Small Water Supply Facilities
A Profile of Motor Energy Efficiency Opportunities

Summary

The water supply industry (SIC 4941) includes establishments primarily engaged in distributing water for sale for domestic, commercial, and industrial uses other than irrigation. Water supply is a diverse industry. While production and distribution are the essential functions of most supply facilities, there is much variation, even among facilities in the Southern California Edison service territory. Below are some quick facts about the industry (with details to follow in text):

- Nationwide water supply industry revenues in the year 2000 total more than $30 billion; revenues for small facilities[1] in the SCE service territory total $905.6 million for 2000.
- Nationwide, water and wastewater treatment account for 3 percent of total electricity use; pump and compressor motors account for 80 to 90 percent of total electricity use in these industries.
- Energy use in the industry is expected to increase with more stringent water quality regulations.
- Energy efficiency measures may save up to 40 percent of annual energy costs and yield returns of thousands of dollars with payback periods ranging from a few months to a few years.
- A new energy efficient 25hp, fully enclosed, 1800-rpm vertical shaft motor running 16 hours per day at 75 percent load will save $600 per year over a standard efficiency motor at rates of $0.10/kWh. With a cost premium of $380 over a standard motor, simple payback is less than 8 months (CEC, 1997).
- For a 50hp 1800-rpm vertical shaft motor, choosing the most efficient model on the market will save almost $1,600 per year over a model with an average efficiency level. With a cost premium of $525 over a standard motor, simple payback is less than 7 months, and the rate of return (IRR) is 175%. The Net Present Value of the incremental investment in the highest efficiency motor is $4,330 over a 10-year horizon with a 15% discount rate.
- Nearly 40 percent of drinking water systems with surface water sources have a need to build, rebuild, or make significant improvements at their treatment facilities.
- Approximately 35 percent of capital in the water supply industry is spent to repair or replace equipment; a significant opportunity for introducing energy efficient motors into the industry exists when failed motors are replaced.

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[1] For the purposes of this document, "small" facilities are defined as those employing 100 or fewer persons with annual electricity consumption of 250 to 1,299 MWh.

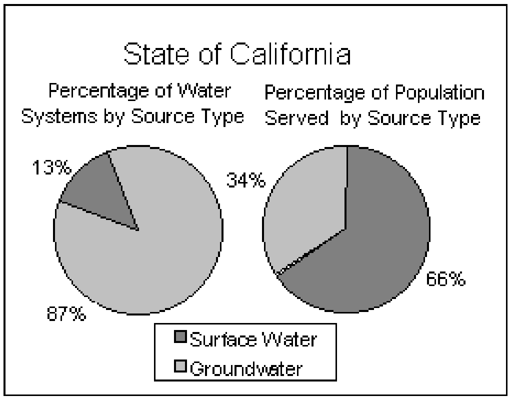
1 INDUSTRY DESCRIPTION

1.1 Employment

In 1997 community water systems (public water systems with at least 15 service connections or serving 25 persons year-round) employed approximately 64,000 full-time operators nationwide, comprising 70 percent of the workforce employed in this industry (US EPA, 2000; 1997a). 76 percent of these operators were certified by their states and additional 10 percent received some formal training from state or national programs (US EPA, 1997a). The state of California employed approximately 9,000 certified operators in 1999 (CA DHS, 2000b). As of December 2000, the 82 small water supply facilities served by SCE employed a total of 3,636 individuals with an average of 44 employees per facility (D&B Marketplace, Oct-Dec 2000). Because of the high level of training in this industry, knowledge of energy efficiency has the potential to reach a high proportion of employees if incorporated into operator education.

1.3 Water Source and System Size

Drinking water originates from groundwater or surface water sources (lakes, rivers, or holding basins). In 1997, 79.8 percent of the nation's community water systems used primarily groundwater sources, and 9.6 percent used primarily surface water (US EPA, 1997a). The remaining systems purchase water that has already been treated by other systems. In 1999, 87 percent of California's community water systems were supplied by groundwater sources. These served 34 percent of the population. The remaining 13 percent of California's community water systems have surface water sources and serve the majority of the population (66 percent, or approximately 22.5 million people) (US EPA, 1999b). Thus, regulations affecting the quality of water supplies with surface water sources (such as the upcoming Interim Surface Water Treatment Rule[2]) will affect the majority of California's population.



The EPA classifies "large" municipal surface water systems as those serving more than 50,000 customers. These types of facilities serve the majority of customers in the United States (several million people), but account for only 2 percent of the total number of water systems. Thirteen percent of community water systems serve between 3,301 and 50,000 customers and are classified by the EPA as "medium-sized" systems. Eight-five percent of community water systems in the United States fit the EPA classification of "small" (501 to 3,301) and "very small" (25 to 3,300) community water systems (US EPA, 1997a). Thus, there are far more small systems in the United States, but large systems serve the majority of customers. Upcoming

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[2] See page 4 for further details.

water quality regulations are aimed at facilities that fall into the EPA’s “large” size category and will thus affect water supplies serving the majority of California’s population.

Five of the largest water supply facilities in the Southern California Edison service territory are:

- Inland Empire Utilities Agency, Rancho Cucamonga
- City of Long Beach Water Department, Long Beach
- Southern California Water Company, San Dimas[3]
- Metropolitan Water District of Southern California, Granada Hills
- Eastern Municipal Water District, Hemet

Contact information for these facilities is provided in Section 5.5 of this report.

1.4 Ownership and Sales

US EPA analyses (1997a) have demonstrated that public agencies (municipalities, counties, water districts or authorities, and townships) own 43 percent of community water systems. Private companies own another 33 percent.[4] The remaining 24 percent are ancillary systems (such as mobile home parks, schools, and hospitals) that do not bill users directly for water service. Annual sales for the 82 small water supply facilities receiving their electricity from SCE totaled $905.6 million in 2000. Total nationwide water utilities revenues for 2000 are estimated at more than 30 billion dollars, a 17 percent increase from 1996 figures (Environmental Business International, 1997 in ETI, 1997).

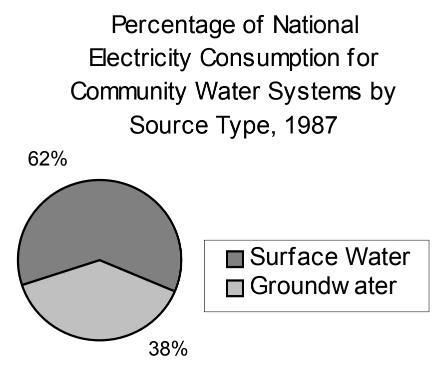
Water Supply Industry Sales, 2000
(Facilities Served by SCE)

# Employees	# Businesses*	Total Sales (Millions)	% Total Sales
10-24	14	62.2	6.9%
25-49	35	215.6	23.8%
50-99	33	627.8	69.3%
Total	*82*	*905.6*	*100%*

* SIC 4941 facilities receiving electricity from SCE.
Source: D&B Marketplace, Oct-Dec 2000

2 ENERGY AND MOTOR USE

As a whole, water and wastewater supply and treatment facilities consume an estimated 75 billion kilowatt-hours (kWh) annually or approximately 3 percent of the nation's total electricity use (Oliver & Putnam, 1997). Energy use in the water supply industry differs for facilities with surface water sources versus groundwater sources, and there is


