacific Northwest.[7] The water and wastewater industry is a significant target for energy efficiency initiatives because of the privatization trends and the new focus on cost cutting. The water and wastewater industry may be extremely accepting of energy efficiency initiatives. Although both the water and wastewater industry segments were studied, the wastewater segment was the core focus of the research due to its greater energy demand.

The dynamics of the water and wastewater industries are very similar. However, the wastewater treatment industry is more energy intensive. The water and wastewater industrial growth directly correlates with population growth. The growth of the wastewater industry is about 10% a year nationally. In the Pacific Northwest, it is estimated that the wastewater industry is growing at a rate of approximately 7% per year. The water treatment industry is growing at a rate of 5% nationally, and 4% in the Pacific Northwest. This growth is slightly higher in metropolitan cities in the Pacific Northwest. Growth in both the water and wastewater segments typically does not translate into new facilities. Rather, growth generally results in the expansion of existing facilities.

1. Segmentation of Water Treatment Plants

Although the purchase decision process, the maintenance and bureaucracy of the water and wastewater facilities are similar, there are some pronounced differences. In addition to the differences in the processes for treatment, the main difference is in the energy requirements for the two processes. The water treatment industry is less energy intensive than the wastewater industry. The lower energy requirements are largely due to the

[7] Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

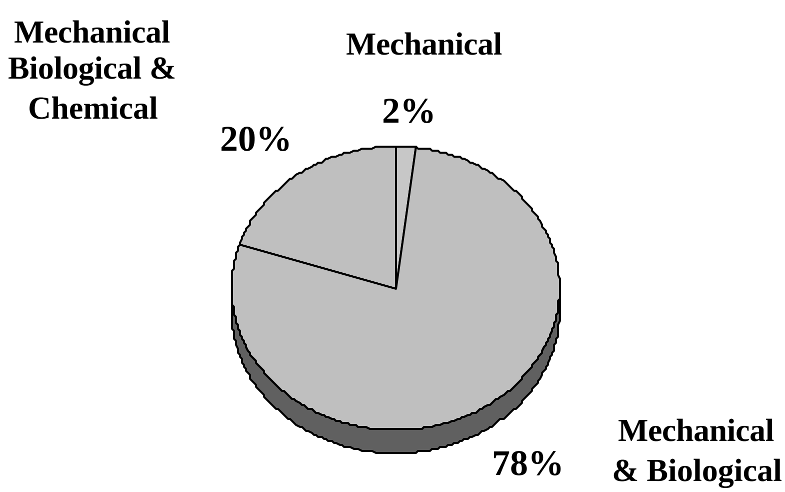
fact that water treatment plants are typically smaller, pumping fewer gallons per day. Also, unlike wastewater treatment plants, water treatment plants are not required to have 50% redundancy in which a plant must be capable of handling twice the load that is currently attained. In addition, water treatment differs from wastewater due to the seasonal nature of water treatment. During the summer months, plants run at their maximum capacity. During the winter, plants typically treat approximately 25% of the maximum capacity.

2. Overview of Water Treatment Plant Process

There are five steps in the water treatment process. Pumps are required to move the treated water from one step to the next. The first step is coagulation. This step involves the adding of aluminum sulfate to the raw water. The second step, referred to as flocculation, involves the mixing of the positively charged aluminum sulfate with the raw water to form an ionic bond. The bond essentially is the formation of flock particles. Sedimentation is the third step. In this step, particle matter formed in the previous step is allowed to settle and is then removed. The remaining water is filtered to remove any remaining debris. In the final disinfecting step, remaining bacteria and odor is eliminated through the addition of chemicals. These steps may be repeated.

3. Segmentation of Wastewater Plants

Wastewater Treatment Plants in the PNW



There are three types of processes for water treatment in the wastewater industry: mechanical, biological, and chemical. The mechanical process involves the transfer of wastewater across the plant and the transfer and removal of solid waste. In this process, an air bubble is created through mixing the wastewater. The air bubble promotes bacteria growth for the consumption of organic or chemical waste. Finally, the treated water is discharged. The biological process is an addition step that involves the growing of microorganisms to dissolve or break down organic waste in wastewater. The additional step of chemical processing involves the chlorination and dechlorination of treated water for additional disinfection.

Every facility utilizes the mechanical process. Facilities that have a more extensive requirement for treatment due to high population or extensive waste use both biological and mechanical processes. For even greater treatment demand applications, water and wastewater use a combination of all three processes, mechanical, biological, and chemical, to treat the water. Facilities utilizing only the mechanical process represent 2% of the plants in the Pacific Northwest. Facilities with both mechanical and chemical processes represent 78% of water and wastewater treatment plants the Pacific Northwest. Finally, 20% of plants utilize all three processes. The number of plants using all three systems is expected to grow as population and waste create a larger demand for treatment facilities.

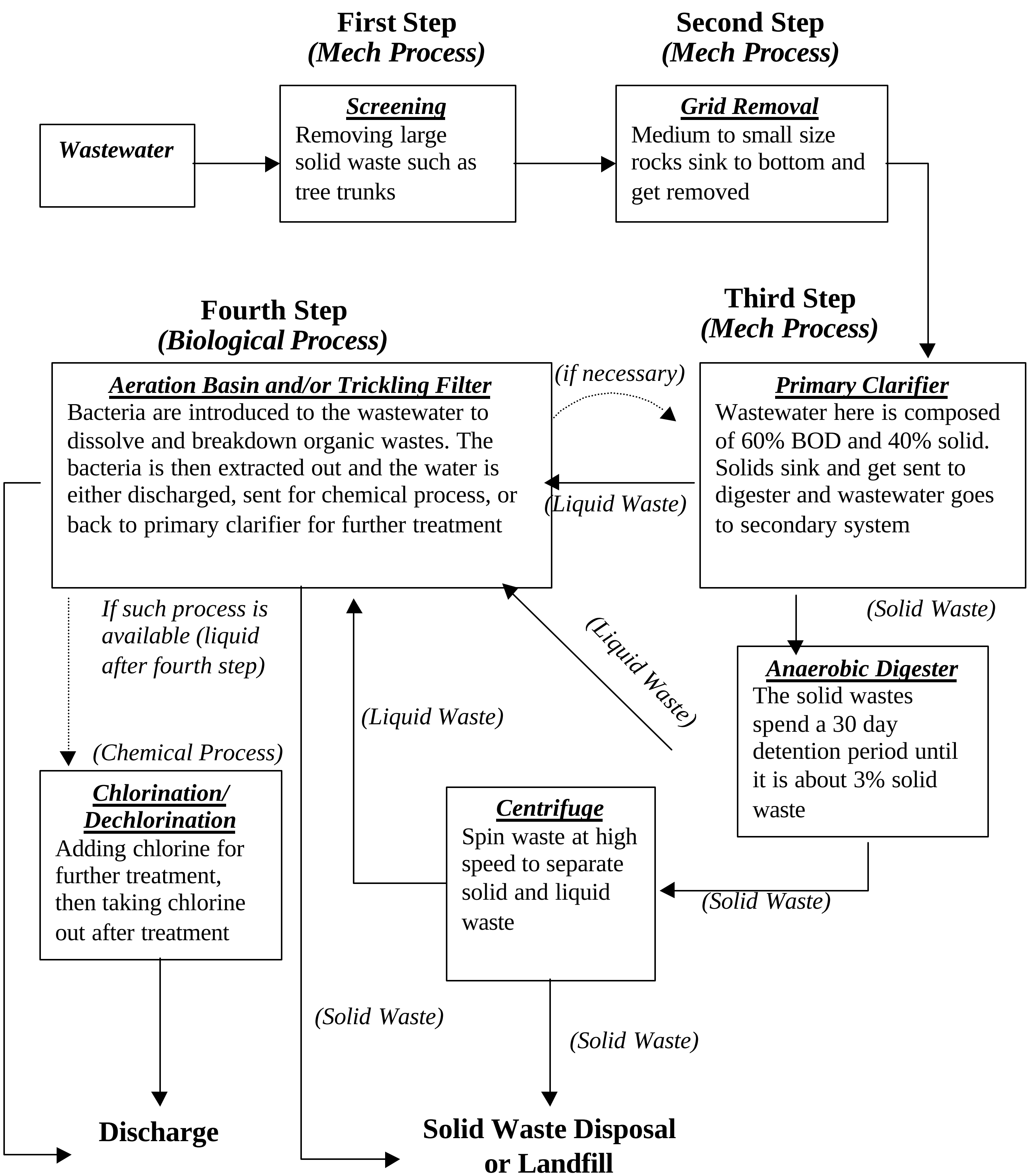
4. Wastewater Treatment Process Overview

Most wastewater treatment plants utilize a treatment method with a primary mechanical process and secondary biological process. The primary mechanical process involves the screening, grid removal, primary clarifying, and anaerobic digestion. The screening stage removes the large solid waste such as tree trunks. The grid removal stage involves the medium and small size debris such as rocks and tree limbs that sink to the bottom and are removed. At the primary clarifier stage wastewater is composed of 60% organic wastewater and 40% solids. The solids sink to the bottom and are sent to the digester, and the wastewater goes directly to the secondary biological process. The anaerobic digester is the final stage of the mechanical process in which the solid wastes settles for 30 days until it is only about 3% solid waste.

The secondary biological process treats the liquid waste after the solids have been removed. This process involves the aeration basin and/or the trickling filter. The aeration basin is essentially a large water tank that promotes the growth of bacteria which digest and dissolve organic wastes. There are two types of aeration methods: diffusion and mechanical. The diffusion method delivers compressed air through the diffuser into the bottom or body of the water tank to produce air bubble on the surface for bacteria growth. The mechanical creates the air bubble by mechanically mixing the water. In addition, the trickling filter may be utilized in the biological process. The trickling filter involves layers of rocks to promote bacteria growth. Wastewater is injected onto the top layer allowing bacteria to dissolve and breakdown as the wastewater flows through.

In some cases, the wastewater may flow through a fourth step for UV disinfection. This step involves the addition and removal of chlorine for further treatment and clarification of the water. The clean water is then discharged.

Treatment Plant Process Overview



5. Water and Wastewater Treatment Facility Sizes

The size of both water and wastewater treatment plants are determined by the amount of water in gallons that is treated per day. By law the plants that treat wastewater must have at least 50% redundancy. This essentially means that a plant treating a certain amount of water a day must be equipped for the treatment of twice that load. Wastewater treatment plants in the Pacific Northwest range in size between 500,000 and 120 million gallons per day. There are approximately 710 wastewater treatment plants in the Pacific Northwest. The average size of a municipal wastewater facility in the Pacific Northwest is between 1.3 to 1.8 million gallons a day. The large difference in demand between a large city such as Seattle and a small rural area accounts for the range of plant sizes in the Pacific Northwest. Large plants that range from 1 million GPD to 100 million GPD (average 16 million GPD) account for 20% of wastewater facilities.

6. Water and Wastewater Industry Trends

A major trend in the water and wastewater industry is privatization. Privatization is essentially to take over of plant operations of a water and wastewater utility by a privately owned company. The takeover may be the assumption of maintenance and operations through contracted services from a municipality or outright sale of the plant. The contracting out of facility maintenance and operations is especially attractive in smaller communities since these smaller communities can take advantage of the economies of scale associated with contracting services to a national company with multiple contracts. Essentially operations and management that is contracted out entails the regular check up and maintenance of a facility. A maintenance engineer employed by a private company may be responsible for the maintenance of multiple facilities. This cuts back on labor costs. Critics maintain that private companies are interested in cutting costs and will be inclined to purchase the lowest cost and often less efficient equipment. However, proponents of privatization maintain that in order to renew the contract, the company must be able to present a track record of efficient operations.

Major private companies with expertise in water and wastewater plant maintenance and operations include USFilter, United Water, PSG, US Water, Schlumberger, American Water Works, Environmental Management Corporation, OMI (a division of CH2M Hill), and ECO Resources. Currently, private water companies serve only 15% of the US population. In the Pacific Northwest, less than 10% of plants have privatized. However, this number is expected to grow at both the regional and national level as budget restraints from local governments continue.[8]

The privatization in this industry may positively impact energy efficiency initiative efforts. Privatization has meant the extensive reexamination of

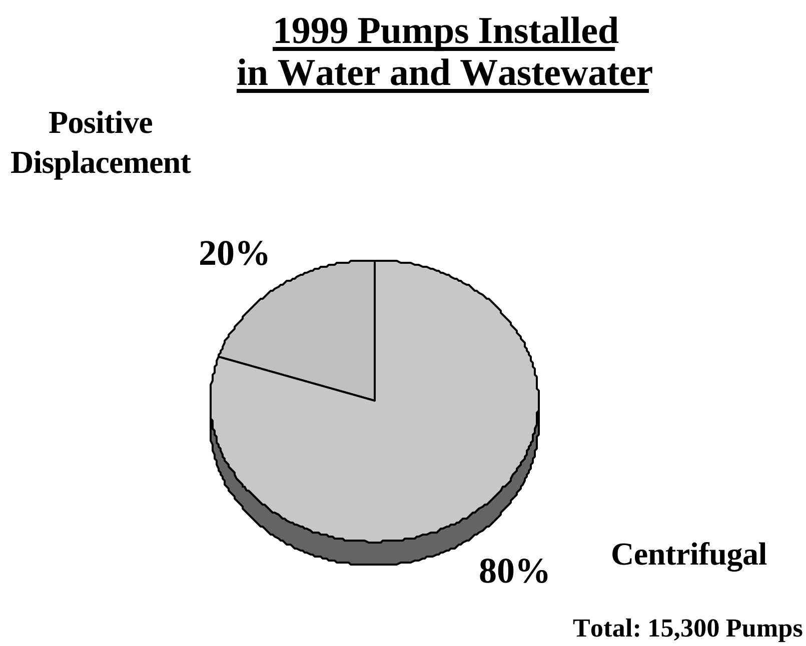
[8] "Privatization Spurs Debate" Silvie Dale (on line editor) Water World. June 2000. Pg. 1, 16-18.

costs and efforts to trim inefficiencies. This translates into the new focus on energy efficiency of processes and equipment.

Another trend impacting energy usage in the water and wastewater industry is the addition of processes and steps in order to provide more clean water and accommodate growing demand on the system. A greater number of water treatment plants are implementing processes with more than one cycle. An increasing number of wastewater facilities will incorporate all three processes, mechanical, biological, and chemical into treatment methods in order to meet demand and maintain quality.

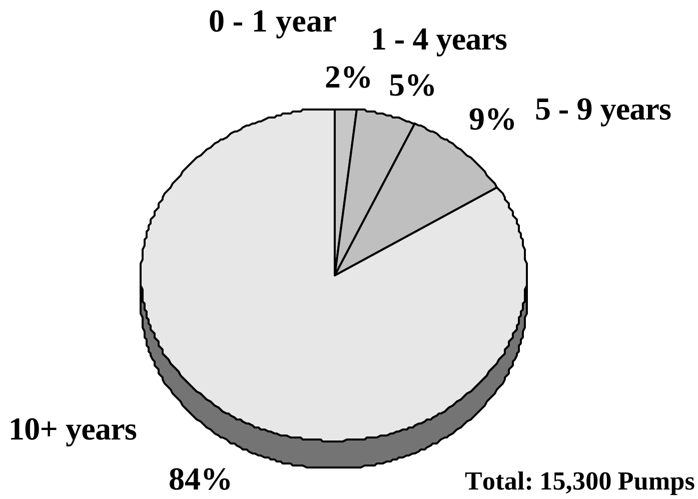
In addition, environmental pressures have lead to the practice of repeating steps in order to ensure that the treated water is clean. In response to federal laws passed and Endangered Species Acts, an increasing number of water and wastewater facilities are treating the water multiple times. Essentially, wastewater coming out of the biological process is sent back through the mechanical and biological processes before it is discharged. Whereas this may increase energy usage, many indicate the environmental implications outweigh energy saving concerns.

7. Existing Equipment

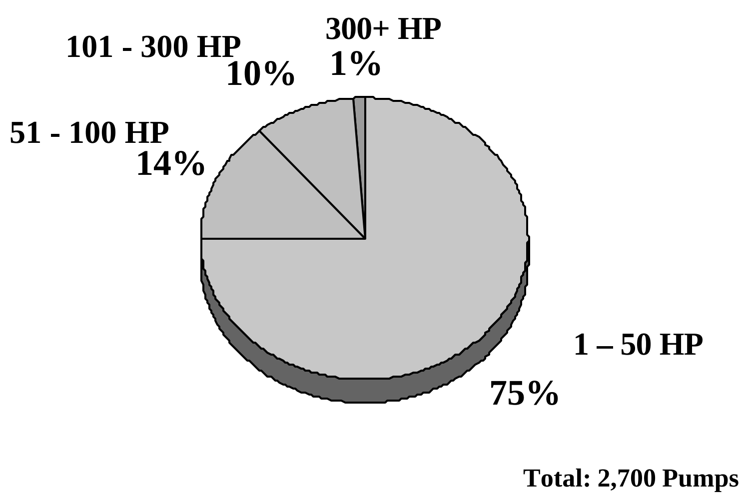


Pumps, fans and blowers as well as conveyor systems account for approximately 60% of a water and wastewater treatment facility's energy consumption. Pumps account for the largest amount of energy consumed in a facility. Typically, 80% of a facility's pumps are centrifugal pumps. Submersible pumps account for 1% of the centrifugal pumps. Positive displacement pumps account for the remaining 20% of pumps in a typical facility. The expected lifetime for the average pump is 10 years to 15 years if the pump is properly maintained.

Age of Pumps Installed in Water and Wastewater

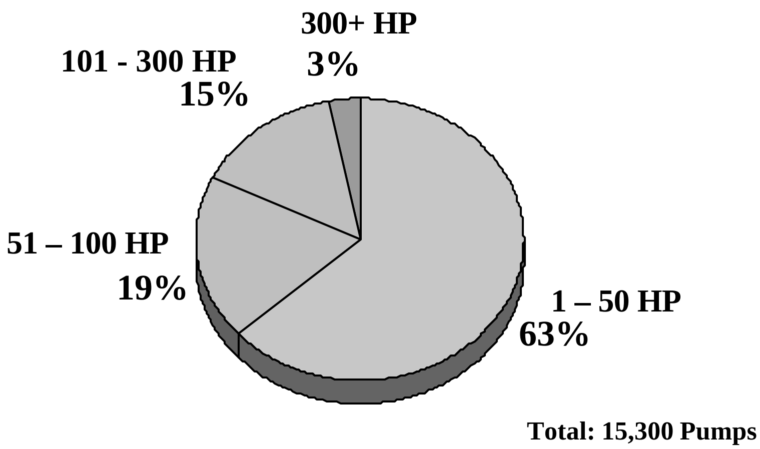


1999 Pump Size (HP) Sold in Water and Wastewater

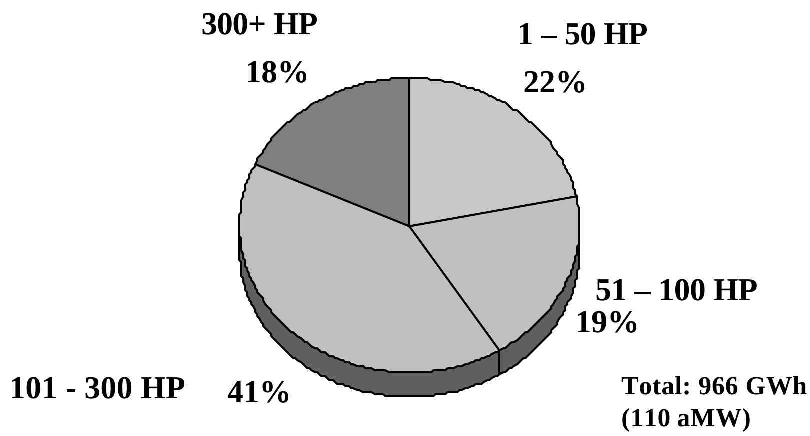


Pumps in the water and wastewater treatment facilities vary in size. A majority of pumps are less than 50 HP. However, pumps in water and wastewater treatment plants can be over 500 HP.

