# Golf course energy use Part 2: Pump stations

## Pump stations and water use can be managed to decrease energy costs on golf courses.

*Editor's note: This article is the second in a three-part series about energy use on golf courses. The series is based on a utility-funded energy efficiency outreach program to 320 golf courses in Southern California conducted from 2006 to 2008. The program was the first energy outreach program of its kind and completely free to the customer. It identified areas of energy savings opportunity, focusing attention on irrigation and water management as well as lighting and golf car charging. The program provided the customer with a cost-benefit analysis for potential work performed. Samples indicated a potential of 30% energy savings for participating courses.*

**Quick fact No. 1:** Experts suggest that pumping systems account for 20% of the world's energy demands (3).

**Quick fact No. 2:** A golf irrigation pump station can account for up to 50% of a golf course facility's energy use (information from the Golf Resource Group energy program in Southern California).

**Quick fact No. 3:** If applied improperly, a variable speed drive can make a pump station less energy-efficient than a typical fixed-speed station (1).

Our outreach program has found that most superintendents control the single piece of equipment that consumes the most energy on the golf course, the pump station. (For example, a typical four-pump system, where each pump has 75 horsepower, draws approximately 225 kilowatts, whereas a typical clubhouse building normally draws less than 100 kilowatts.) The pump station

The pump station for the Chiricahua Course, The Desert Mountain Club, Scottsdale, Ariz. **Photos by Jim Key, CGCS**

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## Typical pump life cycle costs

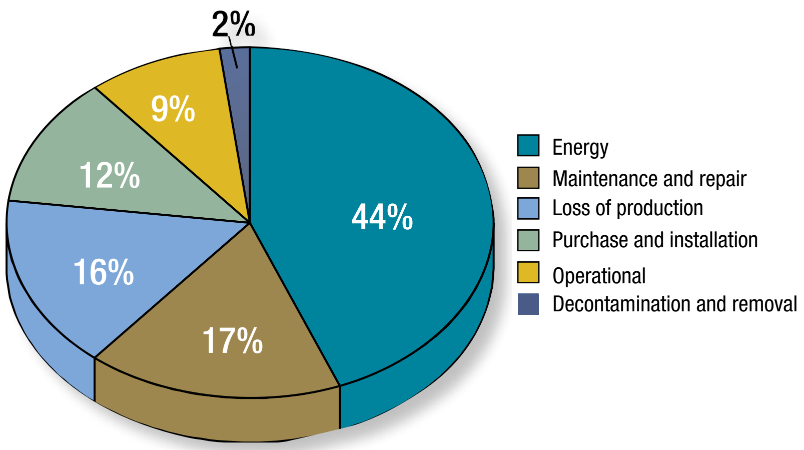


**Figure 1.** The percentage allotted to each cost for a typical pump over its lifetime. Although exact values may differ, these percentages are consistent with those published by leading manufacturers and end-users, as well as industry associations and government agencies worldwide.

## Overall pumping plant efficiency ranges

| Motor HP | Low % | Fair % | Good % | Excellent % |
|---|---|---|---|---|
| 3-5 | 41.9 or less | 42-49.9 | 50-54.9 | 55 or above |
| 7-10 | 44.9 or less | 45-52.6 | 53-57.9 | 58 or above |
| 15-30 | 47.9 or less | 48-55.9 | 56-60.9 | 61 or above |
| 40-60 | 52.9 or less | 53-59.9 | 60-64.9 | 65 or above |
| 75-up | 55.9 or less | 56-62.9 | 63-68.9 | 69 or above |

Note: The above values developed by Center for Irrigation Technology (CIT)

**Table 1.** Overall pumping plant efficiency ranges. Brand-new pumps should fall in the excellent range.

is also the main component responsible for making sure the course is watered every night, ensuring optimal playing conditions for the paying customers. Despite its fundamental importance to the success of the golf course, the pump station is often underappreciated and even ignored, with maintenance postponed until it is no longer functioning.

### What is the true cost of efficient pumping?

Experts suggest that the initial cost of a pump is 12% of its cost over its 20-year lifetime (2) (Figure 1). Therefore, if a pump is purchased for $35,000, the total cost over the life of the pump is $292,000. This means $175,200 will be spent on energy and maintenance over the life of one pump. Most golf course pump stations consist of more than one pump, ranging from as few as two or three to 10 or more. Doesn't it make sense to ensure these pumps are operated at optimal efficiency?

Often a golf course pump station is described by using the total gallons per minute at a specified amount of pressure. For example, a station is designed to pump 2,500 gallons/minute at 115 pounds/square inch. However, to accurately assess a pump station's efficiency, its operating pumping plant efficiency (or OPE), which measures how efficiently a motor powers a pump to deliver water to the system, must be calculated. To make this calculation, the amount of power corresponding to the rate of flow and total heads (pump lift and discharge pressure) needs to be measured (Table 1).

Rarely is the pump station described in terms of efficiency, most likely because the pump station's efficiency is rarely known. However, because a pump station wears down slowly over time, reducing output, a station may be producing 10% to 20% less than it should because of pump inefficiency. As energy costs continue to rise, knowing a pump's operating pumping plant efficiency will become increasingly important.