Percentage of National Electricity Consumption for Community Water Systems by Source Type, 1987

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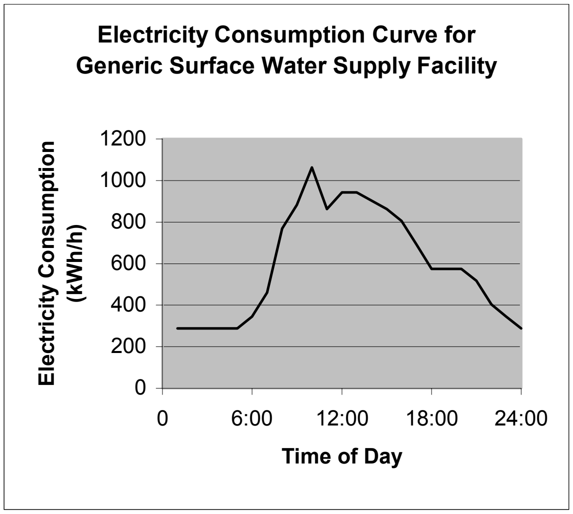
[3] San Dimas is the largest, but the Southern California Water Company has several other locations including Anaheim, Carson, Los Alamitos, and Santa Fe Springs.

[4] Investors own 49.6 percent of privately owned supplies, homeowners associations 34.6 percent, and other entities 15.8 percent.

much variation among these. Most surface water requires treatment and disinfection prior to distribution to customers because of impurities in the water resulting from runoff, silt, debris, and microorganisms (EPRI, 1993). Groundwater, on the other hand, generally requires less processing than surface water and usually undergoes only disinfection. Groundwater thus requires less treatment energy in getting the water from its source to the customer. In contrast, groundwater systems require more pumping energy than surface water systems to transport water from source to customer (US EPA, 1999a).

Using 1993 national figures for the total average production and number of customers, the Electric Power Research Institute (EPRI) estimates that the average per capita water production is approximately 200 gallons per capita per day. A facility serving 5,000 customers would thus require an output of approximately one million gallons per day (mgd). A surface water treatment plant of this capacity requires approximately 1,480 kWh electricity per day, whereas a groundwater system of the same capacity requires approximately 1,820 kWh electricity per day, a difference of about 19 percent (EPRI, 1993). Despite this difference, total nationwide energy consumption for groundwater systems is generally less than for surface water systems because surface water systems produce a larger total volume of water and supply a far greater number of customers.

In the future, energy use in the water supply industry is expected to increase as a result of new drinking water regulations. These regulations, such as the Safe Drinking Water Act (SDWA), require increasing use of energy intensive processes such as ozonation and membrane filtration to bring water up to regulated standards (EPRI 1993). In addition, the US EPA's Interim Enhanced Surface Water Treatment Rule (effective December 2001) will require that large surface water treatment systems incorporate additional processes to reduce presence of microbial contaminants, and this regulation may necessitate additional energy consumption for specific treatment applications (US EPA, 1999a).



Energy use in the industry varies at different times throughout the day and year, and energy use generally increases with increased demand. Daily demand is typically lowest between midnight and 6 a.m., followed by a rapid increase the daylight hours and a significant drop off in the evening (EPRI, 1993). Nationwide, seasonal demand is lowest in the winter months when water use for outdoor purposes is at its lowest, but this seasonal difference is far less dramatic in California than in other areas of the country. In general, demand (and thus energy use) is greatest during the summer months.

The majority of energy in water supply facilities is used to supply motors for pumps and air compressors (46 and 40 percent respectively) (US DOE, 1998e).[5] According to industry experts, the motor speed most widely used in the industry is 1800 rpm. Vertical hollow shaft motors are the most commonly used motors in southern California's water treatment industry. These are generally 250hp or lower (with smaller motors [i.e., 50hp] used primarily for filtration purposes), although motors as large as 1000hp are used on occasion in large operations. Horizontal motors are not widely used for these applications in southern California.

MOTOR EFFICIENCY SAVINGS

When purchasing a new motor, choosing an energy efficient 25hp, 1800-rpm, totally enclosed, fan cooled 460-volt motor that runs 16 hours per day at 75% load will save $600 per year over a standard efficiency motor at an electrical rate of $0.10/kWh. With a cost premium of $378, simple payback is less than 8 months.

Source: CEC, 1997

3 MOTOR EFFICIENCY MEASURES

This section introduces some of the measures for improving the energy efficiency of motor systems, and provides some efficiency and cost data on sample motors, along with calculations to illustrate the financial costs and benefits of premium efficiency motors. However, motor applications vary between different facilities and motor costs and performance specifications change over time. Any site-specific or detailed analysis should be based on updated information from sources listed in section 6, "Tools and Sources of Additional Information," including:

- DOE's Best Practices (http://www.oit.doe.gov/bestpractices/motors/) and
- Consortium for Energy Efficiency (www.ceeformt.org/ind/mot-sys/mot-sys-main.php3 or www.ceeformt.org).

3.1 Types of Motor Efficiency Measures

Potential energy savings for motor systems in the water supply industry range from 20 to 50 percent of total energy use when efficient motors are used in place of standard efficiency models (Oliver & Putnam, 1997). Motor efficiency opportunities are widely available at many water supply facilities, and these measures fall into three broad categories. The first category of efficiency measures occurs at the operations level and may involve very little capital expenditure. Second, component level measures involve replacing inefficient motors with higher efficiency models while incorporating energy efficiency standards into the facility's motor replacement policies. Finally, systems level measures include optimization of pump and motor sizes and installation of variable frequency drives (VFDs). Measures at this level may require consultation with engineers and substantial capital investment. Each of these types of measures are discussed below.

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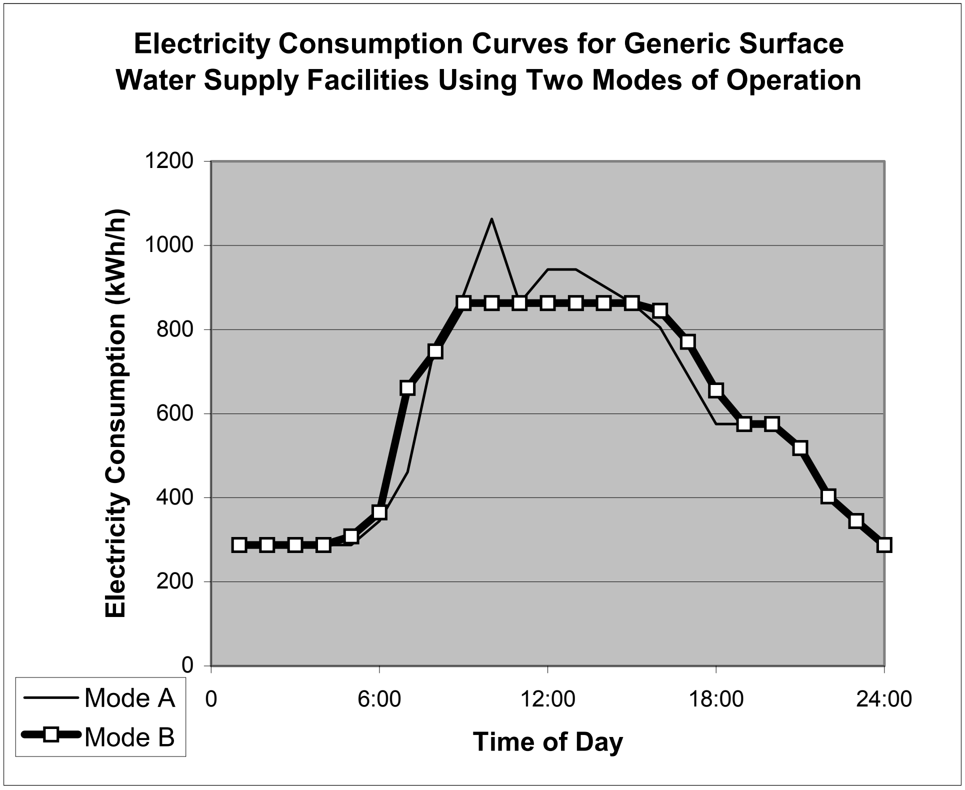
[5] This is consistent with the California Energy Commission (1997) and Department of Energy (1998c) findings that these motors together account for between 80 and 90 percent of energy used in this industry.