1999 Pump Size (HP) Installed Base in Water and Wastewater

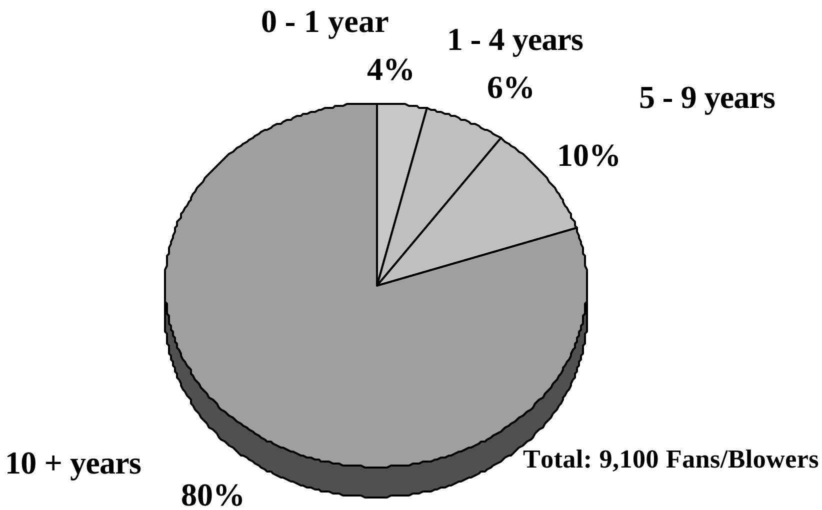


1999 Energy Consumed by Water & Wastewater Pumps (HP) in the PNW



The different size HP pumps in the water and wastewater treatment consume disproportionate amounts of energy. Although 50 HP make up 63% of the pumps installed in the facilities, they consume relatively little energy. Only 22% of pump energy in the water and wastewater industries is from 1-50 HP motors. On the other hand, pumps in water and wastewater treatment plants greater than 300 HP make up only 3% of installed pumps but account for 18% of consumed pump energy.

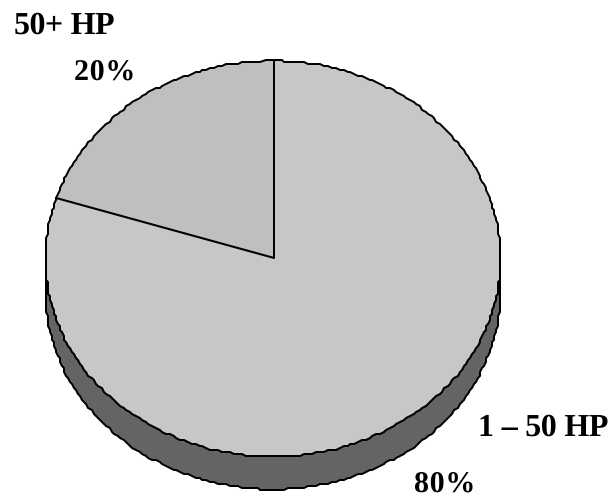
Age of Fans/Blowers Installed in Water and Wastewater



The age of a given pump varies by treatment facility. On average, a water and wastewater plant purchases three new pumps a year. A majority of large pumps which consume a majority of energy in a given treatment facility are 10 years or older. These older pumps have been subjected to years of wear and tear and have decreased its energy efficiency. However, if properly and regularly maintained, a pump's energy loss may be marginal. Perhaps a greater threat these older pumps pose to energy efficiency is with regard to the motor. Of the pumps that are 15 years or older, 75% of the motors in these pumps have been replaced at least once. The remaining 25% of the motors that have not been replaced in over 15 years are likely to have motors below current efficiency requirements as motor manufacturers were not subject to these standards at that time.

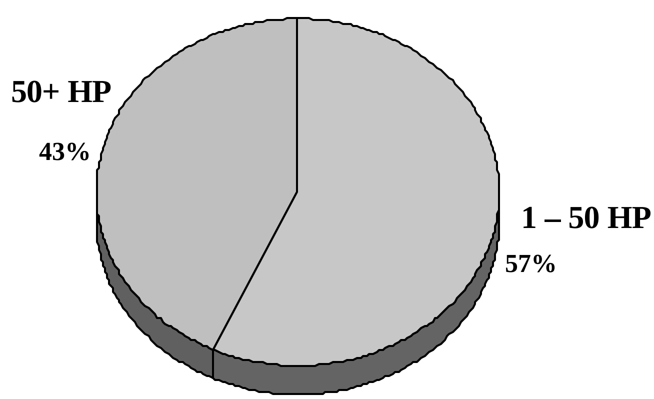
Centrifugal fans and blowers are used in the wastewater industry for aeration purposes. A majority of these fans are less than 50 HP. The lifetime of a fan is expected to be approximately 16 years and could reach 25 years if the fan is properly maintained.

1999 Fan/Blower Sizes (HP) Sold in Water and Wastewater



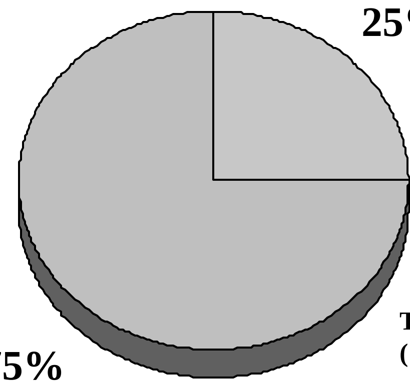
Total: 1,300 Fans/Blowers

1999 Fan/Blower Sizes (HP) Installed in Water and Wastewater



Total: 9,100 Fans/Blowers

1999 Energy Consumed by
Water & Wastewater Fans/Blowers (HP) in the PNW



Fans and blowers in the water and wastewater treatment facilities vary in size. A majority (57%) of fans and blowers installed in facilities are less than 50 HP. However, fans and blowers under 50 HP in water and wastewater treatment plants account for 25% of the fan and blower energy consumed.

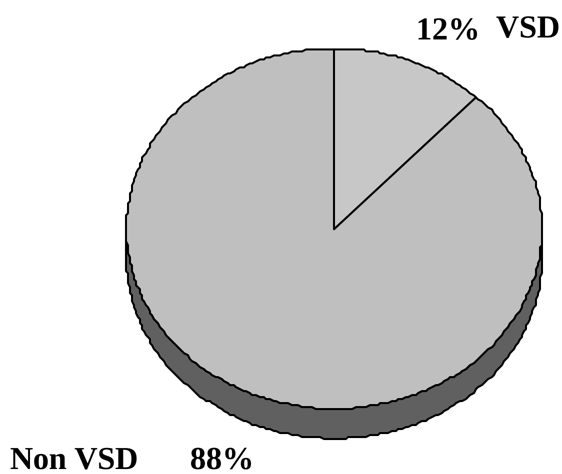
A fan or blower is typically purchased once every other year. A majority of fans and blowers in the wastewater industry are 10 years or older. Like pumps, nearly 25% of these fans' motors have never been replaced.

Conveyor systems are another source of energy consumption in the water and wastewater industries. Conveyor systems consume an estimated 5% of the total energy required for a water and wastewater facility, approximately 105 GWh (12 aMW). The flexible screw conveyor system is commonly used in the water and waste industries to transport water and waste through the different processes. Sizes of the conveyor systems vary significantly based on the application and facility design. A conveyor system is expected to have a life span of at least 15 years. Regular maintenance and replacement of components may double the expected life to 30 years.

8. VSD Penetration in Water and Wastewater Industry

VSDs are suitable for pump and fan/blower applications in the water and wastewater industry in which the flow requirements vary. Throttling motors which restrict flow or movable air vanes on fans are also used for varying flow. However, these devices are significatly less efficient than VSDs. At present VSD motors are typically reserved for applications requiring greater than 100 HP motors. The additional expense makes it difficult to justify VSDs for the smaller motors even with the short payback period. However, operating costs are taken into greater consideration when purchasing motors greater than 100 HP, and as a result, VSDs have a higher penetration within the larger motor segment Approximately, 55% of VSD motors are purchased as a package wih a new pump, fan/blower, or conveyor system.

VSD Motor Penetration in Water and Wastewater (Installed)



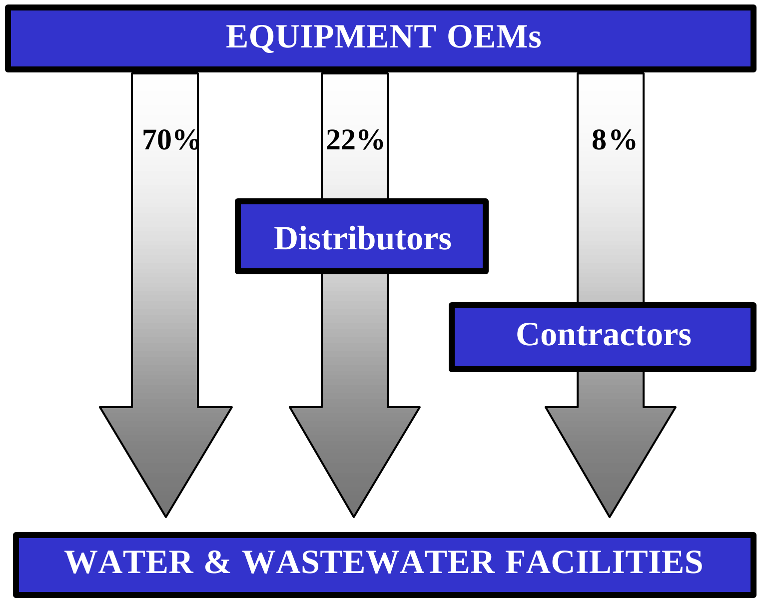
9. Equipment Maintenance

Equipment maintenance is typically a regular process within the water and wastewater industry. Engineers from the maintenance department conduct annual or semi annual equipment checks in which all pieces of equipment undergo visual and computer inspections. Oftentimes a plant engineer will also perform the same checks on a monthly basis for those pieces of equipment that are used more frequently. Some plants will perform routine visual inspections of the equipment. Maintenance engineers concede that the more frequently equipment is checked and serviced, the longer the life span of the equipment.

Once equipment has been checked, the engineer reports any problems with the equipment to the maintenance manager at the facility. The maintenance manager then determines whether to repair or replace the piece of equipment. The propensity in the industry is to repair equipment whenever possible rather than replace equipment. Typically, the only time equipment is replaced is if it is beyond repair or is cheaper to replace than to repair.

10 Equipment Purchase

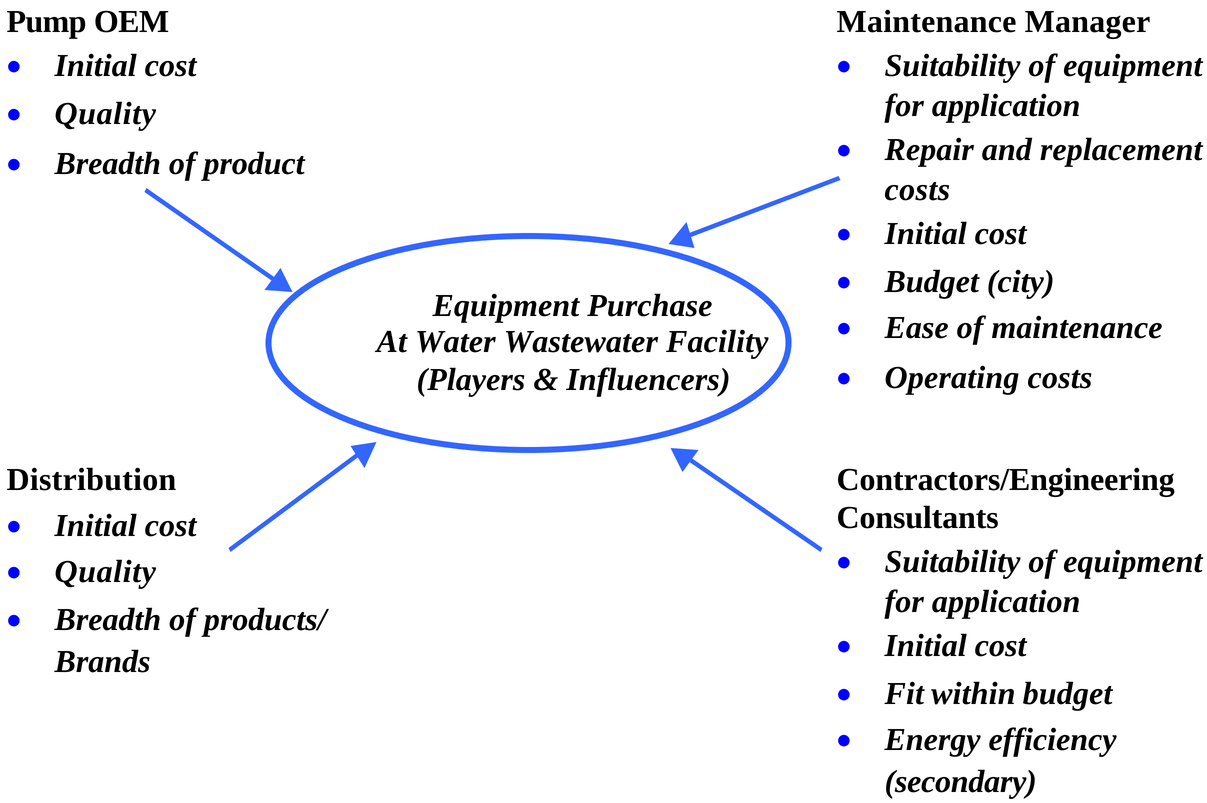
PRODUCT FLOW



The municipal water and wastewater treatment plant's maintenance manager is responsible for purchase decisions. In the case of expansion, the maintenance manager reports expected costs and equipment needs to the plant supervisor who, in turn, reports this information to city officials for approval. All equipment purchases are new. The maintenance manager will purchase equipment components rather than an entirely new piece of equipment whenever possible. Facilities typically solicit price bids from equipment OEM and distributers for new pieces of equipment, and the contract usually is awarded to the lowest bidder.

In cases where facilities are being enlarged or new facilities are being added, contractors or engineering consultants may also be responsible for equipment purchases. Design and construction consulting in the water and wastewater industries are provide by companies including Black & Veatch and CH2MHill. Engineering consultants will make recommendations on equipment sizing and specifications. Depending on the facility, the consultant may order the necessary equipment or defer to the facility manager to order the equipment as usual such as through lowest bidder process. It is necessary to make engineering consultants aware of new technology and initiatives as they may in turn inform the water and wastewater facitlity managers and maintenance.

Purchase Decision Influencers



11. Energy Efficiency

There are several areas in the water and wastewater industries in which energy efficiency can be improved. However, barriers must be addressed in order to achieve energy efficiency improvements. Barriers to energy efficiency include:

- R&D COST: The most recognized area of improvement for energy efficiency is the friction loss due to system design or viscous, heavy materials going through the system. Most engineers and managers recognize that friction decreases energy efficiency. However, those in the industry feel the R&D expenses spent on finding ways to lower friction would not be recovered from the potential energy savings.
- NEW TECHNOLOGY COST: It is recognized in the industry that VSD installation into existing equipment could increase energy efficiency by 20%. However, installing VSD motors require sizable capital investments. A VSD installed drive can range from $3000 for a small HP motor to $48,000 for a customized 300 HP motor. As a result of this initial cost barrier, maintenance managers are extremely conservative when specifying VSD motors.
- EQUIPMENT REPLACEMENT COST: At present, nearly 70% of facility equipment is older than 15 years. Although replacing this equipment would increase energy efficiency, plants tend to retain and repair existing equipment. The additional cost of the new equipment, the down time between purchase

and delivery, as well as the labor spent installing and learning about the new piece of equipment is a disincentive to equipment replacement.

- PURCHASE DECISION RESPONSIBILITY: Although the equipment is specified at the plant level, the maintenance manager is ultimately tied to relatively constrained budgets established at the municipal level. It is difficult to make someone outside the facility understand operating cost and efficiency.
- LACK OF NEW TECHNOLOGY AWARENESS: Most maintenance managers do not know the particular benefits of VSD motors in terms of operating cost savings. Therefore, it is difficult for these managers to justify technology investment with payback period calculations

Initiatives exist that can be undertaken to remove obstacles to energy efficiency. Suggestions made by water and wastewater maintenance personnel, equipment manufacturers, as well as industry officials regarding energy efficiency improvement include:

Market Transformation

- The Alliance should provide specific examples of energy savings incurred as a result of using more energy efficient equipment. Provide a calculation of payback period.
- The Alliance should provide information on new energy efficient equipment. Send brochures providing information about VFD motors including the advantages of the technology and suitable applications.
- The Alliance should provide information on how to properly specify equipment for various applications. An overwhelming amount of variables exist in the industrial environments, and providing equipment overviews may improve the equipment selection process.

Resource Acquisition

- Utilities and other interested parties should provide subsidies to replace older (greater than 8 years) pumps above 100 HP as these size pumps are responsible for 59% of pump energy consumption in the water and wastewater industries.
- In addition, utilities and other interested parties should provide subsidies to replace older (greater than 15 years) fans/blowers above 50 HP as these size fans/blowers are responsible for 75% of fan energy consumed in the water and wastewater industries.
- Utilities should also consider subsidizing potential energy saving equipment such a VFDs for installation on higher HP equipment.

H. Pulp and Paper

Respondent Type	Number of Interviews
Equipment Manufacturers	40
Equipment Distributors	10
Engineering & Consulting Firms	5
Plant Managers & Engineers	50
Utilities	5
Government Organizations	0
Trade Associations and Industry Experts	10
Total	**120**

The pulp and paper market is a major industry in the United States and is the largest manufacturing industry in the Pacific Northwest. Pulp and Paper is a largest industrial consumer of motor energy in the Pacific Northwest. In 1998, the industry required 10,084 GWh (1,150 aMW) for pulp and paper production in the Pacific Northwest.[9] Pulp and paper is, therefore, a necessary focus for energy efficiency initiatives.