3.1.1 Operations Level Measures

Efficiency measures at the operations level may be undertaken at little or no cost. Facilties personnel can perform monitoring and maintenance on equipment to increase system efficiency and prolong equipment life (Oliver & Putnam, 1997; Qayoumi, 1995). Temperature and ventilation can also affect motor efficiency, and manufacturers should be able to provide information to facilities personnel about optimum operating conditions (Qayoumi, 1995). Even though facilities must hire systems engineers to assist with some efficiency assessments, money can be saved if facilities personnel undertake a few of the preliminary steps that the engineers would otherwise handle. These include measuring system pressures, using flow meters to determine flow rates, and sketching pump systems with elevations. Facilities staff can undertake all of these preliminary information-gathering components of the engineering analysis prior to the engineer's involvement (Oliver & Putnam, 1997; Qayoumi, 1995).

Energy costs can be reduced by switching production to off-peak times, thus avoiding the highest electricity costs. When the necessary storage capacity is available, this may be achieved at little or no cost. Rather than following the typical production rate (shown in Mode A in the figure), the rate can be smoothed by increasing pumping and storage at off-peak times so that high energy use does not correspond with times of demand. This will lower the facility's energy expenditures. In ideal situations where large storage capacities are available, systems may operate at a relatively constant rate throughout a 24-hour period. By switching production to off-peak times, the Encina Wastewater Authority (Carlsbad, CA) was able to reduce its peak electricity demand, resulting in an annual savings of approximately $50,000 (US DOE, 1998a). It is generally unnecessary to seek engineering assistance when making these types of changes.



3.1.2 Component level measures

Component level measures involve replacing standard motors with their energy efficient counterparts. Measures at this level present significant potential energy savings for this industry. For pumping applications, it is important to distinguish between hollow-shaft, vertically mounted pump motors and general purpose motors. Vertically mounted motors are not covered by the Energy Policy Act (EPAct), nor are they yet covered by CEE's premium-efficiency specifications. This section addresses efficiency opportunities for vertically-mounted motors as well as for "general purpose" (EPAct) motors, which are covered by EPAct standards and CEE specifications.

The efficiency market in vertically-mounted motors is not yet mature, especially for larger motors. Two manufacturers dominate this market and no clear premium-efficiency threshold has been established. Motors that are more powerful than 50 HP show significantly less variation in efficiency levels, thus providing little opportunity for cost-effective motor efficiency investments.

Nevertheless, a comparison of cost and performance data from the MotorMaster manufactures catalog, motor manufacturers, a consulting report to SCE on agricultural motors (Feldman, 2001), and other sources (CEC, 1997; Qayoumi, 1995) provides the following assumptions for open drip-proof 1800 rpm vertical shaft motors. The standard efficiency in this table is based on the typical or average efficiency of the motors listed in the MotorMaster catalog. The "high" efficiency is the highest efficiency of matching motors in the list.

Size	Standard efficiency	High efficiency	Rewind cost	Standard motor cost	High efficiency motor cost
10 HP	86.5%	91.1%	--	$1,200	$1,551
50 HP	91.7%	94.5%	$2,343	$3,020	$3,543
100HP	92.4%	95.%4	$3,975	$5,600	$6,333

The most attractive opportunities to install energy efficient motors arise when water supply facilities purchase new motors as a result of existing motor failure when expanding facility size or capacity. When motors fail, facilities managers may consider rewinding the motor rather than replacing it, but the rewinding process may cause an efficiency degradation of up to 2.5 percent and is thus a poor decision from the energy use standpoint. While improved rewinding practices may reduce efficiency losses somewhat, the extent to which these practices have been adopted by rewinding shops is difficult to determine (US DOE, 1998e).

Although initial purchasing costs are higher (often between 15-30 percent of the total motor cost), energy efficient motors have longer insulation and bearing lives, lower heat output, less vibration, and are more tolerant of overload conditions and phase imbalance than their standard efficiency counterparts (CEC, 1997). As a result these motors have lower failure rates and for this reason manufacturers generally provide longer warranties for their energy efficient lines (CEC, 1997).

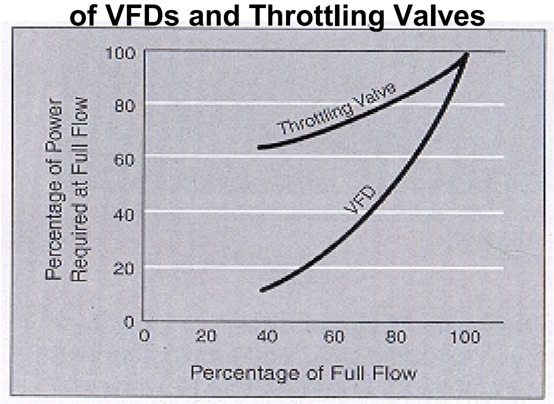
3.1.3 Systems Level Measures

All of these efficiency measures can be approached in concert by employing a "systems approach" to motors efficiency. Rather than viewing motor systems as a distinct part of the operating system, all of a system's components should be considered when implementing efficiency measures.

Some adjustments to "tune up" pump or motor systems may have little cost and may achieve significant efficiency improvements even without purchase of new motor equipment. However, some systems level measures may require consultation with engineers and may require substantial capital investment. Because motors typically have highest efficiency at 70 to 90 percent of their maximum loads, effectively matching motors to loads will result in substantial energy savings (Qayoumi, 1995). Plant level personnel may require outside specialized engineering assistance to make these determinations with regard to specific equipment in their facilities.

An analysis of system efficiency may reveal opportunities to install variable frequency drives (VFDs). A VFD is an electronic control device that modulates the amount of power being delivered to a motor to allow for continuous matching of motor speed to the demands of varying flow and may be used to increase motor efficiency in water supply facilities. These devices accommodate fluctuating demand by running pumps at lower speeds and requiring less energy while more accurately meeting pumping needs. They are efficient alternatives to standard throttling valves (see chart at left) and cause far less stress and damage to mechanical equipment.

Energy Consumption of VFDs and Throttling Valves



Source: US DOE, 1998d.

Variable Speed Drive Example

With a 25hp motor running 23 hours per day (2 hours at 100 percent speed; 8 hours at 75 percent; 8 hours at 67 percent; 5 hours at 50 percent - typical of the water supply industry) a VFD can reduce energy use by 45 percent. At $0.10 kWh, this results in an annual savings of $5,374 (CEC, 1999.)

Successful and Financially Feasible Motor Systems Efficiency Measures

Efficiency Measure	Successful Application	Costs, Savings, & Benefits
Replace overloaded motors with efficient models of proper size.	Davidson Water, Inc., SC. System-wide upgrades to properly-sized energy efficient motors.	Savings: $32,000/yr (Advanced Energy, 1999)
Replace one large motor operating in-efficiently at a partial load with two or more smaller motors oper-ating more efficiently at larger loads.	1 Pumping Station, Trumbull CT. Two pumps driven by 40hp motors (340,000 gal/day). One pump used to handle flow under normal operations, other required only in extreme conditions; neither operated > 5 min at a time. Frequent breakdowns. Added efficient 10hp pump running for longer periods with others kicking in to handle infrequent peak flows.	Initial Cost: $12,000 Payback Time: 1.9 years Savings: $2,600/yr (31,900kWh) Electricity Use Reduction: 40% Additional Savings: $6,000 / yr in equipment maintenance costs. System Capacity Increase: 25% Decreased noise. Extended expected equipment life (US DOE, 1999)
Install VFDs (variable frequency drives).	Madera Valley Water Company, CA Groundwater sourced system supplying up to 8.21 million gal/day. Installed VFDs in 2 of its 5 wells.	Savings: $1,300/yr Reduced equipment wear & tear Decreased maintenance costs Increased expected equipment life (US DOE, 1998b; 1998d)

System-wide efficiency measures can thus result in enormous savings in both money and energy. These measures may involve measures affecting not only motor systems but other components of the water supply process as well. Here are some additional examples:

Efficiency Savings in California Water Supply and Wastewater Treatment Industries			
Facility and Capacity	**Efficiency Measures**	**Energy Efficiency Savings**	**Savings as % of Total Electricity Costs**
City of Willits Wastewater Treatment Plant, Capacity: 1.3 mgd	- install VFDs - replace 1 large pump with several smaller pumps	$15,000	14%
Madera Valley Water Company Capacity: 8.21 mgd	- install VFDs - replace existing motors with efficient motors - retrofit pump bowl for efficiency	$19,000	15%
San Juan Water District Sidney N. Peterson Water Treatment Plant Capacity: 120 mgd	- replace 8 existing motors with efficient motors - install 4 VFDs - reduce pumping and increase lighting efficiency	$68,400	17%
Moulton Niguel Water District Capacity: 48 mgd	- replace existing motors with efficient motors - upgrade existing computer controls	$332,000	25%
East Bay (Oakland) Municipal Utility Special District 1, Wastewater Treatment Plant Capacity: 415 mgd	- cogenerate electricity & thermal energy on-site from waste methane - install high efficiency motors and VFDs - discontinue use of some equipment - replace 2 small with one large efficient compressor	$2,796,000	***[4]
Encina Wastewater Authority Capacity: 36 mgd	- cogenerate electricity & thermal energy on-site from waste methane - upgrade aeration diffusers - install high efficiency motors and VFDs	$611,000	***[4]

Case studies for each of these examples are available from the United States Department of Energy (US DOE), along with information on other motor efficiency measures.[6]

3.2 Financial Analysis of Motor Efficiency Decisions

In this section, we present a financial analysis of hypothetical decisions on replacement of a range of motors, starting with a 50 HP vertical shaft motor and then moving to a 100 HP general purpose motor.

3.2.1 Vertical Shaft Motor Analysis

As noted above, vertical shaft motors are not subject to the EPAct standards, so most such motors are less efficient than their general purpose counterparts. As a result, it is a very

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[6] Department of Energy Motor Challenge Information Clearinghouse, (800) 862-2086 or www.motor.doe.gov

attractive investment to find the most efficient motor available instead of settling for a lower efficiency model. The table below illustrates this by presenting a financial analysis for a 50 HP vertical shaft motor upgrade investment at the time that a motor has failed and needs replacement. The analysis compares the following three investment scenarios:

rewind the existing standard efficiency motor at an estimated cost of $2,343,

replace the failed motor with a new motor with an efficiency of 91.7% at a cost of $3,020, and

replace it with a motor with the highest efficiency available in the market today (94.5%) at a cost of $3,543.

Row 1 of the table compares the efficiencies of these scenarios, and Rows 2 and 3 show how much electricity they require, and how high the annual costs are. For example, the average new motor in Column (c) costs 10 times as much in one year as its initial capital cost, underscoring the importance of taking these operating costs seriously.

Row 4 shows the annual savings from buying a new motor, compared with the cost of operating a rewound motor. The high efficiency motor with the 94.5% efficiency saves $1,584/year, while the typical motor saves only $680.

Most energy cost reduction projects are selected on the basis of a simple payback calculation based on these annual savings. For example, the payback period (in Row 9) for the high efficiency motor is 0.8 years, based on the incremental investment cost of $1,200 ($3,543 for the motor minus the base case cost of $2,343 for the rewind option), divided by the annual savings of $1,584. This represents a slightly better investment than the typical motor, for which the payback is one year compared with the rewind.

Financial Analysis: 50 HP Vertical Shaft Motor Efficiency Investment

	Scenario:	(a) Existing Motor Before Failure	(b) Rewind Existing Motor	(c) Replace with New Motor of Average Efficiency	(d) Replace with Highest Efficiency Motor
Efficiency & Electricity Use:					
1	Efficiency (%)	90.7	89.7	91.7	**94.5**
2	Annual Electricity Use (kWh/year)	308,434	311,873	305,071	296,032
3	Annual Electricity Cost ($ in first year)	$ 30,843	$ 31,187	$ 30,507	$ 29,603
Returns:					
4	Annual Savings ($ in first year)			$ 680	**$ 1,584**
5	Cumulative Savings (for the period)			$ 7,448	$ 17,346
6	Present Value (PV) of Savings			$ 3,656	$ 8,514
Investment Cost:					
7	Equipment or Repair Cost		$ 2,343	$ 3,020	$ 3,543
8	Investment: Incremental Cost			$ 677	**$ 1,200**
Financial Performance: Replace with a New Motor vs. Rewind the Existing Motor					
9	Simple Payback Period (years)		(Base)	1.0	0.8
10	Internal Rate of Return (IRR)			102%	134%
11	Net Present Value (NPV) ………………………………………………………			$ 2,979	**$ 7,314**
Financial Performance: Buy High Efficiency Motor vs. Buy Motor with Average Efficiency					
12	Payback Period: Premium vs Standard Motor			(Base)	0.6
13	Internal Rate of Return (IRR)				175%
14	Net Present Value (NPV) ………………………………………………………				**$ 4,335**

	Assumptions:		
15	Horsepower of Motor to Analyze	**50**	
16	kW Load (Row 12 * .746 kW/HP)	37.3	
17	Annual Operating Hours	7500	86% of 8,760
18	Average Loading While Operating *	100%	86% Load Factor
19	Rewind Efficiency Loss (percentage points)	1.0%	
20	Discount on Price of New Motor	**0%**	
21	Cost of Electricity (cents/kWh)	**10.0**	
22	Electricity Cost Escalation per Year	2.0%	
23	Discount Rate for Present Value Calculations	15%	
24	Period Analyzed for PV & IRR Calculations (years	10	

However, the payback period understates the impressive financial performance of the high efficiency motor scenario. As shown in this table, the Present Value (PV)[7] of the savings over a 10-year period are $8,514 for the highest efficiency motor (from Row 6) – more than double the $3,656 PV of the motor with the average efficiency. After subtracting the incremental cost of these investments ($677 or $1,200 respectively over the rewind cost, from Row 8), the Net

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[7] These present value calculations are based on the assumed discount rate (15 percent, Row 23) over the chosen lifetime of the new motor (10 years). After 10 years, the present values of the subsequent cash flows are discounted so much that it is usually not necessary to extend the financial estimates further, even for equipment with longer lives.