The demand for pulp and paper has remained steady or increased slightly in the past decade, while the capacity has decreased over the past year. The result has been increased prices and improved annual dollar sales for manufacturers. Sales volume for the pulp and paper industry increased 19.6% last year from $29.2 billion in the first quarter of 1999 to $34.9 billion in the first quarter of 2000. This increase is largely attributed to the fact that supply is tight, and prices are rapidly increasing. Specifically, market pulp prices are up 25-40% from last year, depending on the grade. Containerboard prices are up 10-15%. Printing/writing paper prices are up 3-5%, depending on the grade. And linerboard prices are up 2%. In addition, overall net profit margin for the pulp and paper industry improved from 3.2 to 5.3%.

However, in spite of this positive earning growth, the industry is still facing consolidation and facility closures. These closure are due to competition from foreign countries including Brazil, Chile, Indonesia, and Australia, the decrease of timber harvests, the base of the pulp and paper products, as well as the environmental pressures for clean air and efficiency compliance resulting in the mandated purchase of new capital equipment. Industry capacity for pulp and paper production is expected to grow only at a rate of 0.7% per year.

[9] Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

The Pacific Northwest accounts for 10% of national pulp and paper sales. The region produces a disproportionately large amount of pulp, a highly energy intensive process.[10] Within the Pacific Northwest, Oregon and Washington have the highest production of paper and paperboard. Together, pulp and paper plants in Oregon and Washington produced over 3.9 million tons of paper and paperboard.

The pulp and paper industry is characterized by its production of a commodity product. Pulp and paper manufacturers are constantly in search of ways to cut costs. Although only 1% of a typical pulp and paper manufacturer's revenues are devoted to R&D, engineers specifying equipment tend to look for new equipment and technologies that would have lower up front costs or save the plant money in terms of operating efficiencies. Cutting costs through more energy efficient equipment would lower manufacturing costs significantly because the industry is the third largest consumer of purchased energy of all manufacturing industries in the United States. Although pulp and paper plants enjoy relatively low electricity costs, these plants are still motivated to cut costs further to accommodate for the additional freight costs of shipping the product to the more central, more populated areas of the country.

1. <u>Segmentation of Pulp and Paper Manufacturers</u>

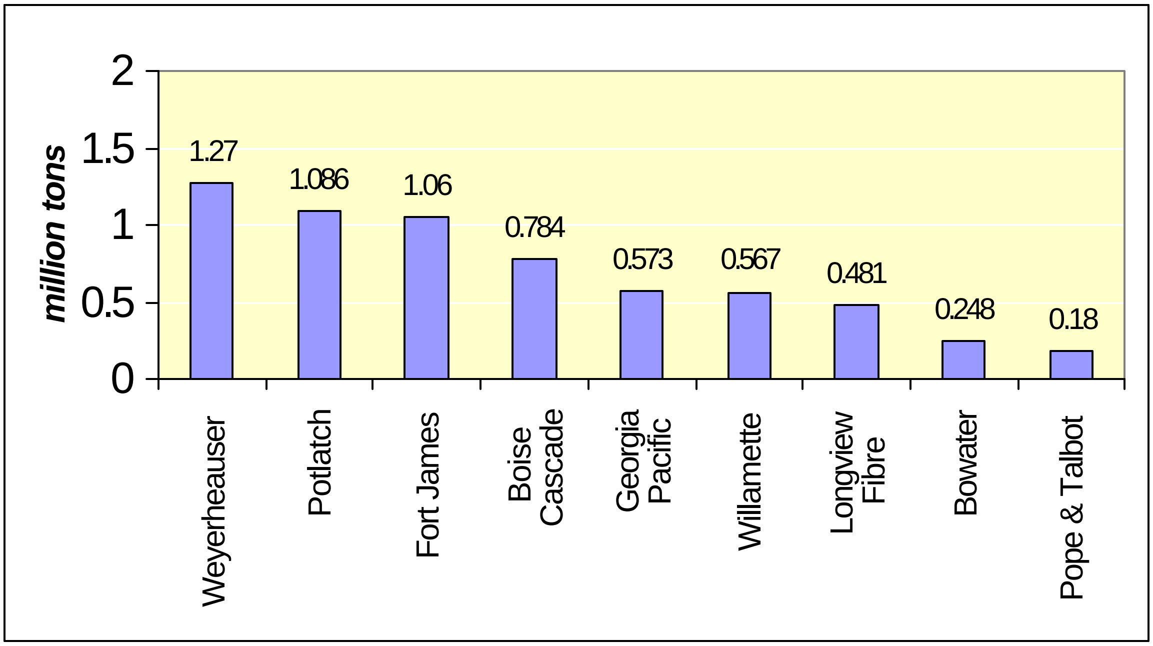
Pulp and paper manufacturers range from being fully integrated pulp and paper manufacturers to highly specialized within one segment of the industry. The large manufacturers typically consist of an entire value chain, from the cultivation of trees for production to the manufacturing of several types of paper for end users. One mill may specialize in one end product or several. Smaller companies tend to be more focused on one aspect of the value chain, such as production of market pulp or the manufacturer of one type of paper product.

The pulp and paper industry in the Pacific Northwest is dominated by several large players, most of which have plants and mills throughout the country. Major pulp and paper manufacturers in this region include Weyerheauser, Potlatch, and Fort James. Plant closures, such as International Paper's closure of the Gardner, OR, have taken large manufacturers such as International Paper out of the Pacific Northwest's manufacturing market.

There are approximately 30 pulp and paper mills in the Pacific Northwest. The top nine manufacturers (11 plants) in this region account for nearly 75% of production.

[10] *Ibid*.

1999 Pulp & Paper Production Volume in the PNW



Weyerheauser

Weyerheauser is considered the leader in the industry in terms of energy efficiency. The company has spent significant R&D and devoted much of its capital expenditures toward energy efficient products and processes. Weyerheauser operates two mills in the Pacific Northwest. One mill in Longview, Washington produces chemical wood pulp for world markets, coated and uncoated fine paper, and paperboard. The other mill in Springfield, Oregon produces containerboard packaging. Together these mills produced an estimated 1,270,000 tons of pulp and paper in 1999, which makes Weyerheauser the top producer of pulp and paper in the region.

Potlatch

Potlatch is a leading supplier of pulp. Potlatch has one mill in Lewiston, Idaho, which produced 1,086,000 tons of pulp, bleached paperboard, and tissue in 1999. Total capacity for the mill is 1,130,000 tons.

Fort James

Fort James has three facilities in the Pacific Northwest. In Oregon, the company has one mill producing communications papers and tissue, and one mill producing only tissue. In Washington, Fort James has one facility that produces both communications papers and tissue. Together these three mills have an estimated annual capacity of 1,060,000 tons of pulp and paper per year.

Boise Cascade

Boise Cascade operates two pulp and paper facilities in the Pacific Northwest. One facility in St. Helens, Oregon produces uncoated free sheet paper and market pulp. The other in Wallula, Washington makes uncoated free sheet paper, market pulp, and containerboard. Together these mills produced 783,822 tons of pulp and paper in 1999. Their combined annual capacity is 850,000 tons.

Georgia Pacific

Georgia Pacific operates one mill in Bellingham, Washington that produces market pulp, lignin products, tissue, and tissue products. The annual capacity of pulp and paper products at this facility is 573,000 tons.

Willamette

Willamette has one brown paper mill in Albany, Oregon with an annual capacity of 567,000 tons.

Longview Fibre

Longview Fibre operates one pulp and paper mill in Longview, Washington that produces pulp, which is manufactured into kraft paper and containerboard. Its annual capacity is 481,000 tons.

Bowater

Bowater has one newsprint mill in Usk, Washington that produced 248,000 tons in 1999.

Pope & Talbot

Pope & Talbot operates one bleached kraft pulp mill in Halsey, Oregon with an annual capacity of 180,000 tons.

2. Segmentation of Pulp and Paper Processes

The pulp and paper industry produces a variety of products for multiple applications. The products typically fall under three major categories: pulp, printing/writing, paperboard, and newsprint. Some companies have plants, which are designed for manufacturing one type of product, while other companies have plants that are used for the production of multiple products.

Pulping Process

Most plants in the Pacific Northwest produce pulp for use in their paper production segments as well as market pulp intended for sale. The two variations of the pulping process are mechanical and chemical.

The mechanical process is an abrasive process, in which wood fibers are separated by mechanical pressure. There are some variations to the traditional mechanical processes, which involve the addition of chemicals and/or heat to soften the wood chips, thereby requiring less mechanical energy. Few pulp and paper plants in the Pacific Northwest utilize the mechanical pulping process without some pretreatment to make the wood softer. Thermomechanical pulping is the process in which wood chips are softened with steam before the grinding step. The Chemi-thermomechanical process further breaks down the wood chips by exposing the chips to a sulfur-based chemical prior to the steaming and grinding steps. The heat and pressure required for the mechanical process make it necessary to utilize durable metal or fiber reinforced plastics, which tend to be bulky and less energy efficient. The more the chips broken down before the grinding step, the less energy is required in the final process.

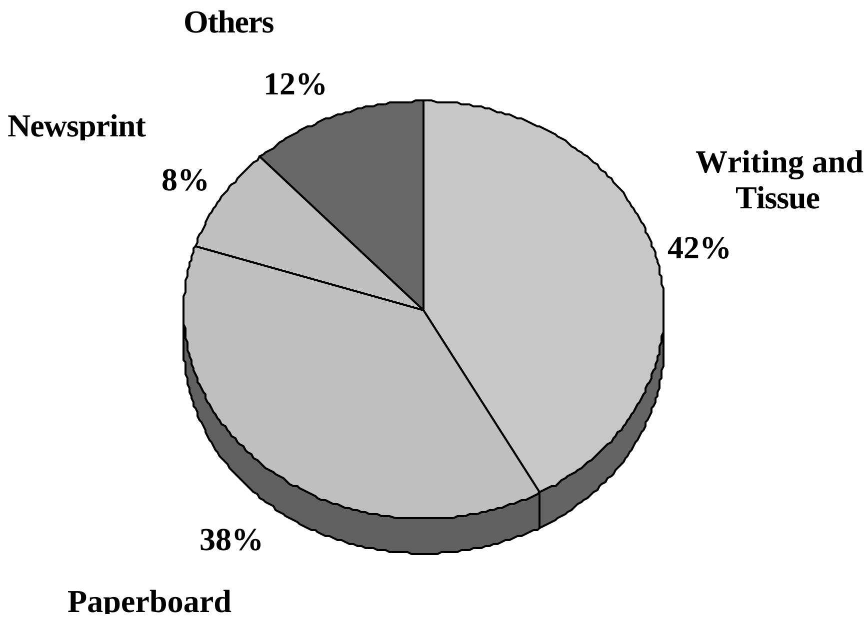
The mechanical process, produces pulp that is opaque and has good printing properties, but it is weak and discolors easily when exposed to light due to residual lignin in the pulp. Mechanical pulp is used to produce newsprint, tissue, or paperboard. Mechanical pulp can also be fluff pulp, which is used in the manufacture of products such as disposable diapers and other sanitary items.

The chemical process is less energy intensive than mechanical pulping. The process is essentially a system of pressure cooking wood chips along with chemicals such as sodium hydroxide and sodium sulfate. The most common type of chemical pulping is the sulfate, or kraft, process. The chemical penetrates the wood and dissolves the lignin, resulting in a pulp that is stronger and more durable, with better color.

The chemical process produces fluff pulp, kraft pulp, sulfite pulp, and unbleached pulp. Kraft pulp is a strong fiber used for writing and communication paper. Sulfite pulp is produced with sodium hydroxide. Bleached pulp is any pulp that goes through a bleaching process.

Paper Making Process

1999 Pulp and Paper Products Produced in the PNW



The paper industry includes the production of printing paper, which is any paper suitable for printing, and paperboard, which is generally thicker and more rigid. These broad categories can be broken down further into five sub categories: writing paper, newsprint, tissue, paperboard and packaging, and specialty paper products. Some companies have plants, which are designed for manufacturing one type of product, while other companies have plants that are used for the production of multiple products.

All paper manufacturing begins with watery pulp, which is sprayed onto a giant plastic screen. The pulp fibers bond together and then the water is drained out. Finally, the paper is pressed between heated rollers to make it dry and smooth.

An additional step may be added to the stages of either process. This involves the recovery of recycled paper. In this step, the recovered paper is immersed in water, forming pulp slurry. The slurry is screened, cleaned and de-inked to form a pulp, which is ready to be formed into paper. The recovery rate of waste paper is greater than 45%, making the use of this additional step more common. Waste recovery increases energy efficiency as it is simpler to break down pre processed paper than to produce paper from the wood.

3. Pulp and Paper Industry Trends

The pulp and paper industry is often subjected to pressures from government and environmental groups to incorporate processes, which are more environmentally friendly. One such pressure may come from the enactment of the Cluster Rules, which is sponsored by the Environmental Protection Agency (EPA). In 1998, the EPA published regulations and established standards for non-combustion sources under the Clean Air and Clean Water Acts. The Cluster Rules are aimed at regulating water and air emissions in the pulp and paper industry. All pulp and paper manufacturers must be in compliance with the Clusters Rules by the first quarter of 2001. The capital requirements for most companies to comply these new regulations are projected to be between $30-40 million dollars on average. These funds will be spent on new capital equipment that would meet these stricter emission requirements. The purchase of new equipment may provide an opportunity for the investment in more energy efficient equipment and technologies.

The Cluster Rule has been a major reason for the recent trend in mill closing. Major manufacturers have had to closely evaluate the costs associated with purchasing new equipment meeting the Cluster Rule standards. It is simply too expensive in some cases, especially in the older mills, to purchase the necessary equipment.

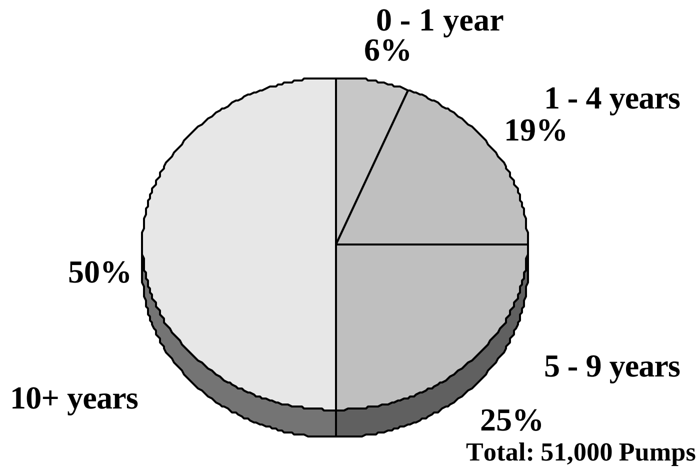
Consolidation is another industry trend in recent years, making the market less fragmented and drastically decreasing smaller companies. Industry consolidation in recent years is largely due to the increased foreign competition and capital necessary to meet environmental requirements.

4. Existing Equipment

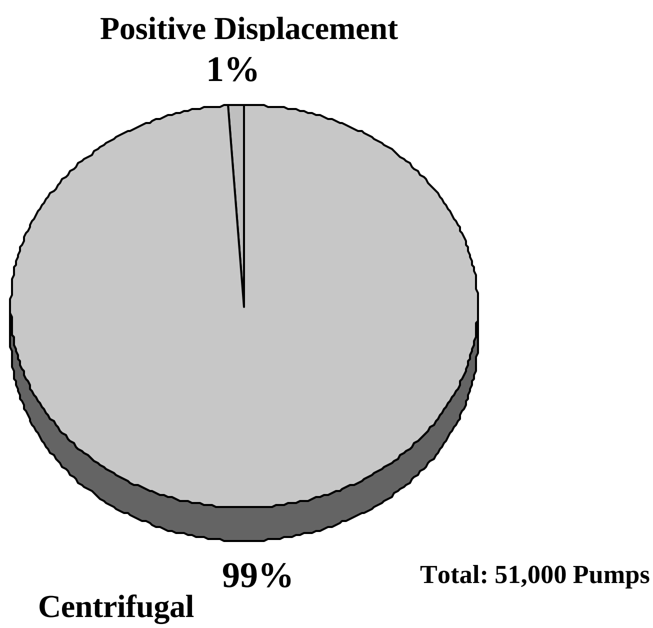
The pulp and paper industry consumes a large amount of energy to manufacture and produce paper and paperboard. Pumps, fans and blowers as well as conveyor systems account for 75% of the energy consumed in a typical plant. Due to the highly corrosive nature of the production process, the equipment is replaced more often than in other industries. Every five years, equipment pieces have to be significantly overhauled or replaced. The impeller is often replaced on the pumps and fans/blowers. In addition, the motor is often rewound or replaced during this five-year period.

Pumps account for the largest amount of energy consumed in a given plant. Typically, 99% of a facility’s pumps will be centrifugal pumps. Positive displacement pumps account for the other 1% of the pumps. The expected lifetime for the average pump is less than 10 years, although some of the larger HP pumps have life expectancies of 20 years. Pumps in the pulp and paper industry receive frequent maintenance.

Age of Pumps Installed in Pulp and Paper

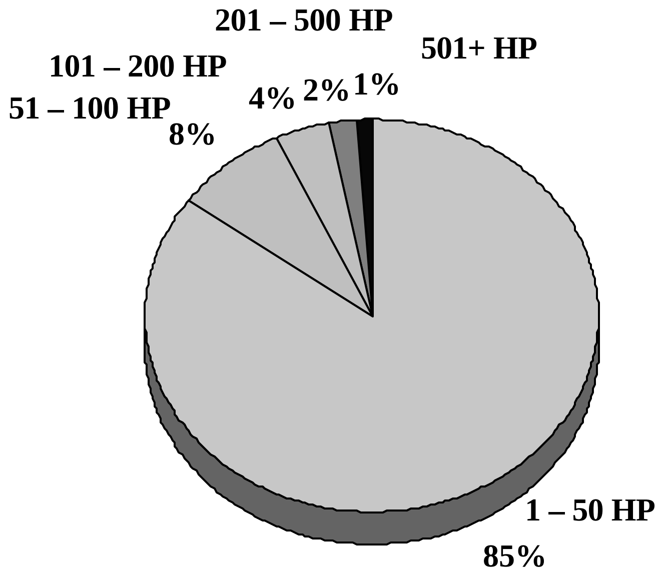


Types of Pumps Installed in Pulp and Paper



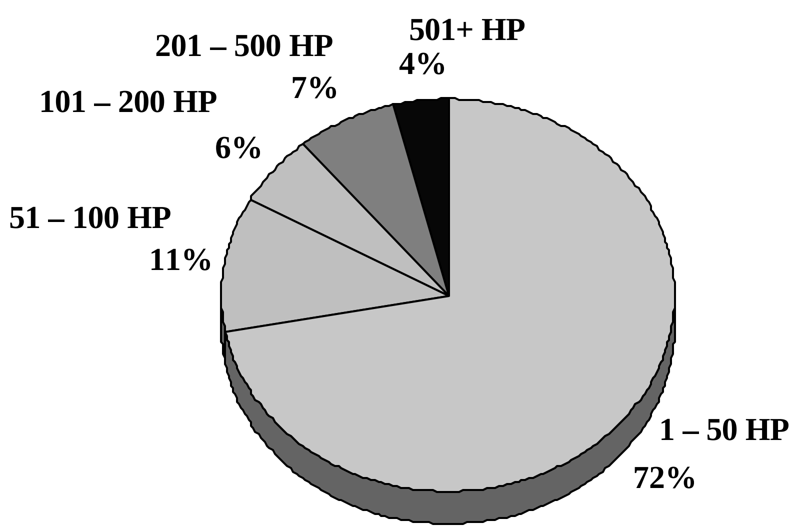
Pumps in the pulp and paper plants vary in size. A majority of pumps are less than 50 HP. However, pumps in the pulp and paper industry can be greater than 500 HP.

1999 Pumps Sizes (HP) Sold in Pulp & Paper Industry



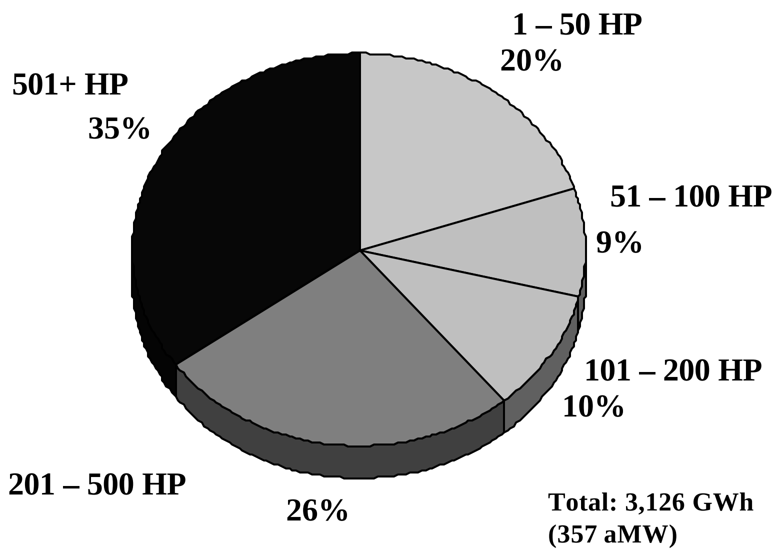
Total: 8,900 Pumps

1999 Pumps Sizes (HP) Installed in Pulp & Paper Industry



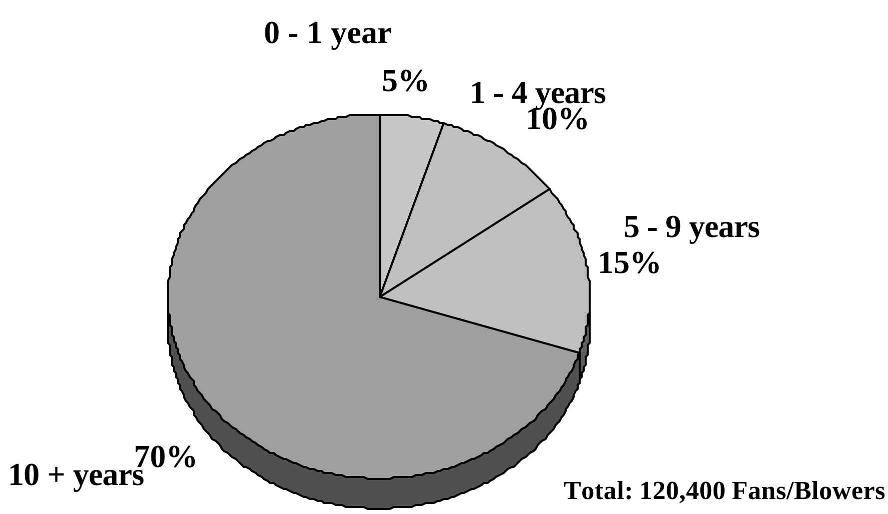
Total: 51,000 Pumps

1999 Energy Consumed by Pulp & Paper Pumps (HP) in the PNW

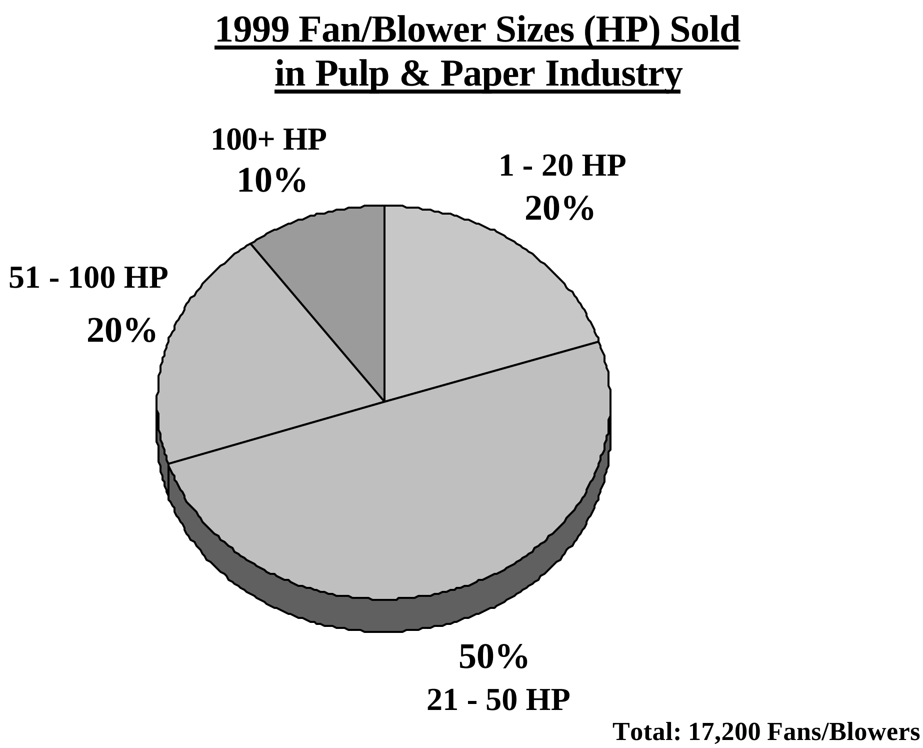


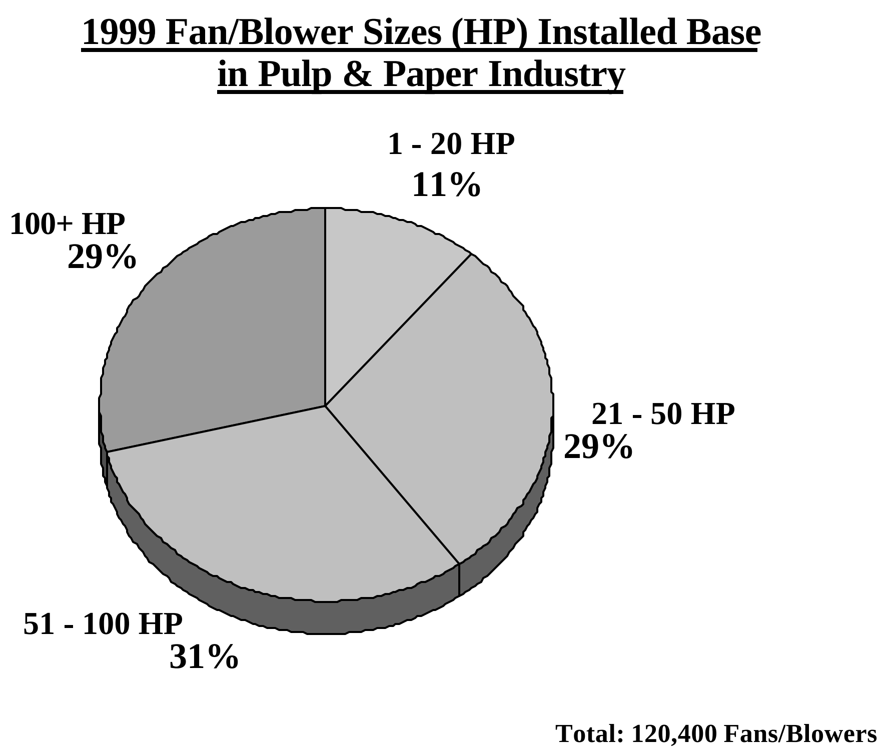
The installed base of pumps in the pulp and paper industry range from 1 to greater the 500 HP, with a substantial concentration of 1-50 HP pumps. However the greatest consumer of pump energy are the pumps greater than 500 HP in spite of the fact that these pumps have the lowest installed base in the pulp and paper industry.

Age of Fans/Blowers Installed Pulp and Paper

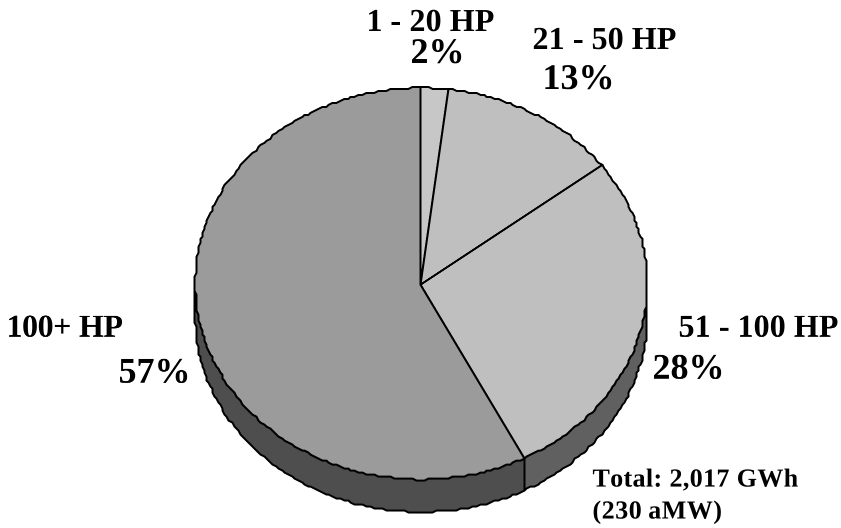


The pulp and paper industry uses predominately centrifugal fans and blowers. A large majority of these fans are less than 50 HP. The lifetime of a fan is expected to be approximately 10 to 15 years. Plant engineers and equipment experts consider fans and blowers to hold the greatest potential for VSD penetration in the pulp and paper industry.





1999 Energy Consumed by Pulp & Paper Fans/Blowers (HP) in the PNW



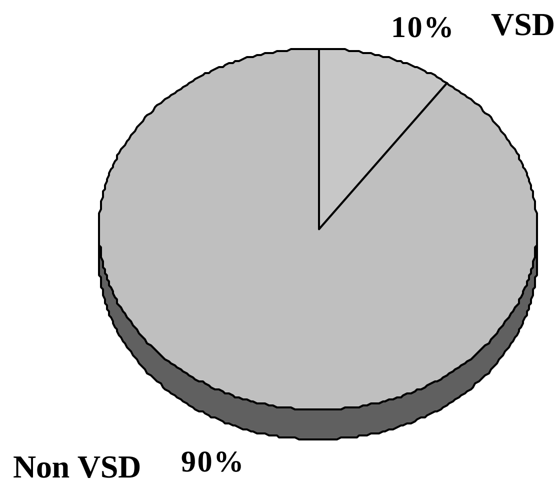
The installed base of fans and blowers in the pulp and paper industry range from 1 to greater than 100 HP, with a relatively even range of installed base distribution among HP ranges. However the greatest consumer of fan and blower energy are the fans and blowers greater than 100 HP, which consume 57% of fan and blower energy consumed.

Conveyor systems are another major source of energy consumption within the pulp and paper industry. Conveyor systems consume an estimated 20% of the total energy required for a facility. There are two primary types of conveyor systems used in the pulp and paper plants: the belt driven conveyor system and the pneumatic conveyor systems. The belt driven system transports solids including wood into the plant and final products to an area of the plant for delivery. The pneumatic system typically is used for transporting wood chips elsewhere in the plant to be reused or for disposal. Sizes of the conveyor systems vary significantly based on the application and facility design. Some plants in the industry assemble conveyor systems on site, specifying equipment components. A conveyor system is expected to have a life span of 10 to 15 years.

5. VSD Penetration in the Pulp and Paper Industry

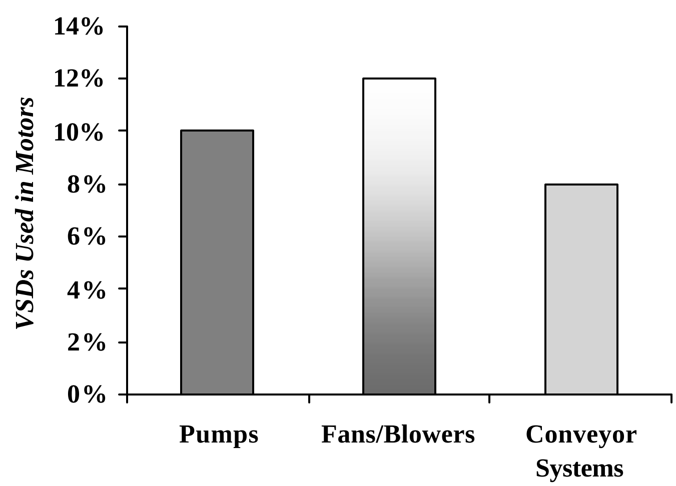
VSD motors in this industry are applied to an array of motor sizes. However, the highest penetration of VSDs is in motors greater than 100 HP. The additional expense makes it difficult to justify for the smaller motors even with the payback period. However, operating costs are taken into greater consideration when purchasing motors greater than 100 HP, and as a result, VSDs have a higher penetration within the larger motor segment.

VSD Motor Penetration in Pulp and Paper Industry (installed base)



VSD motors are utilized in pumps, fans and blowers, as well as conveyor systems. However, VSD motors are thought to be most suited to fan and blower applications in the pulp and paper plants. As a result, penetration is expected to be higher in fan and blower applications in this industry.

VSDs Installed by Equipment in the PNW Pulp & Paper Industry

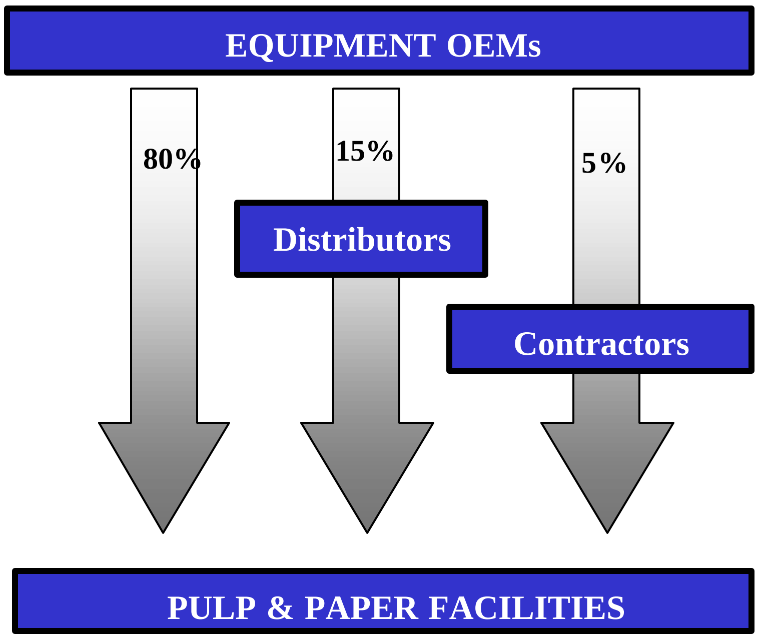


6. Equipment Maintenance

Equipment maintenance is an ongoing process within the pulp and paper industry. Due to the corrosive nature of much of the plant's processes, equipment must be frequently. Most equipment that is used frequently is inspected on a weekly basis. In addition, large motors are typically rewound every 2 years. The average pump is completely overhauled, except for the casing, twice in a 5 year period. Plant engineers from the maintenance department are responsible for these equipment checks. The maintenance engineer reports any problems with the equipment to the maintenance manager at the facility.

7. Equipment Purchase

PRODUCT FLOW



The maintenance manager determines whether to repair or replace the piece of equipment. The maintenance manager then determines the specifications of the new piece of equipment. Although the purchase processes vary by company, approximately 70% of the decision process regarding the purchase of new equipment is at the plant level. However, the remainder of the authority is at the corporate headquarter level. Many companies have guidelines and standards regarding the types of equipment that should be ordered. As a result, the purchase of new equipment with novel innovations is often a hurdle as the corporate level purchasing department as well as those in charge of new equipment purchases at the plant level must be convinced. This may be a barrier for energy efficiency.

Contractors or engineering consultants may also purchase equipment for pulp and paper mills. National consultants such as CH2Mhill and local consultants including Columbia Consulting typically work on projects in which a new plant is being built or an older plant is being refurbished or enlarged. Typically these projects require new equipment purchases. Engineering consultants will make recommendations on equipment sizing and specifications, however, the final decision for the specification of equipment ultimately lies with the pulp and paper company. It is necessary to make engineering consultants aware of new technology and initiatives as they have access to pulp and paper companies at times when major process and plant changes as well as new capital expenditures are being made.

All equipment purchases are new. There is a greater propensity than in the water and wastewater as well as the irrigation industries to replace rather than repair worn equipment. One reason for this tendency is to allow plants to capitalize on newer, more efficent equipment in terms of operating cost savings.

When purchasing new equipment, initial cost is a major consideration. Reliability and operating costs are primary factors in the purcahse decision process as well. Pulp and paper maintenance managers do take into consideration the return on investment for a given piece of equipment and relay this to the purchasing agent at the corporate headquarters level. In most cases, it is difficult for specifiers of equipment to justify a payback period for the investment on a piece of equipment greater than two years.

Purchase Decision Influencers

Equipment OEM

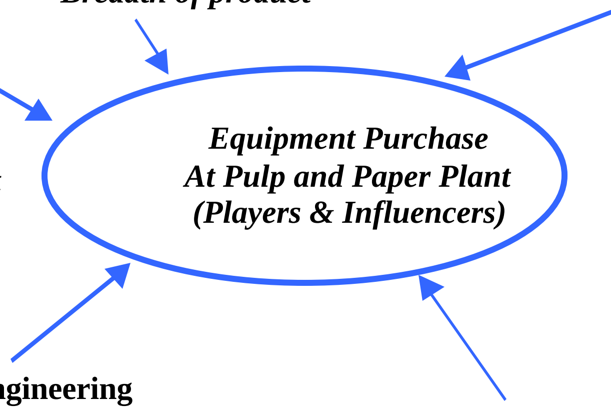
- ***Initial cost***
- ***Quality***
- ***Breadth of product***

Maintenance Manager

- ***Suitability of equipment for application***
- ***Repair and replacement costs***
- ***Initial cost***
- ***Ease of maintenance***
- ***Equipment's compliance to application/product/price standards set by corporate level***
- ***Operating costs***

Distribution

- ***Initial cost***
- ***Quality***
- ***Breadth of product brands***



Contractors/Engineering Consultants

- ***Suitability of equipment for application***
- ***Initial cost***
- ***Fit within budget***
- ***Energy efficiency (secondary)***

Corporate Level Purchasing Department

- ***Initial cost***
- ***Operating costs***
- ***Brand name-history of good service/quality***
- ***Energy savings potential***

8. <u>Energy Efficiency</u>

According to the Technical Association of the Pulp and Paper Industry (TAPPI), the pulp and paper industry is becoming more energy efficient. However, this energy effiency often translates into process efficiencies rather than energy efficient equipment investments. Process efficiencies include increasied use of recovered paper for paper production and energy generation from waste fuel. Currently, about 60-70% of total energy consumption in a pulp and paper plant is from recovered waste. Weyerheauser, perceived to be a leader in energy effiency in the industry, has initiated several energy saving processes. Some new process technologies Weyerheauser has begun implementing include:

- Combining its current black liquor and biomass gasification with turbine technology, which would reduce the required energy by half.
- Development of a pulp and paper plant that will transform biomass into heat for the mill, reducing fuel requirements by nearly 25%.
- R&D efforts being placed on developing a closed system, in which materials, water and energy used in a cycle are reintroduced to the system.