Present Value (NPV) of the investment in buying the most efficient motor is $7,314 (in Row 11)[8] – which is 2 ½ times better than buying the typical motor (for which the NPV is only $2,979 over the 10-year period). Both of these NPV calculations are based on the comparison with rewinding the old motor. The NPV measure is an important part of a motor buying decision because it is the best way to capture and weigh all the costs and benefits of buying the most efficient motor.

This financial analysis also shows the calculations of one other performance measure that may be of interest to water system financial and accounting managers. The Internal Rate of Return percentage (IRR)[9] is a measure to be compared against the municipal or corporate cost of capital. In this example, the IRR figures (in Row 10) are very attractive: 134% and 102% respectively for the different types of new motors over the term of this analysis (10 years).

These same financial measures are applied in Rows 12 – 14 to the incremental investment in the same new high efficiency motor, compared against the different "base case" of buying the motor with average efficiency (rather than rewinding the failed motor). As noted above, the NPV for the most efficient motor is higher than that for the typical motor; this means that the NPV for this same motor is $4,335 when compared against this base case. This is equivalent to saying that, once the decision has been made not to rewind the failed motor, but to buy a new one, the payback period is only 0.6 years for the incremental investment in the most efficient motor over the average motor. This represents an IRR of 175% -- an unusually attractive investment from a financial point of view. In other words, there is an additional value of $4,335 available from the most efficient motor.

3.2.2 General Purpose Motor Analysis: 100 HP

The table below illustrates a financial analysis of a general purpose motor upgrade investment at the time that a 100 horsepower motor has failed. The analysis compares the following three investment scenarios:

rewind the existing standard efficiency motor at an estimated cost of $3,975,

replace the failed motor with a new standard motor that meets the EPAct efficiency standard at a cost of $4,893 (after a 20% discount on the price of the new motor), and

replace it with a "premium efficiency motor" that meets the higher CEE standard at a cost of $5,922.

These 3 scenarios are compared against each other and against the cost of the old efficiency motor before failure, in the table below for 100 HP motors. Row 1 shows that the new standard

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[8] In other words, the NPV for the high efficiency motor is calculated as the discounted present value of the savings ($8,514) minus the cost of the incremental up-front investment $1,200 over the rewind cost).

[9] This measure is sometimes also known as the ROI for Return on Investment.

motor has an efficiency of 94.5%, which saves $1,667/year (from Row 4), compared with the cost of operating the rewound motor. The CEE premium efficiency motor has a higher efficiency of 95.4%, saving $2,086. Both new motors are substantially more efficient that the rewound motor, which is assumed to have an efficiency of 89.7% (based on a 1% loss from the 90.7% base efficiency level assumed for the failed motor).

Financial Analysis: 100 HP Motor Efficiency Investment

		(a)	(b)	(c)	(d)
	Scenario:	**Old Standard Efficiency Motor Before Failure**	**Rewind Standard Efficiency Motor**	**Replace with New Standard Motor**	**Replace with Premium Efficiency Motor (CEE)**
Efficiency & Electricity Use:					
1	Efficiency (%)	92.1	91.1	94.5	**95.4**
2	Annual Electricity Use (kWh/year)	455,718	460,721	444,048	439,858
3	Annual Electricity Cost ($ in first year)	$ 45,572	$ 46,072	$ 44,405	$ 43,986
Returns:					
4	Annual Savings ($ in first year)			$ 1,667	**$ 2,086**
5	Cumulative Savings (for the period)			$ 18,257	$ 22,844
6	Present Value (PV) of Savings			$ 8,961	$ 11,213
Investment Cost:					
7	Equipment or Repair Cost		$ 3,975	$ 4,893	$ 5,922
8	Investment: Incremental Cost			$ 918	**$ 1,947**
Measures of Financial Performance: Replace with New Motor vs. Rewind Existing Motor					
9	Simple Payback Period (years)		(Base)	0.6	0.9
10	Internal Rate of Return (IRR)			184%	109%
11	Net Present Value (NPV)			$ 8,043	**$ 9,265**
Measures of Financial Performance: Buy New Premium Efficiency vs. Buy New Standard Motor					
12	Payback Period: Premium vs Standard Motor			(Base)	2.5
13	Internal Rate of Return (IRR)				41%
14	Net Present Value (NPV)				**$ 1,222**

	Assumptions:		
15	Horsepower of Motor to Analyze	**100**	
16	kW Load (Row 12 * .746 kW/HP)	74.6	
17	Annual Operating Hours	7500	86% of 8,760
18	Average Loading While Operating *	75%	64% Load Factor
19	Rewind Efficiency Loss (percentage points)	1.0%	
20	Discount on Price of New Motor	**20%**	
21	Cost of Electricity (cents/kWh)	**10.0**	
22	Electricity Cost Escalation per Year	2.0%	
23	Discount Rate for Present Value Calculations	15%	
24	Period Analyzed for PV & IRR Calculations (years)	10	

The following table details the source or methodology for each row of this financial analysis.

	Variable	**Source**
	Efficiency & Electricity Use:	
1	Efficiency (%)	From Table of Motor Efficiencies
2	Annual Electricity Use (kWh/year)	R1 Efficiency x R16 kW x R17 Hours x R18 Loading
3	Annual Electricity Cost ($ in first year)	R2 kWh * R21 Cost
	Returns:	
4	Annual Savings ($ in first year)	R3: Col. (c) or (d) minus Col. (b) Base Cost
5	Cumulative Savings (for the period)	R4 Savings Cumulated over the Period
6	Present Value (PV) of Savings	Discounted PV of R4 Savings over the Period
	Investment Cost:	
7	Equipment or Repair Cost	From Table of Motor Costs, Minus R20 Discount
8	Investment: Incremental Cost	R7: Col. (c) or (d) minus Col. (b) Base Cost
	Measures of Financial Performance: Replace with New Motor vs. Rewind Existing Motor	
9	Simple Payback Period (years)	R8 Incremental Cost/ R4 Annual Savings
10	Internal Rate of Return (IRR)	IRR: Investment & Returns over Period
11	Net Present Value (NPV)	R6 PV Savings Minus R8 Incremental Cost
	Measures of Financial Performance: Buy New Premium Efficiency vs. Buy New Standard Motor	
12	Payback Period: Premium vs Standard Motor	[(d)-(e) R8 Cost] / [(d)-(e) R4 Savings]
13	Internal Rate of Return (IRR)	IRR: Investment & Returns over Period
14	Net Present Value (NPV)	(d)-(e) R21 Net Present Value

The payback period (in Row 9) for the premium efficiency motor is 0.9 years, based on the incremental investment cost of $1,947 ($5,922 for the motor minus the base case cost of $3,975 for the rewind option), divided by the annual savings of $2,086/year. The 0.6-year payback is even faster for the standard, EPAct motor.

However, the payback period is not always a reliable indicator of the best financial investment, as noted above. As shown in this table, the Present Value (PV) of the savings over a 10-year period are $11,213 for the CEE premium efficiency motor (from Row 6) – substantially greater than the $8,961 for the new EPAct standard efficiency motor. After subtracting the incremental cost of these investments ($918 or $1,947 over the rewind cost respectively, from Row 8), the Net Present Value (NPV) of the investment in buying the CEE premium motor is $9,265 (in Row 11) – which is better than buying the new EPAct motor (for which the NPV is $8,043 over the 10-year period).[10]

Finally, we have applied these same three measures of financial performance to the investment in the same new CEE premium efficiency motor, compared against the different "base case" of

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[10] In other words, the NPV for the CEE premium efficiency motor is calculated as the discounted present value of the savings ($11,213) minus the cost of the incremental up-front investment ($1,947 over the rewind cost).

buying a new EPAct standard motor. As noted above, the NPV for the most efficient motor is higher than that for the standard motor; this means that the NPV for this same motor is $1,222 when compared against this new base case. This is equivalent to saying that, once the decision has been made not to rewind the failed motor, but to buy a new one, the payback period is 2.5 years for the incremental investment in the CEE premium motor over the EPAct motor. This represents an IRR of 41% -- still an attractive investment from a financial point of view. In other words, there is an additional value of $1,222 available from the most efficient motor, even though the rate of return has diminished somewhat for this incremental efficiency step.

3.2.3 Financial Analysis of Specific Motor Investments

This same financial analysis can be performed by end users, or with the assistance of utility field personnel, to analyze motor measures that are specific to each facility or application. Where the investment under consideration is a motor replacement, relative efficiency figures can be obtained through DOE's MotorMaster+3.0 software or website, at:

http://mm3.energy.wsu.edu/mmplus/

This DOE motor selection and management tool includes catalog of over 20,000 AC motors. Once the motors and their efficiency performance have been identified, and motor costs have been quoted by local suppliers or contractors, the payback periods can be calculated, and Net Present Value and rate of return calculations can be made as well. Worksheets such as those presented above, along with other financial tools, are available from the sources listed below to help identify the most cost-effective repair or replacement strategies for the most critical motors before they fail.

As noted above, motor investments may often require an engineering analysis, especially in the case of adjustments to the operation of motor systems, such as those associated with pumps and fans. In such cases, it may take more work to identify the costs and savings, but the same financial measures can be calculated for presentation to water system managers.

4 MARKETING MOTOR EFFICIENCY TO SMALL WATER SUPPLY FACILITIES

California's water supply industry presents a number of opportunities for incorporating energy efficient motors into its operations but also presents a number of challenges. These challenges include generally matching marketing tools to industry needs and in particular building energy efficiency specifications into regulatory-driven system upgrades, making energy efficiency a priority when replacing failed motors, and addressing the availability of energy efficient motors. These obstacles are not insurmountable and can be addressed by the means detailed below. This section provides recommendations for utility representatives or other energy efficiency professionals when contacting or visiting small water supply facilities.

4.1 Key Contacts and Decisionmakers to Target

When approaching an individual water supply facility to present technical motor efficiency information, the plant's Operations and Maintenance Manager / Supervisor is often the best individual to approach. Smaller water supply facilities may have a General Manager who acts in this capacity. Business or administrative managers (for example, CFO, CEO and their staffs) will be more interested in the financial aspects of motor efficiency upgrades, but interviews with industry professionals indicate that plant-level contacts are generally the most promising for motor efficiency discussions.

As noted above, municipalities, counties, water districts or authorities, townships or other public agencies own 43 percent of community water systems. To impact these facilities it may be necessary to contact the municipal agency, which may or may not be located at the water supply plant itself. When the accounting or financial administrators are located off-site, it may be expedient to approach them with information on costs and savings, expressed in terms of the potential to reduce the water bills of the voters to whom they are ultimately responsible. Meanwhile, an exchange of technical information with plant-level personnel may be helpful to identify the promising opportunities and to arm the operational personnel with the data they will need to answer questions from water department administrators.

Private water companies own another 33 percent of the water supply facilities. Approaching these companies will be similar to the approach to industrial companies. The Plant Manager is generally the best person to engage about motor efficiency at most plants. Other personnel to approach could include a Facilities Manager, Maintenance Manager, Operations Manager or General Manager. If it is not possible to reach the top on-site manager at the outset, contact can be made with lower-level engineering, operations, manufacturing or technical personnel.

For privately-owned water facilities that are owned by multi-plant corporations with headquarters out of state, it may be necessary for most plant managers to go through a centralized approval process. Likewise, it may be necessary for utility representatives to treat such customers as they would other "national accounts." At headquarters there may be a

Facilities Manager, Procurement Manager or other position with responsibility for decisions across many plants.

The remaining 24 percent of systems consist of schools, hospitals, mobile home parks or other "ancillary systems," most of which do not bill users directly for water service. Each such facility may be organized differently, and it will be necessary to tailor the approach to the particular financial issues experienced by each type of customer. For example, many such facilities will have a critical need for reliable water supply and water costs will represent a small part of their annual budgets. In addition, many such facilities will have many other energy uses that SCE representatives may want to address in a coordinated or systematic way, rather then discussing motors separately from other energy-related systems.

The most significant barriers to incorporating usage of efficient motors into the industry are primarily financial rather than related to a lack of awareness. Experts in the water supply industry estimate that awareness of energy efficient motors within the industry is very high (perhaps even pervasive).[11] The challenge for marketing representatives is thus to present relevant and compelling information to individuals within the industry who already have a high level of knowledge about energy efficiency. This requires a high level of understanding of water supply motor applications on the part of marketing specialists who will be approaching facilities engineers and operations staff. Tailored, case-specific data with concrete numbers will likely be the most effective in gaining facility-level interest in incorporating efficient motors into these plants. The examples provided in the previous section of this report may be useful in this respect.

Although knowledge of energy efficient motors within the industry is considered high, education continues to play a key role in maintaining awareness and motivating action. Because of the rapport established between the American Water Works association (AWWA; see pp11-12) and facilities personnel, it may be useful for electric utilities to partner with AWWA to promote efficiency in the water supply industry. Industry professionals have suggested that regional AWWA meetings may provide a good forum for disseminating information; marketing specialists can contact their local AWWA chapters and request the opportunity to make a presentation at one of these meetings. Contact information is provided in Section 6 of this report.