The pulp and paper industry is a prime target for energy efficiency initiatives due to its level of consolidaton as well as its investment in new equipment. In addition, this industry is highly competitive. Manufacturers are constantly looking to their competitors to learn about new innovations. Fearing that the innovator may gain a competitive edge, pulp and paper manufacturers are very quick to accept and implement new technology and equipment into their processes. However, some major barriers to energy efficiency do exist. These include:

- NEW TECHNOLOGY JUSTIFICATION: It is difficult for maintenance managers to accurately calculate payback period. This is due to the use of waste fuel rather than purchased energy for a sizable amount of its production. As a result, true payback period appears longer than in other industries.
- R&D COST: As a whole, the pulp and paper industry devotes a very conservative percentage of revenues to R&D. Only 1% of a typical pulp and paper manufacturer's revenues are devoted to R&D. As a result, new technologies and equipment often must be tested for reliability in other industries before the technology is adopted into the mainstream of the pulp and paper industry.
- PURCHASE DECISION RESPONSIBILITY: Although the equipment decision is predominately the within the authority of personell at the plant level, the maintenance manager and the department are ultimately tied to corporate specifications and budgets. As a result, clear communication between the plant and the corporate headquarters must be established in order for the corporate officials to be made aware of current inefficiencies at the

plant level and receive suggestions on what technology is available to improve the inefficiency.

- LACK OF NEW TECHNOLOGY AWARENESS: There is still a level of unawareness about the benefits of energy efficient technology such as VSD motors and proper applications for the technology.

There are initiatives that can be undertaken to remove obstacles to energy efficiency. These initiatives include:

Market Transformation

- The Alliance should promote awareness. Pulp and paper maintenance personnel as well as managers at the corporate level indicated the need for more information about what products are available and their potential impact on the industry. Seminars and case studies are believed to be the best medium for creating awareness.

- The Alliance should seek a company focused on energy efficiency such as Weyerhauser to be the leader in the industry for energy efficient and cost cutting actions. By championing a company that has created awareness internally and installed energy efficient equipment, others in the industry will likely take notice and follow the innovators lead in order to remain competitive.

Resource Acquisition

- Utilities and other interested parties should provide subsidies to replace older (greater than 20 years) pumps above 200 HP as these size pumps are responsible for 61% of pump energy consumption in the pulp and paper industry.
- In addition, utilities and other interested parties should provide subsidies to replace older (greater than 20 years) fans/blowers above 50 HP as these size fans/blowers are responsible for 58% of fan energy consumed in the water and wastewater industries although they account for only 29% of the installed base.
- Perhaps the biggest impact the utilities and other interested parties may have is in incentivizing VFDs for installation on higher HP equipment as once payback period awareness is created, energy efficient practices become the norm.

I. ***Irrigation Industry***

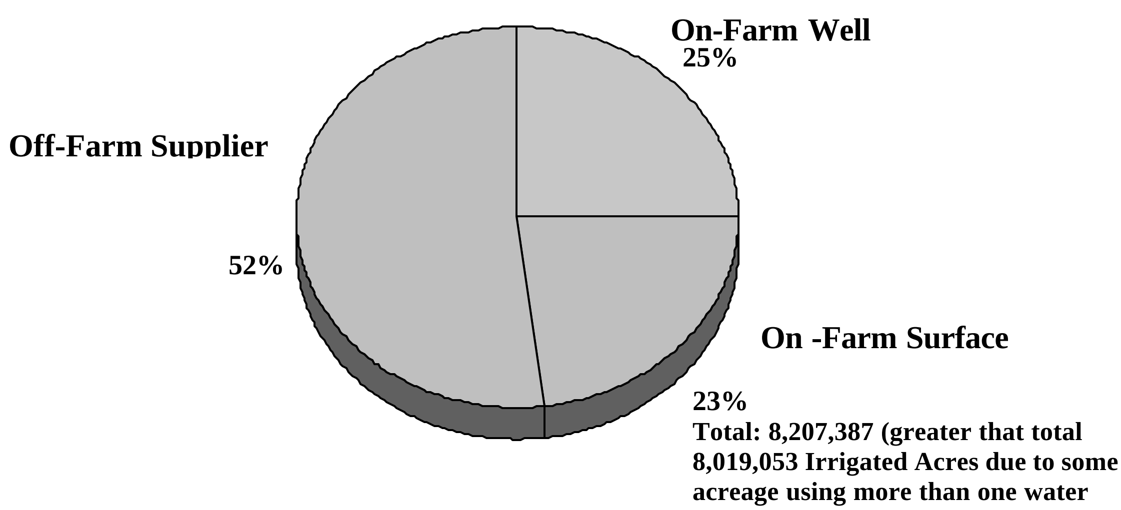
Nearly 75% of the water removed from lakes and streams in the Pacific Northwest is utilized for agriculture. Irrigation in the Pacific Northwest has experienced a growth rate of less than 2% per year over the past decade. Competing interests for water include fish migration and hatcheries as well as minimum water requirements for shipping needs. The industry is an extremely fragmented market made up of several pump operators, differing in size and ownership. However, the industry is an especially important area of focus for energy efficiency initiatives as the industry consumes a significant amount of energy in the Pacific Northwest. In 1998, irrigation accounted for 6,278 GWh (717 AMW).[11] The industry accounts for the second greatest motor load in the region. As a result, there is significant opportunity for energy efficiency savings.

1. *Irrigation Overview*

Respondent Type	Number of Interviews
Equipment Manufacturers	25
Equipment Distributors	10
Engineering & Consulting Firms	2
Plant Managers & Engineers (canal/ditch co's)	13
Utilities	5
Government Organizations	5
Trade Associations and Industry Experts	20
Total	**120**

Farmers in the Pacific Northwest have three possible water sources: from a well, from on-farm surface water, or from off-farm suppliers, which may be irrigation districts or canal and ditch companies. Farmers may use one or combination of the three water sources. Of the irrigated acres, over half of the water used to irrigate this land is from off-farm suppliers.

1998 Acres Irrigated in PNW

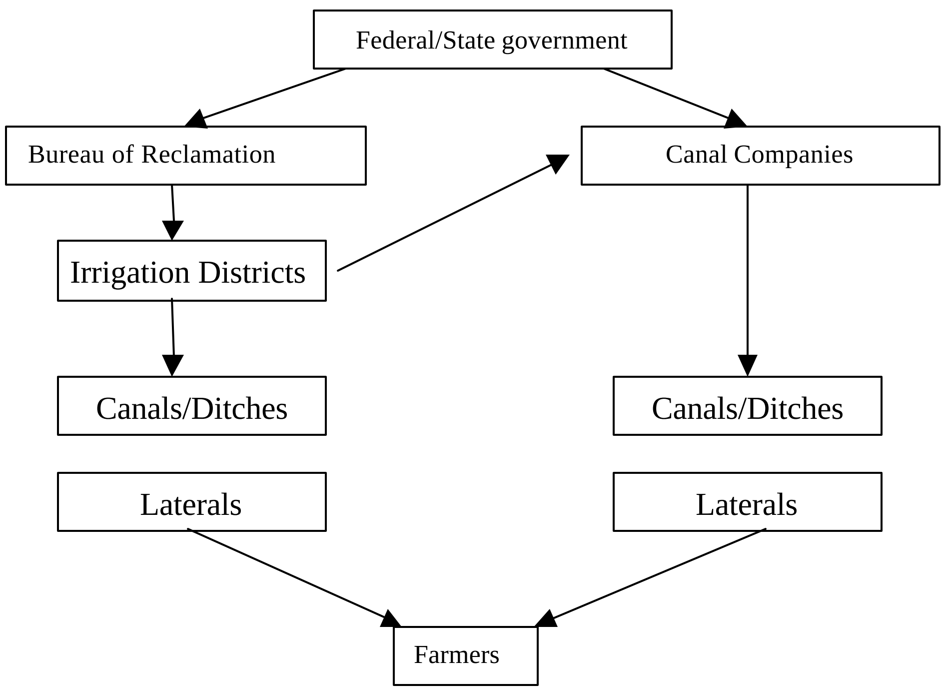


(Source: Farm & Ranch Irrigation Survey 1998)

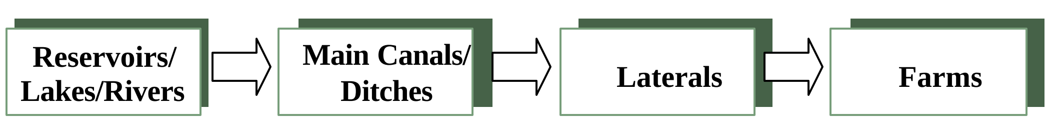
[11] Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

The federal government grants rights to the Bureau of Reclamation and canal companies for the irrigation of reservoirs, lakes or rivers. The Bureau of Reclamation establishes irrigation districts formed under state charters as well as grants water rights to canal companies. The established irrigation districts are quasi municipalities. The irrigation districts formed by the Bureau of Reclamation deliver 60% of the total water to irrigated land. In the Pacific Northwest, the are 140 irrigation districts. Both the irrigation districts and private canal districts manage and operate the ditches and canals. They are managed by the irrigation districts or by private owners, but are more often private. There are approximately 250 private ditch operators and canal companies. Farmers can own a share of the canal or ditch companies. The canal and ditch companies supply water for irrigation to farms. Irrigation districts canal and ditch operators and farmers each purchase pumps to facilitate the distribution of water.

Water Suppliers in the Irrigation Industry

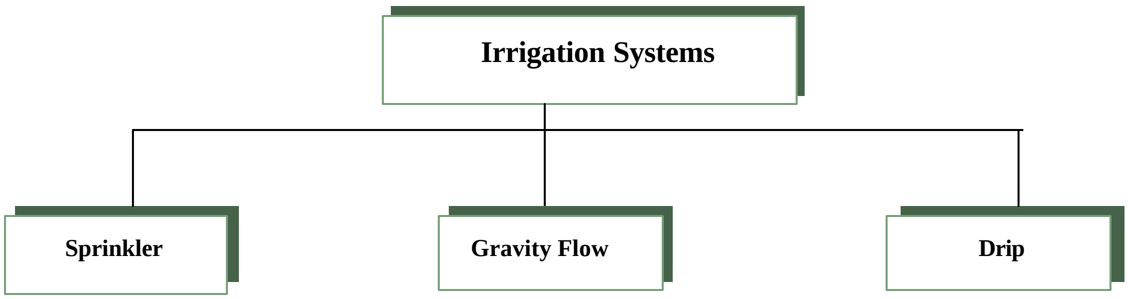


Irrigated water flows from reservoirs, lakes, or rivers to a main canal. The water from the main canal is then diverted into smaller canals or ditches, also known as laterals. Farmers divert water from the laterals into smaller canals. Farmers may also retrieve water stored in deep wells from diverted laterals.



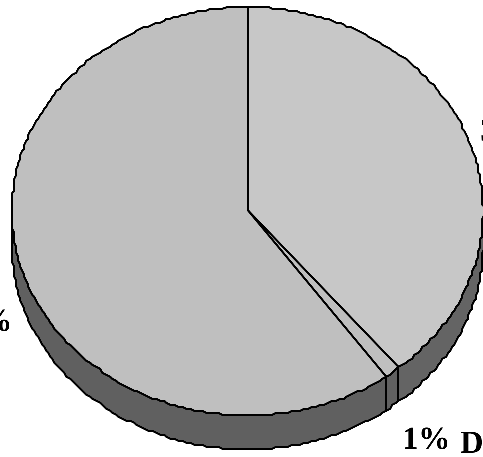
2. Segmentation of Irrigation Methods

Irrigation Methods in the PNW



Farmers use three basic forms of irrigation: sprinkler, gravity flow, and drip system. The form of irrigation used is the product of the nature of the geography rather than the ultimate crop that is to be watered. The gravity flow system is the method of distributing water to farms from a higher level canal. This method of distribution requires fewer pumps and lower HP motors because water movement is achieved through gravity. As a result, this irrigation method is not energy intensive. Sprinkler irrigation involves the spraying of water supplied from ditches and canals. The water must be pressurized in order to spray; therefore, pumps are required. The sprinkler system is the fastest growing irrigation method in the Pacific Northwest. The main impetus for this segment's growth is interest in water conservation and Wildlife Protection Acts. Unlike the gravity flow system, sprinkler irrigation allows for the control of the amount and location of water delivery. Therefore, run off and soil erosion is kept at a minimum, which saves water and protects the environment. In spite of the greater energy requirements, the sprinkler irrigation is considered to be an efficient irrigation due the conservation of water. An increasing amount of farmers are pressurizing their gravity flow system in order to achieve greater efficiencies. The drip system, also sometimes referred to as the trickle system, involves the delivery of water to agriculture via small plastic tubing. The tubing can be buried, laid on the surface, or placed above the plant on trellises. The tubing has small pores that emit water to the plant. The drip system allows for accuracy of water distribution and is perceived as an environmentally friendly irrigation method. Relative to the sprinkler and gravity flow methods, drip irrigation is a new irrigation system and has not penetrated the Pacific Northwest irrigation method.

1998 Irrigation Acreage in PNW

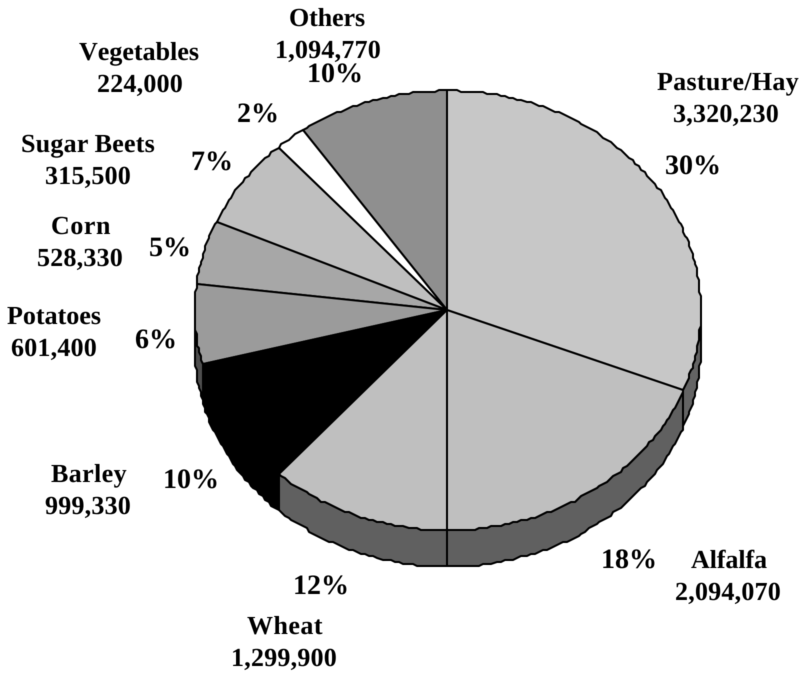


(Source: Farm & Ranch Irrigation Survey 1998)

3. Agriculture in the PNW Overview

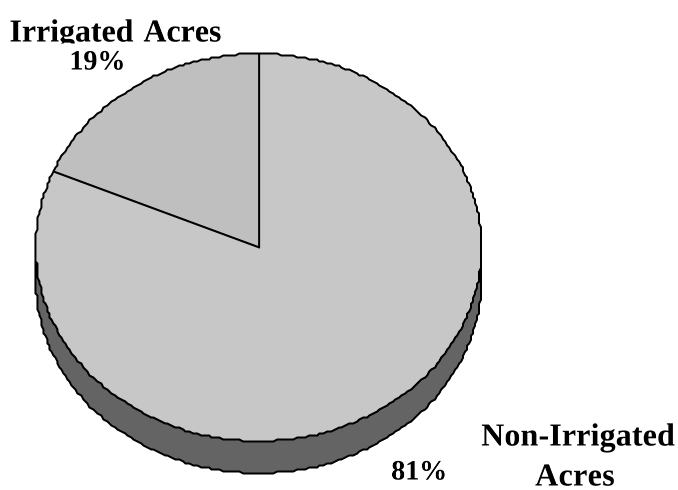
A wide variety of crops comprise the agricultural industry in the Pacific Northwest. Each crop has specific needs with regard to harvesting seasons, watering needs and other farming practices. Pasture hay and alfalfa have the greatest yield in the Pacific Northwest. These crops tend to have slightly lower water requirements than other crops such as apples and vegetables. However, in Oregon for instance, water demand and, therefore, energy requirements for irrigation of hay and alfalfa have been increasing. In recent years the hay and alfalfa farms have begun to relocate to the northeast part of Oregon, following one of the crop's largest customer base, the dairy farms. The dairy farms have had to relocate from the western part of the state which needs little irrigation due to rainfall to the eastern part of the state requiring irrigation due to environmental pressures from animal waste run off.

1998 Agricultural Acreage in PNW



(Source: Farm & Ranch Irrigation Survey 1998)

1998 Farm Acreage in PNW

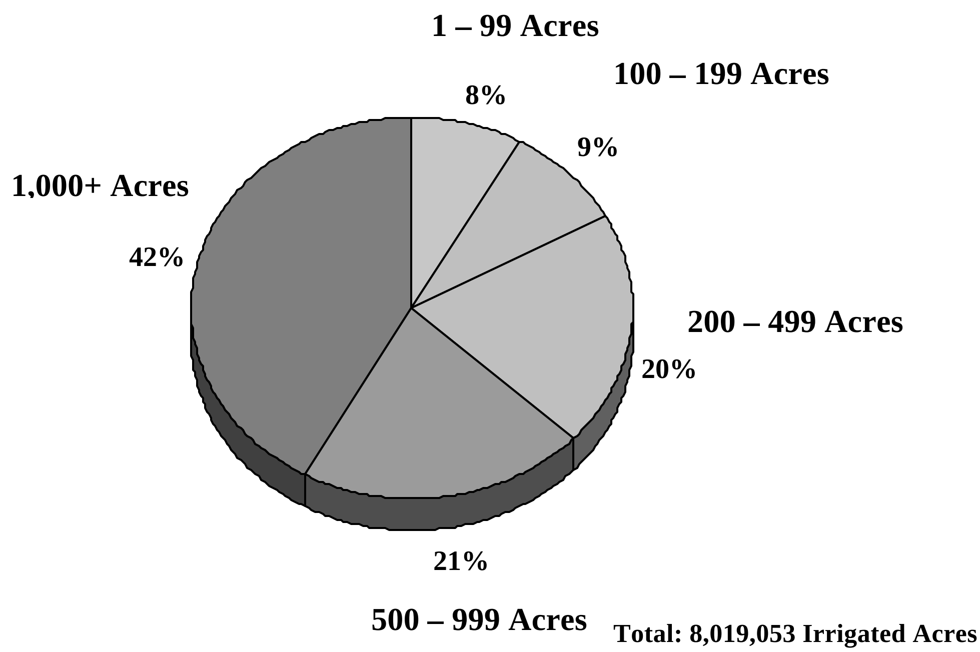


Total: 97,437,738 Acres

(Source: Farm & Ranch Irrigation Survey 1998)

There is over seven million irrigated acres in the Pacific Northwest. The Columbia River Basin, Grand Coulee Dam, Minidoka (along the Snake River in ID), and Yakima Valley are examples of major irrigation projects in the Pacific Northwest. The climates and water sources in the Pacific Northwest vary tremendously. In Idaho and Montana, the arid climate makes irrigation a necessity. Idaho has 3.1 million irrigated acres, and Montana has 1.7 million irrigated acres. Western Oregon and Washington significant rainfall reducing the need for irrigated lands. However, the eastern parts of these states rely on irrigation for crops. Washington and Oregon have 1.6 million and 1.5million irrigated acres respectively.

1998 Acres Irrigated in PNW

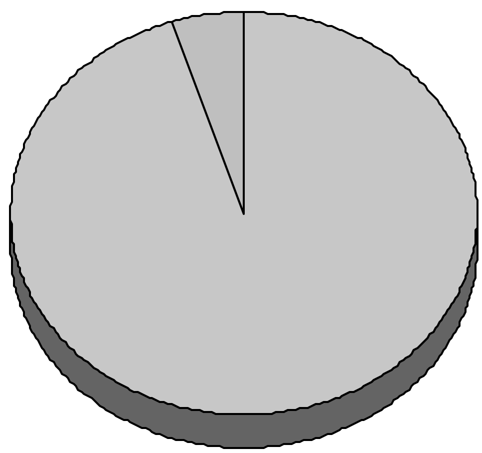


(Source: Farm & Ranch Irrigation Survey 1998)

The Pacific Northwest has been affected by the national trend toward the decreasing number of small family farms. These smaller farms have been unable to compete with large corporate farms. Over half the farms in the Pacific Northwest are large farms greater than 500 acres. As a result, a number of the farms in the Pacific Northwest are sophisticated and employ individuals responsible for equipment purchase and maintenance. The smaller farms typically do not have the capital necessary for specialized staff, regular maintenance and expensive, state of the art equipment investments. As a result, these smaller farms tend to be less energy efficient.

4. Existing Equipment

Types of Pumps Installed in Irrigation

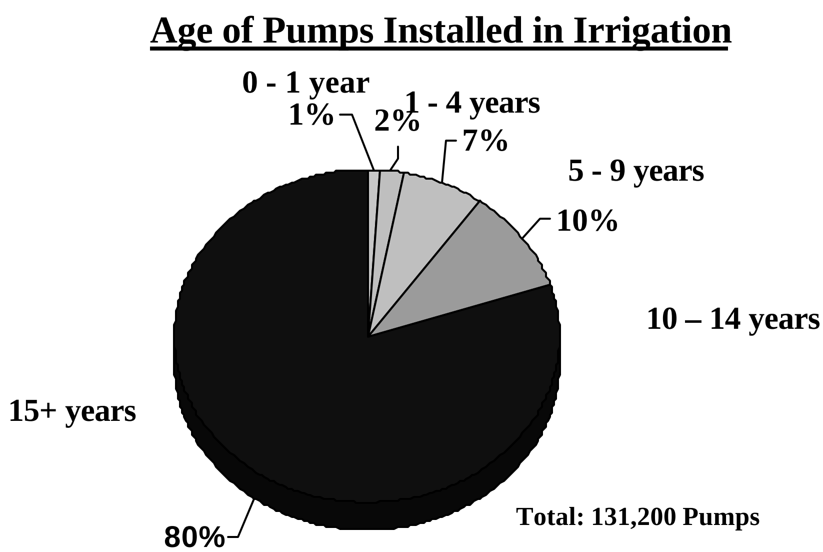


Pumps are the primary source of energy consumption within the irrigation industry. The pumps suited for irrigation are typically more efficient as most have a closed impeller design for clear water applications. Typically, 95% of pumps for irrigation are centrifugal pumps. Positive displacement pumps account for the remaining 5% of pumps in irrigation.

These positive displacement pumps are primarily used in small systems requiring less than 2 liters per second of pump discharge. Small system suitable for positive displacement pumps may include vegetable growers using drip irrigation or hobby farms.

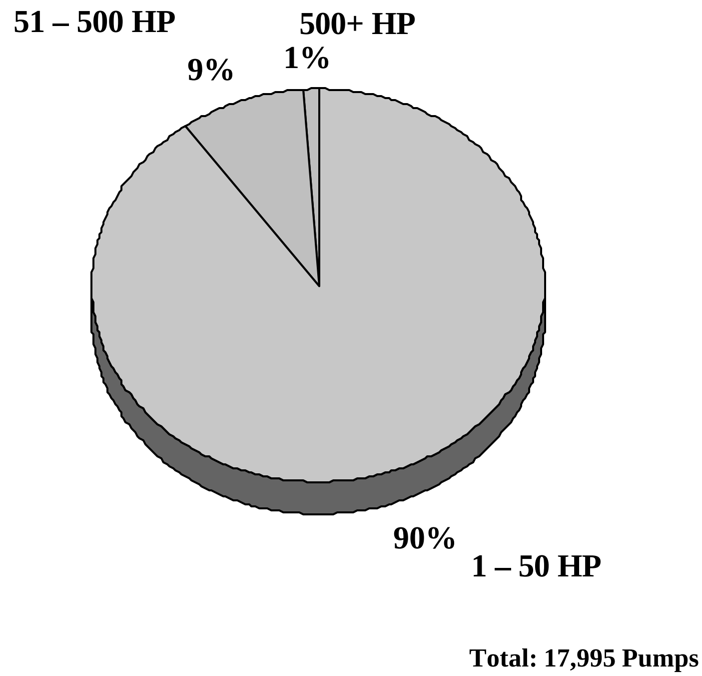
Centrifugal pumps are the most common pumps used in irrigation. The standard radial flow centrifugal pump can be installed as a portable unit and is installed above the surface of the water, making maintenance relatively easy. The turbine centrifugal pumps are used in applications which a large amount of water must be pumped at low heads. Turbine pumps are used most often in bores or wells as well as dams, creeks and rivers. A submersible type of turbine pump may also be suitable for these applications. The submersible pump is essentially a turbine pump in which the motor and pump are in one unit with the motor submerged. Unlike other turbine pumps, the submersible pump can be installed in waters that are prone to flooding as the submersible pump has no working parts above the ground. The submersible pumps account for nearly 80% of the total pumps used by the farmers. However, the submersible pump is not suited for silty or sandy water and is more difficult to maintain due to its submerged motor. The difference in energy efficiency amongst these pumps is negligible. However, the submersible pump is much difficult to maintain and is checked less regularly than other turbine pumps because the working parts are submersed. As a result of the less regular maintenance, submersible pumps are often running less efficiently than other pumps.

Centrifugal pumps can be installed with horizontal or vertical shafts. Over 80% of centrifugal pumps in irrigation are vertical pumps, that are used for applications such as pumping water from aquifers and wells. The vertical pumps are more difficult to maintain because they must be lifted out of the water source for inspection or repair.

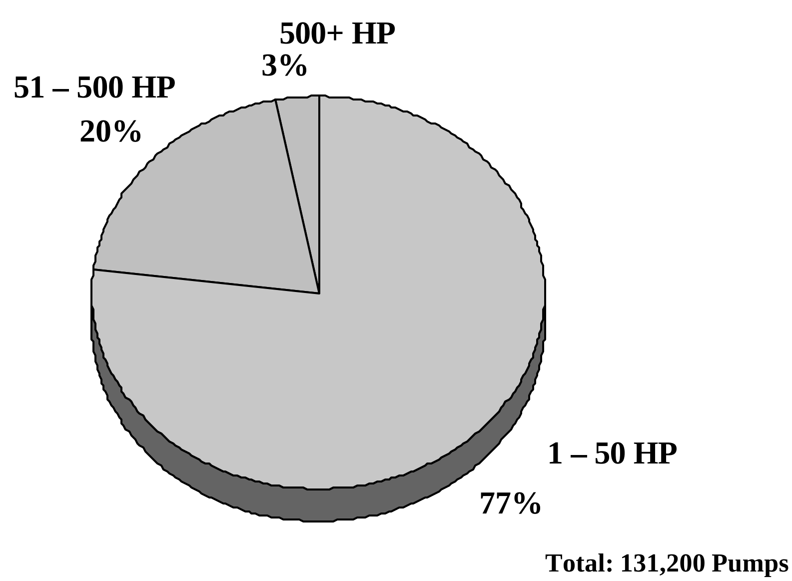


The industry is extremely conservative concerning the replacement of pumps. Farmers and other pump owners across the value chain will typically repair the pump rather than replace it. The expected lifetime of a pump in the irrigation industry can be as much as 50 years.

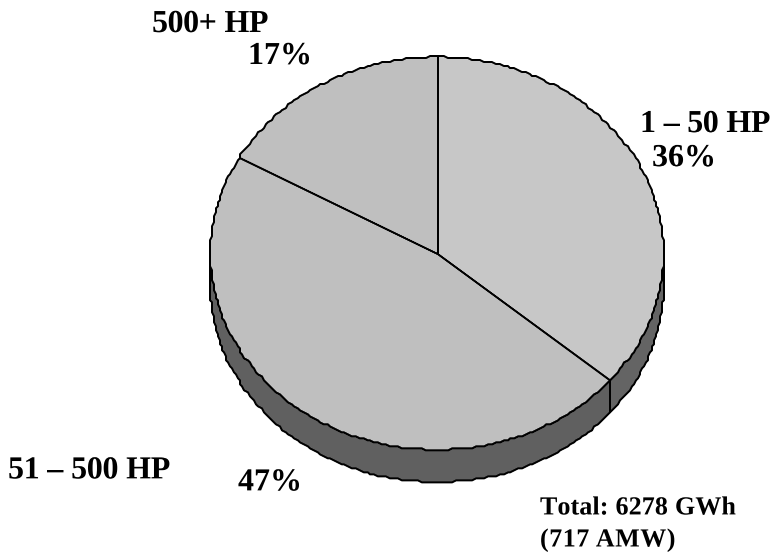
1999 Pumps Sizes (HP) Sold in Irrigation Industry



1999 Pumps Sizes (HP) Installed Base in Irrigation Industry



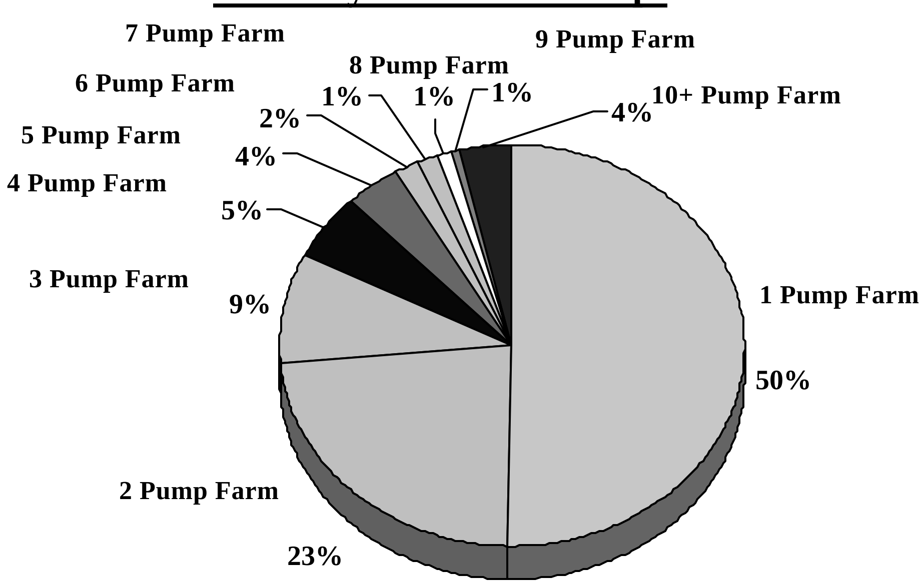
1999 Energy Consumed by Irrigation Pumps (HP) in the PNW



The irrigation district, ditch and canal companies, as well as farmers have pumps in their respective systems. The type of pump and its size depends on the type of system and the water source. Gravity flow systems, for instance, require less pumps and lower HP. Ditch and canal companies as well as irrigation districts pumping from deep well aquifers require large vertical turbine pumps with greater than 100 HP requirements. Most pumps in the irrigation industry are at least 20 HP.

The horsepower requirement for a pump on a farm is a product of the irrigation method implemented. Farms using sprinkler irrigation typically require larger HP pump motors or addition pumps in order to achieve necessary pressure requirement. Most farms have only one pump.

Farms by Number of Pumps

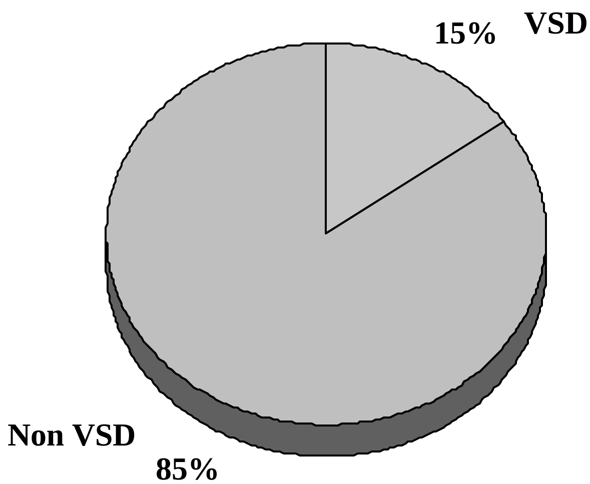


(Source: Farm & Ranch Irrigation Survey 1998)

5. VSD Penetration in Irrigation

The penetration of VSD motors depends on the application, design and the pump operator. VSDs are suited for applications with large flow peaks. VSD are used most often for applications requiring multiple pumps. The VSD is installed on one pump allowing the farmer or water supplier to change the speed on only one pump in a series rather than tending to all of the pumps. Since water and energy costs are low in the Pacific Northwest, farmers are not motivated to invest in the technology. Ditch and canal operators as well as irigation districts have more incentive to purchase VSD motors because the energy savings and water conservation would be greater due to the volume being handled. Approximately 70% of VSD motors purchased in the irrigation are purchased for the retrofit of older equipment. The remaining 30% of VSDs are purchased with new equipment.

VSD Motor Penetration in Irrigation (Installed)



6. Equipment Maintenance

Equipment maintenance varies according to the value chain member in the irrigation industry. Irrigation districts and canal and ditch companies typically will have established routines. Most farmers, except for large corporate farms, will typically have much more haphazard maintenance rountines.

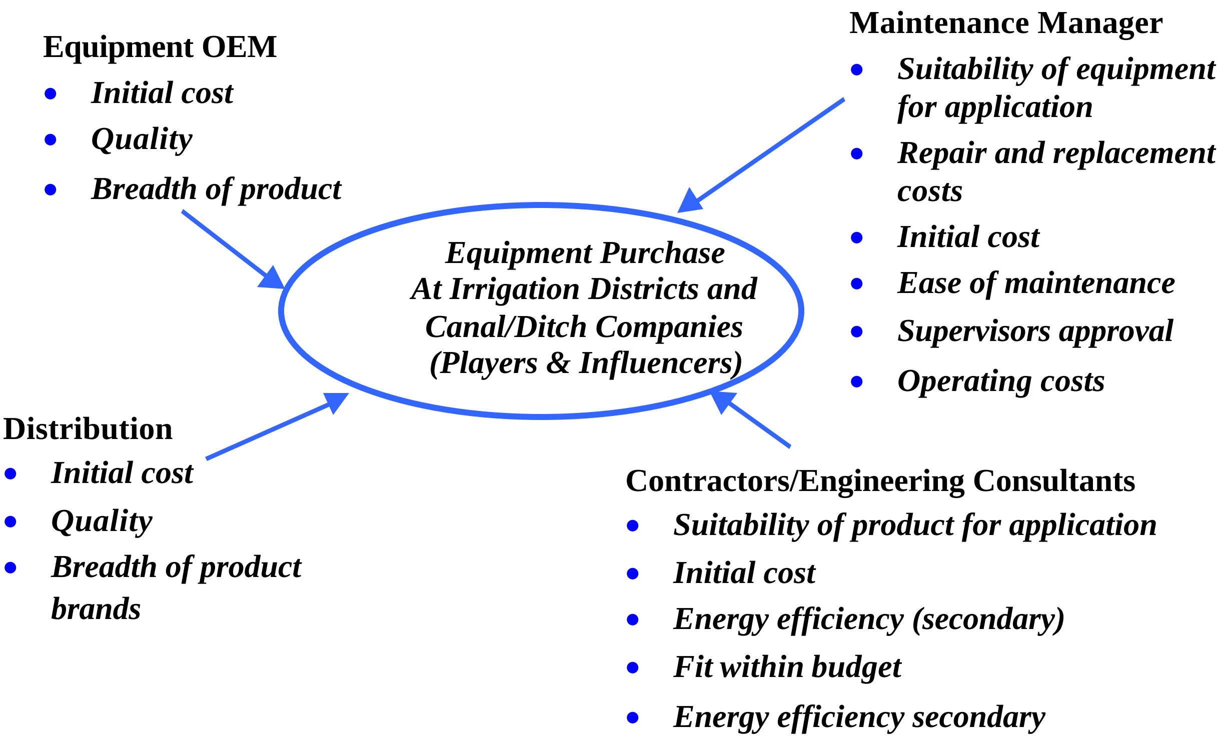
Farmers will visually inspect the equipment on a sporadic basis. However, most farmers rely on the energy and water bills to determine if the system is fully operation. If in one month the farmer’s utility bills spike, the farmer will inspect the pumps for problems as well as the systems for any leaks. Except for the large, sophisticated farmers, most farmers will solicit local contractors in the irrigation industry to handle any repair work necessary.