4.2 Building Energy Efficiency into Regulatory-Driven System Upgrades

EPA's Drinking Water Infrastructure Needs Survey (1997b) estimates that the state of California will require approximately $18.8 million to repair, replace, and upgrade community water systems between 1995 and 2015. In this 20-year period, approximately $2.2 million will be required for compliance with existing Safe Drinking Water Act regulations (84 percent of this

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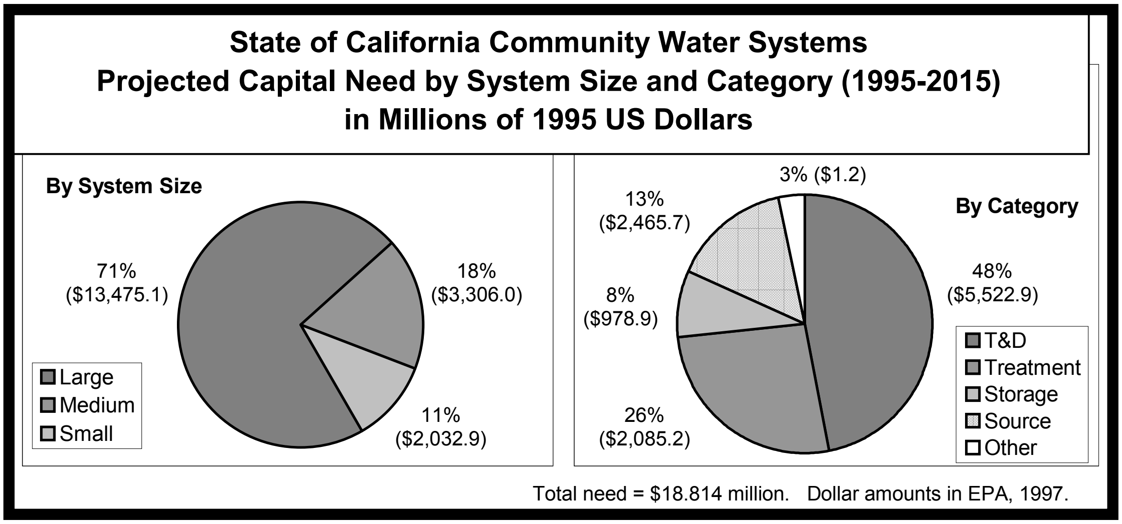
[11] Water supply facility personnel work with pumps all the time and are more familiar with motor technology than most industrial facilities personnel in the United States, among whom only approximately 19 percent were even aware of energy efficient motors (US DOE, 1998e).

money will be spent on protecting against microbial contaminants that pose significant human health risks), and $1.6 million for proposed SDWA regulations. Another $3.9 billion is required in the state of California for SDWA-related needs (US EPA 1997b; these needs are detailed in the chart below).



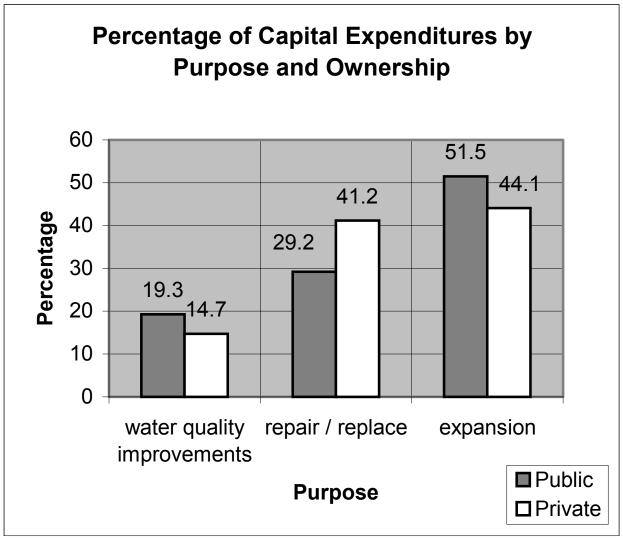
State of California Community Water Systems
Projected Capital Need by System Size and Category (1995-2015)
in Millions of 1995 US Dollars

Total need = $18.814 million. Dollar amounts in EPA, 1997.

Legislation regulating the safety and quality of drinking water is having a significant impact on capital expenditures. System upgrades necessitated by drinking water regulations thus present significant opportunities to introduce energy efficient motors into the water supply industry. This is a key point in marketing presentations to water supply industry professionals: capital input is required *anyway*, so it makes sense at this point to incorporate energy efficiency to achieve the fastest rate of return on the investments.

Between October 1992 and January 1995, 23.5 percent of all U.S. community water systems violated Safe Drinking Water Act microbiological standards at least once, and 1.3 percent violated chemical standards (NRC, 1997). Nearly 40 percent of drinking water systems with surface water sources have a need to build, rebuild, or make significant improvements at their facilities (US EPA, 1997b). One industry expert, a Maintenance & Systems Operations Engineer for a large California Municipal Water District, has cited regulatory necessity as the impetus for a new water pumping and processing facility in his district. This project required an enormous input in capital but also presented an excellent opportunity for using energy efficient motors in the new facility. A system-wide retrofit with energy efficient motors may be infeasible for most water supply facilities, but when a regulation requires the purchase of new motors, the cost to achieve the efficiency gain is only the incremental cost of the motor: payback in this situation is less than for a system retrofit. Depending upon the circumstances in question, this may be important to stress when approaching supply industry professionals on marketing calls.

The EPA (1997b) estimates that between 15 and 19 percent[12] of capital expenditures in the water supply industry are related to improving water quality (see table below). The Interim Surface Water Treatment Rule (effective December 2001) is a regulation requiring source water protection and increased filtration and processing for larger surface water facilities (US EPA, 1999a). The Rule is relatively typical of public health related water quality regulations in that it may require large investments of capital to meet its water quality requirements. Again, regulatory-driven system upgrades are prime opportunities for incorporating energy efficient motors and other efficiency measures into water supply facilities; this point cannot be stressed enough when marketing efficient motors to water supply industry professionals.



Efficiency expenditures and regulatory compliance are especially difficult for smaller water facilities with lower revenues. These compliance struggles place populations served by these systems at greater public health risk than the general population. In a report to the California State Legislature in January 1993, the California Department of Health Services (CA DHS) concluded that small water systems have "a significant problem in complying with drinking water standards," primarily because these systems lack the technical and financial capacities to do so (CA DHS, 2000a).

Similarly, in 1996 Congress found that "because the requirements of the Safe Drinking Water Act (42 U.S.C. 300f et seq.) now exceed the financial and technical capacity of some public water systems, especially many small[13] public water systems, the Federal Government needs to provide assistance to communities to help the communities meet Federal drinking water requirements" (US EPA, 1996). The 1996 amendments to the SDWA authorized the EPA to make grants totaling up to $7 million until 2003 to assist institutions of higher learning in establishing Small Public Water Systems Technology Assistance Centers to provide technical assistance and employee training to small public water systems. (These Centers are invaluable sources of information for small systems and contact information is included at the end of this profile.)

To provide additional support to small systems, the California State Legislature enacted the Safe Drinking Water State Revolving Fund Law of 1997 which established the State Revolving Fund (SRF), enabling the state to create a comprehensive technical assistance program for small

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[12] The breakdown of capital expenditures differs between publicly- and privately-owned water supply facilities.

[13] For clarification of EPA's size designations, please refer back to Section 1.3.

systems.[14] Preference in distribution of SRF funds is given to improving conditions related to safety and quality of the water supply and also to the smallest systems. The statute also prevented public water systems from being built or changing hands unless that system could be certified by the State as having adequate technical, managerial and financial capacity to ensure safe, reliable drinking water on a long-term basis (CA DHS 2000a).

4.3 Making Energy Efficiency a Priority When Replacing Failed Motors

A national average of 29 to 41 percent of the water supply industry's total capital expenditures are related to equipment repair and replacement (US EPA 1997a). Replacing a motor upon failure is another excellent opportunity to incorporate energy efficient motors into the water supply industry (US DOE, 1998e). System-wide retrofits with energy efficient motors may be too expensive for most facilities in terms of initial capital costs, but replacement of failed motors with energy efficient models may be a practical option because the incremental cost of efficiency is lower than in a retrofit situation.