A ditch or canal operator or a irrigation district has a staff responsible for operating and inspecting the pumps. The districts and companies essentially have two maintenance periods over the course of the year: the irrigation and non irrigation periods. The irrigation period typically runs from Novemer 1st through March 15th. During this time pumps are inspected daily and can be serviced immediately. During the non irrigation period the pumps are taken off line and overhauled. Motors on these pumps are rewound every 3-5 years. Impellers and cases are serviced every 7-10 years.

7. Equipment Purchase

Purchase Decision Influencers

(Canal/Ditch Companies and Irrigation Districts)



Purchase Decision Influencers

(Irrigators/Farmers)

Equipment OEM

- ***Initial cost***
- ***Quality***
- ***Breadth of product***

Irrigators/Farmers

- ***Suitability of equipment for application***
- ***Repair and replacement costs***
- ***Ease of maintenance***
- ***Operating costs***
- ***If large terms with corporate ties may have to meet price/product standards set at corporate purchasing level***

Distribution

- ***Initial cost***
- ***Quality***
- ***Breadth of product brands***

Equipment Purchase At Farms (Players & Influencers)

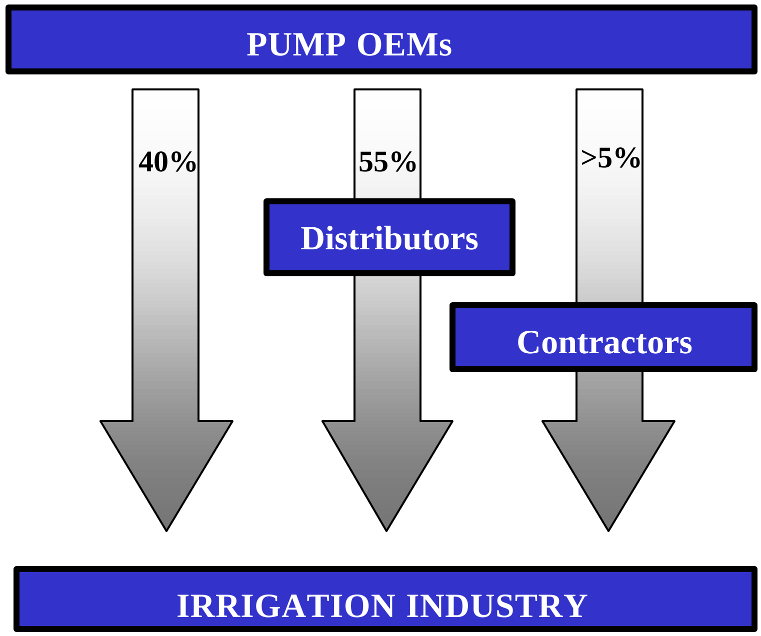
Contractors/Engineering Consultants

- ***Suitability of product for application***
- ***Initial cost***
- ***Energy efficiency (secondary)***
- ***Fit within budget***
- ***Energy efficiency secondary***

The maintenance manager at the ditch or canal company or the irrigation district is typically responsible for purchase decisions. Most irrigation districts have a supervisor who must approve the purchase. The tendency of all members of the value chain is to repair damaged equipment rather than replacing it. The primary driver in the decision making process for all value chain members is initial cost. This is especially true for the farmers that are running relatively small operations. Operating cost is not a large factor due to the low energy costs in the Pacific Northwest. However, suppliers consuming a large amount of energy such as irrigation districts and large canal and ditch companies are becoming more aware of the importance of operating efficiencies and potential cost savings.

A majority of pumps are purchased from distributors. Farmers and most ditch and canal companies purchase new equipment through a local distributor. Irrigation districts typically purchase pumps directly from a pump manufacturer. Maintenance managers or the purchasing agent will purchase directly from the manufacturer for smaller projects. In the case of large projects, the irrigation district will publish an announcement for a bidding process. Contracts are typically awarded to the lowest bidder.

PRODUCT FLOW



8. Energy Efficiency

Efficiency in the irrigation industry often is associated with water conservation rather than energy savings. Energy efficiency is not a primary concern for irrigators as the cost of energy in the Pacific Northwest is less than 7 cents per kWh. As a result, energy costs is a key barrier to the success energy efficiency initiatives.

Another barrier to energy efficiency is the cost of equipment replacement and the conservative nature toward the purchase of new equipment. The fact that new equipment may not be replaced for 20 to 50 years is a major barrier to the penetration of new, more energy efficient technology and equipment into the industry.

Another barrier is the lack of awareness of energy efficiency and proper installation on the part of a majority of the farmers. For instance, many farmers oversize their pumps in order to accommodate for potential greater water demands in the future. Oversizing these pumps have a negative effect on energy efficiency and increases operating costs. In the past, the Bureau of Reclamation as well as utilities such as Bonneville Power have sponsored pump testing programs. Utilities or government agencies would test pumps utilizing existing data such as volume pumped and flow rate or conduct field work at the farm location. These tests would determine efficiency of the current system and provide farmers with suggestions for improving the system. Most of these programs were discontinued in the early 1990's due to lack of funding and competing programs with greater appeal.

There are initiatives that can be undertaken to remove obstacles to energy efficiency. Suggestions regarding energy efficiency improvement made by experts in the irrigation industry include:

Market Transformation

- The Alliance should provide examples of energy savings for using more energy efficient equipment. Provide a calculation of payback period.
- The Alliance should provide information on new energy efficient equipment and system concepts. A brochure or video on such concepts as implementing a "retrofit process" were suggested. This would include a background on how to size pumps correctly. Also, a brief description of how replacing high head sprinklers with low pressure head sprinklers would decrease pumping pressure needs. In addition, system efficiencies such as replacing steel pipes with plastic pipes to eliminate corrosion and leaks and ultimately lower pumping pressure requirements.
- The Alliance should capitalize on existing programs within the irrigation industry. The Regional Scientific Irrigation Scheduling (SIS) Program, currently funded by the Alliance, includes workshops and training courses on water management. The US Bureau of Reclamation is one of the participants in the Regional SIS Progam. The Bureau operates 53 Agrimet stations in the Northwest which provide crop ET (evapotranspiration), or crop water use, data necessary for irrigation scheduling. The are some obvious synergies between water management and pump and energy efficiencies. One could incorporate pump testing programs and the promotion of new energy efficiency technologies with marginal efforts through cooperation with the existing SIS programs.

Resource Acquisition

- The greatest deterrent to energy efficiency is initial cost. The Irrigation Association as well as others in the industry support the incentivation of farmers for the investment in new irrigation technologies and energy efficient technology through low interest loans and tax credits.
- Utilities and other interested parties should provide subsidies to replace older (greater than 17 years) pumps above 50 HP as these size pumps are responsible for 75% of pump energy consumption in the irrigation industry, while only accounting for 24% of the installed pump base.

IV. Conclusions

The pulp and paper, water and wastewater and irrigation industries are major consumer of energy in the Pacific Northwest. Industrial motor load reached nearly 18,500 GWh for the pulp and paper, irrigation, as well as water and wastewater industries. Pumps, fans and blowers as well as conveyor systems account for a bulk of their energy consumption. Hence, initiatives aimed at improving energy efficiency within these three industries specific to the use of the equipment under study are key targets for energy efficiency initiatives established by the Alliance.

The pulp and paper, water and wastewater, and irrigation industries have varying levels of consolidation, which may affect the Alliance's ability to impart change relative to energy efficiency. The pulp and paper industry is a suitable candidate for energy efficient initiatives due to the industry's high level of consolidation. The dominance of large companies and recent mergers would require the Alliance to have energy efficiency initiatives in only small number companies in order to impact substantial change. The water and wastewater is also a reasonably consolidated industry. Industry practices and energy usage are fairly uniform largely due to the municipal standards. The irrigation is a very fragmented industry with many levels of the value chain, which consist of end users of the equipment under study. In addition, the industry is comprised of a multitude of smaller end users. The fragmented nature of the irrigation industry makes it a less attractive target for initiatives for energy efficiency.

The industries under study have high inertia to change. The pulp and paper industry manufactures commodity products and devotes very little and R&D. However, opportunities do exist for improved energy efficiency. The pulp and paper industry has a relatively high replacement rate for replacing plant equipment, providing an opportunity for the penetration of more energy efficient pumps, fans/blowers, and conveyor systems. In addition, each of the manufacturers is quick to adopt cost saving technology or system improvements that a competitor may have implemented in order to remain competitive. This level of implementation and competition may work to the advantage of the Alliance when trying to initiate more energy efficient practices in the industry. The water and wastewater industry is slow to change due to government constraints. Most water and wastewater facilities are subject to strict budget constraints. As a result, maintenance engineers and managers must be extremely conservative regarding equipment replacement or new technology investment. Finally, the irrigation has a high inertia to change due to its fragmented nature. Irrigation systems and their requirements vary significantly among locations, applications and end users, making specific targets and demonstration of improvement of energy usage practices a challenge for the Alliance. In addition, the number of players and the lack of consolidation make targeting initiatives and impacting major industry change difficult.

The Alliance should tailor its market transformation approach for each of the three industries. The Alliance should establish a champion for energy efficiency within the more consolidated industries, pulp and paper and, to a lesser extent, the water and wastewater industries. Through the creation of a model for energy efficiency in the industry, the Alliance would establish a goal for the industry. For the less consolidated industries such as the irrigation industry, the Alliance should capitalize on existing programs to affect change and exploit already established lines of communication to the industry. For instance, the Scientific Irrigation Scheduling Project targeted toward farmers in the Pacific Northwest would be an ideal project for collaboration due to the synergies regarding target audience and efficiency goals.

Incrementally iterative steps are a necessity to impact change in the industries. In order to make more efficient practices a reality in the industries under study, the Alliance must create the two A's: Awareness and Affordability. Most players in the three industries are not aware of what can be done to improve efficiency. Corporate bureaucracy, lack of information sharing and low industry consolidation account for the lack of awareness. The Alliance should create more universal awareness through market transformation initiatives such as case studies, workshops, and videos on what can be done to improve energy efficiency and the benefits of adopting more energy efficient practices. The Alliance must present energy efficiency initiatives as affordable within the three industries. In order for the industries to initiate change with regard to energy efficiency, the Alliance must demonstrate that the change would positively effect the bottom line. Currently, the three industries are not aware of exact monetary benefits for properly specifying equipment or installing more efficient equipment such as VSD motors. The alliance can impact change and improve energy efficiency through incremental, iterative steps.

V. APPENDICES

Appendix I. Sources

Opportunities for Industrial Motor Systems in the Pacific Northwest (12/99) E99-044 (www.nwalliance.org/resources/all_reports.html)

Conveyor and Conveying Equipment Manufacturing, 1997 Economic Census, Manufacturing Industry Series. US Census Bureau

Farm and Ranch Irrigation Survey (1998). 1997 Census of Agriculture. US Department of Agriculture.

Pump and Pumping Equipment Manufacturing. 1997 Economic Census, Manufacturing Industry Series. US Census Bureau

Research in the Market for Motor Management Services. Pacific Energy Associates, Inc. December, 1998.

Energy Efficient Irrigation Practices Handbook: Irrigation Technology in the 90's. IDWR Energy Division, University of Idaho and local utilities.

Pumps and Compressors. 1998 Current Industrial Reports. US Census Bureau. March, 2000.

Appendix II. Definitions

VOLUTE: The curved funnel within the pump casing. The funnel increased in size at the discharge point. The larger the funnel area causes the speed of the liquid to decrease and the pressure to increase. A pump can have a single volute or a double volute. The double volute, which creates a more balanced load, is more common in the three industries under study.

IMPELLER: Curved blade within pump casing which pushes water through the volute.

CAVITATION: Cavitation is the result of low suction pressure. Liquid flowing through the inlet, which has low head, becomes vaporized. Once this vapor travels to the discharge area of the pump where the low-pressure environment no longer exists, the vapor liquefies. This action causes damage to the rotors, screws and other parts of the pump.

HEAD: Suction pressure in pump operation. Head is measured in terms of units of force per unit of area (pounds per square inch).

NET PUMP SUCTION HEAD REDUCTION (NPSHR): Minimum amount of head necessary for the pump to operate without cavitation.

PERFORMANCE CURVE: The curve plots the total head against the flow rate for a constant impeller diameter. The flow rate starts at zero and goes to the maximum rate at which the pump can operate.

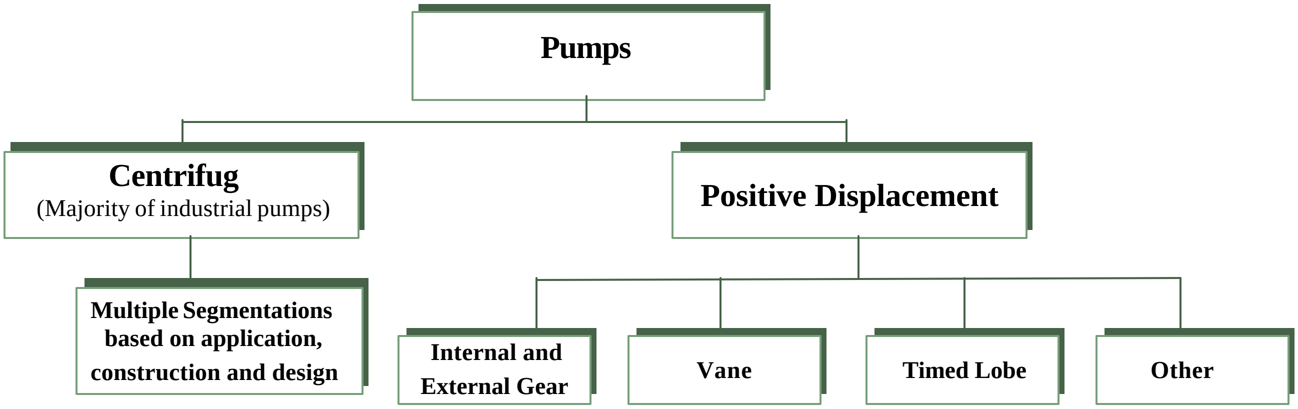
BEST EFFICIENCY POINT (BEP): The point on the performance curve that indicates the optimal operating flow and head rates. The points on either side of the BEP indicate lower operating efficiencies, which often translates into vibration due to the asymmetry of the impeller.

GPM: Gallons per minute

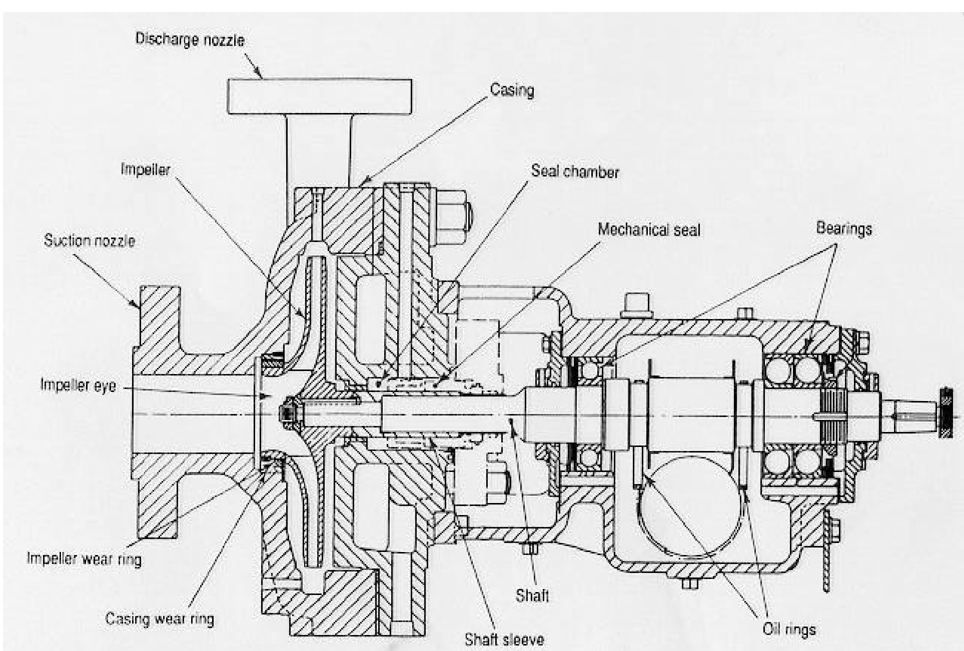
TDH: total dynamic head in feet created by pump. TDH incorporates the sum of pressure, lift and system friction losses.

Appendix III.
Pump Design & Segmentation

Pump Segmentation



There are essentially two basic types of pumps: positive displacement pumps and centrifugal pumps. Positive displacement pumps require mechanical energy to move liquid. These pumps are limited to low volume applications. Positive displacement pumps are used when the fluid being pumped is extremely viscous or abrasive. There are four different types of positive displacement rotary pumps: internal gear, external gear, timed lobe, and vane pumps. Positive displacement pumps with an internal gear are suited for pumping small, suspended solids. External gear positive displacement pumps are designed for slightly less viscous fluids. The timed lobe pump is suited for applications such as food processing in which solids that must not be damaged are moved through the pump. Finally, the vane pumps are designed for low viscosity, non-lubricating liquids, and these pumps are designed to withstand running dry. The positive displacement pump has tight internal clearances, minimizing the amount of liquid that flows back from the discharge to the suction side of the pump. This allows for greater efficiency.



(Source: Purdue University http://abe.www.ecn.purdue.edu/~agen 555/Caramel/pumps.html)

The centrifugal pump (pictured above) is the second type of pump used. These pumps are capable of conveying large volumes of fluid, and as a result, make up a large majority of the pumps in the pulp and paper, water and wastewater and irrigation industries. Centrifugal pumps rely on kinetic energy to pump liquid rather than mechanical energy. These pumps are best suited for low-pressure applications. Centrifugal pumps can withstand not only large volumes of clear liquid, but also fluids that are dirty and abrasive as well as fluids with a high solid content.

Centrifugal pumps have several subcategories based on design, construction, and application. Variables include the number of impellers, impeller suction, volute type, nozzle orientation, type of bearing support, shaft location, as well as type of case-split. The impeller can be single stage in which there is one impeller for low head applications, two-stage in which there are two impellers for medium head applications, or multi-stage in which there are multiple impellers in series for high head applications. The impeller suction type, which is determined by the primary impeller, can be single suction or double suction. The single suction pump impeller has a simpler design however may be subjected to impeller imbalance because fluid is flowing on one side of the impeller. The double suction impeller has suction cavities on both sides and as a result has lower Net Positive Suction Head Required (NPSHR).

Volute types include single volute, which has a single lip and has low capacity, and the more common double volute pump, which has two lips and a more balanced load. The bearing support can be overhung, in which the impeller overhangs on one end of a shaft unsupported by a bearing, or between bearing, in which the shaft has support from bearing on either end. The orientation of the case split can be axial or radial. The axial split pump case has limited temperature and pressure resistance due to the design's uneven thermal expansion and small case gasket. The radial split pump case supported at the centerline of the shaft and has a circular bolt pattern make the pump more resistant to temperature and pressure.