A motor purchasing policy must be developed in advance in order to ensure that replacement motors are energy efficient even when the replacement decision must be made quickly to minimize downtime. Such a policy [15] can be developed by:

- preparing an inventory of existing motors,
- developing in advance a set of specifications for high efficiency motor to be used to replace each existing motor when it fails (and where appropriate marking the replacement motor model, type or source on each such existing motor), and
- developing advanced purchasing arrangements with contractors or other motor suppliers of the high efficiency motor types, models and sizes which will be needed for in local dealer inventory to guarantee delivery for rapid replacement of failed motors in the future.

4.4 Addressing the Availability of Energy Efficient Motors

Some facilities personnel and motors distributors have cited availability rather than cost as the primary factor prohibiting energy efficient motor use. Distributors have a difficult time stocking energy efficient motors in general because of their higher initial cost and because pumps manufacturers are not particularly interested in the efficiency of their motors. If distributors are not stocking the motors, it becomes difficult to get them to the water supply facilities when

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[14] California State Revolving Fund loans are available to public and private community water systems and nonprofit non-community water systems only (not to federally-owned or for-profit noncommunity systems). The SRF pre-application form is available for download at http://www.dhs.cahwnet.gov/ps/ddwem/technical/dwp/tmf/srf_pre-app.pdf.

[15] Note: CEE's Motor Systems Toolkit will include a leave-behind step-by-step guide to developing such a policy and a draft policy that could be adopted. See sources of information in Section 5. IEL, 1993.

they're required. Maintaining an inventory of efficient motors is a greater problem for the very large or custom motors used by water facilities than it is for smaller or more standardized motors users.

Because access to energy efficient motors may be a substantial barrier in this industry, creative programs may be necessary to ensure their availability to water supply facilities. San Diego Gas and Electric developed a unique way to handle this situation by financing the return of several standard efficiency motors from large distributors back to the manufacturers, and replacing these motors with energy efficient models. Customers will generally purchase the motors in stock over a specially ordered motor (especially when acting quickly to replace a failed motor), so this was an effective method of ensuring the availability of energy efficient models to customers. Other utilities companies may wish to promote similar programs.

5 TOOLS AND SOURCES OF ADDITIONAL INFORMATION

The best general sources of motor management tools and information are:

- DOE's Best Practices (www.oit.doe.gov/bestpractices/motors) and
- Consortium for Energy Efficiency (www.ceeformt.org/ind/mot-sys/mot-sys-main.php3 or www.ceeformt.org).

These two web sites include the resources listed below.

5.1 Motor Management and Planning Tools

Energy Management for Motor Driven Systems – DOE guidebook designed to help establish a facility energy-management program, to identify and evaluate energy conservation opportunities involving motor-driven equipment, and to design a motor improvement plan.

Energy Star® Procurement Toolkit – www.epa.gov/nrgystar/purchasing.

5.2 Motor Replacement Tools

CEE Premium-Efficiency Specifications – utility-developed and supported efficiency recommendations for 114 classifications for motors.

Efficient Motors: Selection and Application Considerations **--** CEE brochure provides a brief guide to understanding and selecting efficient motors. It contains several examples to help determine when using a premium-efficiency motor is appropriate.

MotorMaster+3.0 – A DOE energy-efficient motor selection and management tool including a catalog of over 20,000 AC motors: http://mm3.energy.wsu.edu/mmplus/

5.3 Motor Repair Tools

DOE-OIT's BestPractices Repair Tools for Motors

- **Motor Repair "Tech Brief"** – A general brochure explaining what is meant by quality repair and why it is important
- **A Shop Evaluation Guide** – to assist the customer in selecting a repair shop
- **A General Motor Repair Specification** – to request quality repair services
- **A Bibliography** –listing motor repair publications and materials.

Electrical Apparatus Service Association (EASA)

- **Tech. Note 16** – Guidelines for Maintaining Motor Efficiency During Rebuilding
- **A Guide to AC Motor Repair and Replacement**
- **AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus.**

California Motors Initiative's Guidelines to a Good Motor Repair.

5.4 *Key Associations Serving the California Water Supply Industry*

The American Water Works Association (AWWA) was founded in 1881, as an international nonprofit "scientific and educational society" dedicated to the improvement of drinking water quality and supply. It is the largest organization of water supply professionals in the world with more than 50,000 members including more than 4,000 utilities that supply water to roughly 180 million people in North America. In Southern California, district meetings are highly attended, and AWWA-sponsored training classes have received favorable reviews. Operations and maintenance staff feel that the Association caters specifically to their needs at the facilities level, while other organizations accentuate issues more germane to the needs upper-level management staff in the industry. Contact information for AWWA is as follows:

American Water Works Association
6666 West Quincy Ave.
Denver CO 80235
(303) 794-7711
http://www.awwa.org

1404 New York Ave. NW, Suite 640
Washington DC 20005
(202) 628-8303

Another useful source of information is the Hydraulic Institute (HI). Founded in 1917, HI is a non-profit industry (trade) association. It is considered to be the industry's primary forum for the exchange of pump industry information for management decision-making. HI provides a number of services to its members and publishes many useful publications, including *A Guide to Energy Efficient Pumps and Pumping Systems* (HI, 2000). Contact information for the Hydraulic is as follows:

Hydraulic Institute
9 Sylvan Way
Parsippany, NJ 07054
(973) 267-9700
http://www.pumps.org

The California Energy Commission (CEC) is the best statewide source of energy efficiency information, supported at the national level by the Department of Energy's Office of Industrial Technologies (OIT). These two agencies have worked closely together on energy efficient motor systems initiatives and have published a great deal of helpful information. Contact information for these agencies is as follows:

California Energy Commission
1516 Ninth Street, MS-29
Sacramento, CA 95814-5504
(916) 654-4989
http://www.energy.ca.gov/index.html

US Department of Energy
Office of Industrial Technologies (OIT)

(202) 586-2090
http://www.oit.doe.gov

The Small Public Water Systems Technology Assistance Centers established by the 1996 SDWA amendments are valuable sources for information, technical assistance, and employee training for small public water systems. Contact information for the Center at the California State University at Sacramento is as follows:

Office of Water Programs

California State University
6000 J Street
Sacramento, CA 95819-6025
(916) 278-7375
http://www.owp.csus.edu

Contact information for Centers throughout the United States can be found on the Montana Water Center website at http://water.montana.edu/epa_drinking_water_discussion/default.htm.

5.5 Selected Water Facility Contact Information

Contact information for five of the largest water supply facilities in the Southern California Edison service territory:

1) Inland Empire Utilities Agency
PO Box 697
Rancho Cucamonga, CA 91729-0697
Phone: (909) 947-4131

2) City of Long Beach Water Department
1800 East Wardlow Road
Long Beach, CA 90807-4931
Phone: (562) 426-5951

3) Southern California Water Company
604 East Foothill Boulevard
San Dimas, CA 91773-1208
Phone: (909) 394-3600

4) Metropolitan Water District of Southern California, Granada Hills
13100 Balboa Boulevard
Granada Hills, CA 91344-1199
Phone: (818) 368-3731

5) Eastern Municipal Water District
440 East Oakland Ave.
Hemet, CA 92543-2928
Phone: (909) 766-1810

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