The different nozzle locations include end suction and top discharge, top suction and top discharge, and side suction and side discharge. The end suction and top discharge pump type requires an overhung bearing support and generally has low NPSHR due to the flow of the liquid directly into the center of the impeller. The top suction and top discharge pump type requires a radial split case pump. The side suction and side nozzle pumps can have either a radial or an axial split case as well as overhung or between bearing supports.

Finally, the orientation of the shaft can be either horizontal or vertical. The horizontal pump is often preferred due to the pump design's ease of maintenance. The vertical is suited for applications when pumping from a pit or well or the pump is in a confined space. The decision to use vertical or horizontal is most clearly defined within the irrigation industry. Within irrigation, 80% of the pumps are vertical and 20% horizontal. The horizontal pumps are used in irrigation applications in which the water is supplied at surface level, such as a lake, canal or shallow well. Deep well and reservoirs require vertical turbine pumps also known as the deep well turbine. The number of variables in pump design as well as the number of applications in a given pulp and paper plant or water and wastewater or irrigation facility make it nearly impossible to clearly segment the centrifugal pumps in these industries.

Appendix IV.
Engineering Consultants/Contractors

Company Name	Size	Industries Served
Burns and McDonnell	International Company	water & waste, irrigation, pulp & paper
Black & Veatch	International Company	water & waste
Camp Dresser & McKee Inc	International Company	water & waste, irrigation, pulp & paper
CH2M Hill	International Company	water & waste, irrigation, pulp & paper
David Evans and Associates, Inc	International Company	water & waste, irrigation, few pulp & paper
Entranco, Inc	Nationwide Company	water & waste and irrigation
Gray & Osborne, Inc	Statewide Company (Washington)	water & waste
Harza Engineering Company	International Company	water & waste, irrigation, few pulp & paper
HCMA Consulting Group, Inc	Local Company (Oregon)	pulp & paper
J-U-B Engineers, Inc	Statewide Company (Idaho)	water & waste and irrigation
O'Neal, Inc	Offices in GA, NC, SC, services worldwide	pulp & paper
Parametrix, Inc	Nationwide Company	water & waste and irrigation
R.W. Beck, Inc	International Company	water & waste, irrigation, pulp & paper
W & H Pacific, Inc	Pacific Northwest Region	water & waste
Walk Haydel & Associates, Inc	International Company	pulp & paper

Appendix V.
Interview Guidelines

TALKING POINTS
Equipment Manufacturers
(Pumps, Fans/Blowers, Conveyor Systems)

- What industries are you supplying to?
- How do you segment your products? By industry? By size? What types of products go into the Pulp & Paper industry? Waste & Water? Irrigation?
- How do your products flow through the channel? (i.e. direct to plants or through distributors) Does this differ by industry or plant size?
- How does the product flow to the end user?
  - % direct to OEM % to equipment man % motor distributor % other (contractor)
- Who specs the equipment? Are your products custom made based on the specs?
- What technology and other trends are affecting your business?
- Are you or the industry as a whole passive or active with regard to innovation of new products?
- What percent of dollars is allocated to R&D? Are there firms regarded as industry leaders in this respect?
- Are there any major suppliers to your industry? (e.g. motors, drives, impellers)
- What are the states of the industry of Pulp & Paper, Waste & Water and Irrigation?
- Are there any State, Local and National Codes regulating your product? Specific to Energy Efficiency? Materials?
- Are there different dynamics in the Pacific Northwest? (codes, drivers, industries, energy awareness)
- What products exist that are more energy efficient? Do they sell?
- What more can be done with regard to energy efficiency? Product refinements?

TALKING POINTS
Northwest Plants & Mills
Irrigation

- How big is your company (overall & in MT, OR, WA, ID)?
- Acres of irrigated land, and when applicable acres of farm?
- Water supplied? Water Pumped? (different due to evaporation, seepage, overflow loss)
- Avg. head of water lifted?
- Returns to river flow?
- How do you classify yourself?
- Public v. Private?
- Federal v. Irrigation Districts or Cooperatives?
- Deep well pump v. Surface Water v. provided by water supplier?
- Pressurized system v. Flood Irrigation?
- How do you order Pumps, Fans/Blowers, & Conveyance Systems
- Direct or through OEM?
- New or used? Through auction houses?
- How many pumps do you order a yr.?
  - % 1-5 Horsepower ; % 6-20 HP; % 21-50 HP; % 21-50 HP; %51-100 HP; %100-200HP; %200-500 HP; %501-1000 HP)
- # of pumps by size (b/c larger tend to get rewound rather than replaced)
- Reliability of the pumps…Any issues with specific pumps/ fans/blowers & conveyance?
- Do you order entire systems or pumps, fans/blowers, conveyance parts and assemble in house?
- When ordering equipment, what factors do you consider? (initial cost, brand, energy efficiency and/or operating cost)
- Do "energy efficient" products exist? Is that of any interest to you?
- What kind of payback period do you expect to offset the additional expense of more energy efficient products?
- Are there any codes or regulations regarding pumps, fans/blowers, and conveyance parts? Specific to energy efficiency? Materials?
- What is the state of the industry? Stagnant or growing? Does this impact how you order equipment? Nationally and PNW?
- What technological trends are you experiencing in the industry with regard to process or regulation? Prompt on stream flow issues and reduction in turbulence and drip irrigation & and how that effects energy efficiency and/or equipment purchase decisions.

- How do your products flow through the channel? (i.e. direct to plants or through distributors) Does this differ by industry or plant size?
- Are there any State, Local and National Codes regulating your product? Specific to or affecting Energy Efficiency? Materials?
- Are there different dynamics in the Pacific Northwest with regard to product purchase? (codes, drivers, industries, energy awareness)
- What more can be done with regard to energy efficiency? Product refinements?

TALKING POINTS
Northwest Plants & Mills

Pulp & Paper

- How big is your company (overall & in MT, OR, WA, ID)?
- How do you classify your plant?
- Mechanical vs. chemical process (does this change the type or amount of pumps/fans/blowers/conveyance systems you purchase)
- Type of paper (paperboard, newsprint, etc)
- Is the plant integrated or non-integrated?
- How do you order Pumps, Fans/Blowers, & Conveyance Systems
- Direct or through OEM?
- New or used? Through auction houses?
- How many do you order a yr.?
- Do you order entire systems or pumps, fans/blowers, conveyance parts and assemble in house?
- How many pumps do you order a yr.?
  - % 1-5 Horsepower ; % 6-20 HP; % 21-50 HP; % 21-50 HP; %51-100 HP; %100-200HP; %200-500 HP; %501-1000 HP)
- # of pumps/fans/blowers conveyance by size (b/c larger motors to get rewound rather than replaced)
- Reliability of the pumps…Any issues with specific pumps/ fans/blowers & conveyance?
- When ordering equipment, what factors do you consider? (initial cost, brand, energy efficiency and/or operating cost)
- Do "energy efficient" products exist? Is that of any interest to you?
- What kind of payback period do you expect to offset the additional expense of more energy efficient products?
- Are there any codes or regulations regarding pumps, fans/blowers, and conveyance parts? Specific to energy efficiency? Materials?
- What is the state of the industry? Stagnant or growing? Does this impact how you order equipment? In the Nation? In the PNW?
- How do your products flow through the channel? (i.e. direct to plants or through distributors) Does this differ by industry or plant size?
- Are there any State, Local and National Codes regulating your product? Specific to Energy Efficiency? Materials?
- Are there different dynamics in the Pacific Northwest with regard to product purchase? (codes, drivers, industries, energy awareness)
- What more can be done with regard to energy efficiency? Product refinements?

TALKING POINTS
Northwest Plants & Mills
Waste & Water

- How big is your company (overall & in MT, OR, WA, ID)?
- Throughput or gallons per day
- Type of Waste Treatment facility technology
- Private v. Public
- How do you classify your plant?
- Mechanical vs. chemical process (does this change the type or amount of pumps/fans/blowers/conveyance systems you purchase)
- Type of paper (paperboard, newsprint, etc)
- Is the plant integrated or non-integrated?
- How do you order Pumps, Fans/Blowers, & Conveyance Systems
- Direct or through OEM?
- New or used? Through auction houses?
- How many pumps do you order a yr.?
  - % 1-5 Horsepower ; % 6-20 HP; % 21-50 HP; % 21-50 HP; %51-100 HP; %100-200HP; %200-500 HP; %501-1000 HP)
- # of pumps/fans/blower/conveyance by size (b/c larger motors tend to get rewound rather than replaced)
- Reliability of the pumps…Any issues with specific pumps/ fans/blowers & conveyance?
- Do you order entire systems or pumps, fans/blowers, conveyance parts and assemble in house?
- When ordering equipment, what factors do you consider? (initial cost, brand, energy efficiency and/or operating cost)
- Do "energy efficient" products exist? Is that of any interest to you?
- What kind of payback period do you expect to offset the additional expense of more energy efficient products?
- Are there any codes or regulations regarding pumps, fans/blowers, and conveyance parts? Specific to energy efficiency? Materials?
- What is the state of the industry? Stagnant or growing? Does this impact how you order equipment? Nationally? PNW?
- How do your products flow through the channel? (i.e. direct to plants or through distributors) Does this differ by industry or plant size?
- Are there any State, Local and National Codes regulating your product? Specific to Energy Efficiency? Materials?

- Are there different dynamics in the Pacific Northwest with regard to product purchase? (codes, drivers, industries, energy awareness)
- What more can be done with regard to energy efficiency? Product refinements?

Appendix VI.
Equipment Base Numbers and Explanation

A. **Pumps**

The pumps sold assumption is based on 1998 Census data. According to the Census, there were 11,931,808 (pumps & parts) sold in 1998. Ducker assumed a conservative 5% growth rate. This growth rate is based on 7% growth reported in the Census Report between 1997 and 1998. As a result, Ducker estimates that there were 12,528,397 pumps and parts sold in the United States in 1999. Ducker used the GDP for the states in the Pacific Northwest to estimate the proportion of pump sales in the region. Northwest represents 4% of GDP. Therefore, 4% of 12,528,397 is 501,136 pumps and parts sold in the Pacific Northwest. In order to determine the proportion of pumps and parts in the three industries under study in the Pacific Northwest, Ducker used the Easton report's energy consumption. Ducker weighted the amount of pumps and parts based on Easton's data that 73% of pump energy used in 3 industries (Table A of the resort). As a result, Ducker deduced that there are 365,829 pumps and parts within the three industries under study in the PNW (501,136*.73). Based on conversations with pump distributors and manufacturers, Ducker was able to estimate that every twelfth part shipped is a pump, which indicates that there are 30,485 pumps shipped to the three industries in the Pacific Northwest (365,829/12=30,485). Ducker learned that some shipped are inventoried. Hence, 29,500 pumps sold in water & waste, irrigation and pump & paper industries in the Pacific Northwest.

TOTAL PUMPS SOLD

PUMPS SOLD

HP	% by HP	Total	% Total
1-50	0.9	26550	90.0%
51-500	0.08	2360	8.0%
500+	0.02	590	2.0%
Total		29500	

Ducker then found the installed base of pumps based on life expectancies of the pumps in the three industries. These life expectancy estimates were the result of iterative interviews with plant managers, engineers, and consultants for each of the industries as well as pump manufacturers. Total estimates as well as industry specific estimates were verified with these plant managers, engineers, and consultants.

PUMPS INSTALLED BASE

INSTALLED BASE

HP	Life	Total	Rounded	% Total
1-50	6	159300	159,000	80.7%
51-500	11	25960	26,000	13.2%
500+	20	11800	12,000	6.1%
Total		197060	197,000	

Based on the installed base estimates, Ducker then found the horsepower breakdown by taking the installed base and multiplying it by the mid range horsepower for each category. This provided Ducker with the estimated total horsepower for each category. Based on the category totals, the percentage breakdown could be deduced from the total.

PUMPS HORSEPOWER BREAKDOWN

HP	Installed Pumps	Avg HP	Total HP	HP % Breakdown
1-50	159,000	25	3,975,000	20.4%
51-500	26,000	250	6,500,000	33.4%
500+	12,000	750	9,000,000	46.2%
Total	197,000		19,475,000	

Industry specific pump numbers were derived from manufacturers, distributors and end users as well as the Easton report energy usage. Total pumps sold by industry is based on the overall total pumps sold and the ratio of energy usage in the industry and the total energy usage as the reported in the Easton report. The percent horsepower breakdown as well as the life expectancy are based on iterative conversations with plant engineers, maintenance managers, and engineering consultants as well as pump manufacturers. Ducker multiplied the life estimate derived from these market conversations with units sold in each horsepower category to arrive at the installed base. Ducker then found the horsepower breakdown by taking the installed base and multiplying it by the mid range horsepower for each category. This provided Ducker with the estimated total horsepower for each category. Based on the category totals, the percentage breakdown for each industry could then be deduced from the total horsepower.

PUMPS BY INDUSTRY

W&W

	Percentage	Life	Units Sold	Installed Base	Installed %	Avg HP	HP and Installed Base	HP Energy Breakdown in Percent
1-50	75.0%	4.90	1991.25	9757.13	63.7%	25.00	243928.13	21.9%
51-100	14.0%	7.75	371.70	2880.68	18.8%	75.00	216050.63	19.4%
101-300	10.0%	8.60	265.50	2283.30	14.9%	200.00	456660.00	40.9%
300+	1.0%	15.00	26.55	398.25	2.6%	500.00	199125.00	17.8%
Total	100.0%		2655.00	15319.35			1115763.75	100.0%
								Total Energy in WW is 966 GWHr

Pulp and Paper

	Sales %	Life	Units Sold	Installed Base	Installed %	Avg HP	HP and Installed Base	HP Energy Breakdown in Percent
1-50	85.0%	4.90	7522.50	36860.25	72.2%	25.00	921506.25	19.7%
51-100	8.0%	7.60	708.00	5380.80	10.5%	75.00	403560.00	8.6%
101-200	4.0%	8.60	354.00	3044.40	6.0%	150.00	456660.00	9.8%
201-500	2.0%	20.00	177.00	3540.00	6.9%	350.00	1239000.00	26.5%
500+	1.0%	25.00	88.50	2212.50	4.3%	750.00	1659375.00	35.5%
Total	100.0%		8850.00	51037.95			4680101.25	100.0%
								Total Energy in PP is 3126 GWHr

Irrigation

	Sales %	Life	Units Sold	Installed Base	Installed %	Avg HP	HP and Installed Base	HP Energy Breakdown in Percent
1-50	90.0%	6.20	16195.50	100412.10	76.5%	25.00	2510302.50	25.0%
51-500	9.0%	16.90	1619.55	27370.40	20.9%	200.00	5474079.00	54.5%
500+	1.0%	19.00	179.95	3419.05	2.6%	600.00	2051430.00	20.4%
Total	100.0%		17995.00	131201.55			10035811.50	100.0%
								Total Energy in Irr is 6278 GWHr

B. **Fans and Blowers**

Fans sold assumption based on Ducker Industrial/Commercial Fan Database. According to the Ducker Industrial/Commercial Fan Database, the total industrial Fan/Blower market $400 million. According to multiple conversations with fan and blower manufacturers and distributors, the average price of Fan/Blower $320 per unit. Ducker divided $400 million by the per unit cost of $320 to derive that 1.25 million Fan/Blowers sold nationally. Ducker used the GDP for the states in the Pacific Northwest to estimate the proportion of pump sales in the region. Northwest represents 4% of GDP. Therefore, 4% of 1.25million Fans/Blowers is 50,000 units sold to all industries in the Pacific Northwest. In order to determine the proportion of Fans/Blowers in the two industries they are utilized (water and wastewater as well as pulp and paper), Ducker used the Easton report's energy consumption data. Ducker weighted the amount of Fans/Blowers based on Easton's data that 37% ((1993+151)/5830 = 37%) of Fan/Blower energy used is in the two industries (Table A of the Easton report). As a result, Ducker estimates that the amount of Fans/Blowers sold in the two industries within the Pacific Northwest is 18,500 (.37*50,000)

TOTAL FANS/BLOWERS SOLD

SOLD HP	**% by HP**	**Total**	**% Total**
1-50	80.0%	14800	80.0%
51-100	10.0%	1850	10.0%
100+	10.0%	1850	10.0%
Total		18500	

Ducker then found the installed base of fans/blowers based on life expectancies of the fans/blowers in the two industries. These life expectancy estimates were the result of iterative interviews with plant managers, engineers, and consultants for each of the industries as well as fan/blower manufacturers. Total estimates as well as industry specific estimates were verified with these plant managers, engineers, and consultants.

FANS/BLOWERS INSTALLED BASE

INSTALLED HP	**Life**	**Total**	**Rounded**	**% Total**
1-50	5	74000	74000	57.1%
51-100	10	18500	18500	14.3%
100+	20	37000	37000	28.6%
Total			129,500	

Based on the installed base estimates, Ducker then found the horsepower breakdown by taking the installed base and multiplying it by the mid range horsepower for each category. This provided Ducker with the estimated total horsepower for each category. Based on the category totals, the percentage breakdown could be deduced from the total.

FANS/BLOWERS HORSEPOWER BREAKDOWN

HP	Installed Fans	Avg HP	Total HP	HP % Breakdown
1-50	74000	25	1850000	17.4%
51-100	18500	75	1387500	13.0%
100+	37000	200	7400000	69.6%
Total	129,500		10637500	

Industry specific fan/blower data was derived from manufacturers, distributors and end users as well as the Easton report energy usage. Total fans/blowers sold by industry is based on the overall total fans/blowers sold and the ratio of energy usage in the industry and the total energy usage as the reported in the Easton report. The percent horsepower breakdown as well as the life expectancy are based on iterative conversations with plant engineers, maintenance managers, and engineering consultants as well as pump manufacturers. Ducker multiplied the life estimate derived from these market conversations with units sold in each horsepower category to arrive at the installed base. Ducker then found the horsepower breakdown by taking the installed base and multiplying it by the mid range horsepower for each category. This provided Ducker with the estimated total horsepower for each category. Based on the category totals, the percentage breakdown for each industry could then be deduced from the total horsepower.

FANS/BLOWERS BY INDUSTRY

W&W

	% Sold	Life	Units Sold	Installed Base	% Installed Base	Average HP	HP and Installed Base	HP Energy Breakdown in Percent
W&W								
1-50	80.0%	5.00	1036	5180	57.1%	25.00	129,500	25.0%
50+	20.0%	15.00	259	3885	42.9%	100.00	388,500	75.0%
Total	100.0%		1295	9065			518,000	100.0%
								Total Energy in WW is 147 GWHr

Pulp and Paper

	% Sold	Life	Units Sold	Installed Base	% Installed Base	Average HP	HP and Installed Base	HP Energy Breakdown in Percent
1-20	20.0%	4.00	3441	13764	11.4%	25.00	344,100	1.7%
21-50	50.0%	4.00	8603	34410	28.6%	75.00	2,580,750	12.5%
51-100	20.0%	11.00	3441	37851	31.4%	150.00	5,677,650	27.5%
100+	10.0%	20.00	1721	34410	28.6%	350.00	12,043,500	58.3%
Total	100.0%		17205	120435			20,646,000	100.0%
								Total Energy in PP is 2017 GWHr