### What is the true cost of inefficient pumping?

In the example above, a golf course pays $35,000 for a single pump and spends $175,200 on energy and maintenance over the life span of a pump. Therefore, for eight pumps, the course would spend $1,401,600 on energy and maintenance over the pumps' life span. If each pump is operating at 90% efficiency, an extra $140,160 will be spent over the life of the pumps, which translates to an extra $7,003 per year. In addition, there will be 10% more wear on the motor, bearing, shaft and impeller of each pump, and, in theory, the pumps will be replaced 10% sooner.

### How to save energy and money

A golf course should focus on improvements that have the greatest initial impact and the quickest payback for the investment made. Pump stations consume more energy than any other equipment on a golf course because of the size of the

To achieve maximum energy efficiency, golf courses should always call in a professional to program a new pump or a new pumping station to fit the irrigation schedule.

pump motors and the energy required to power the pumps. Because billing is based on the total load on the power system, a pump station will cost more to operate as more horsepower is used (and therefore, more kilowatts are drawn).

Based on results from our energy program in Southern California, the easiest available savings with the shortest financial paybacks come from three areas.

- Installing energy-efficient hardware: a variable frequency drive; a 15- to 40-horsepower jockey pump controlled by a variable frequency drive; and National Electrical Manufacturers Association (NEMA) Premium efficiency-rated motors
- Operating the pumping system to ensure the pump runs at its best efficiency point (BEP) for as long as feasible, maximizing the amount of flow to the amount of demand from the sprinkler heads
- Watering less; therefore, pumping less

## Installing energy-efficient hardware

*Variable frequency drives*

When applied properly, a variable frequency drive is perhaps the single largest energy-saving measure available to golf course pump stations even though it takes more than five years to recoup the upfront costs. The drives give pumps the ability to "soft start," which allows the motor to slowly ramp up to full speed. Variable frequency drives increase the ability to control flow relative to the amount of energy used by fixed-speed pumps. The soft start can also reduce the amount of wear and tear on the irrigation system by reducing water hammer and prolonging the life of the pipes. Because golf course watering demands vary throughout the year, a variable frequency drive on a pump is a necessity when it comes to managing energy use. Evidence gathered by the Golf Resource Group over the course of the outreach program suggests a single well pump can also benefit from the addition of a variable frequency drive. Because flows from groundwater vary throughout the year, a variable frequency drive can adjust to account for these variances, cutting the cost of pumping dramatically.

The increasing popularity of the variable frequency drive has brought with it a number of misapplications that actually increase energy costs (1). For example, if a pumping station operates only at maximum flow rate for a short period of time or at low flow rates for an extended period of time, the pumps will be running inefficiently and off their BEP on the pump curve, causing an increase in energy costs. Investigation into these misapplications by a pumping expert is recommended. These problems can arise when new pumps or a new pumping station are installed without being professionally programmed to fit the irrigation schedule.

*Jockey pump controlled by a variable frequency drive*

The outreach program in Southern California discovered that golf courses have moved away from smaller-sized jockey pumps (pumps in the

## Typical pump life cycle costs

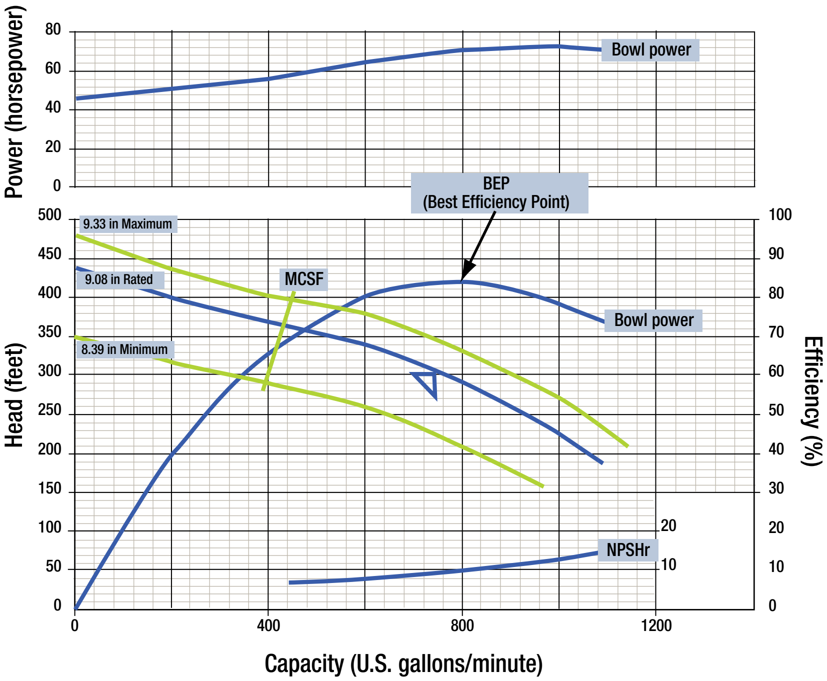


Figure 2. The pump curve shows the effect of increasing or decreasing pressure on pump production. The bowl power is the power input required to generate a given flow or pressure. Bowl efficiency is the ratio of hydraulic power output from the bowl to the power input to the bowl. The Best Efficiency Point (BEP) is the point of the highest bowl efficiency. The operating point should be as close to the Best Efficiency Point as possible. NPSHr is new positive head suction, which is the pressure required on the intake side of the pump to ensure proper operation. Graph courtesy of Rain Bird

## Premium efficiency motor savings

| Motor HP | Standard efficiency motor | Annual kWh 2000 hours operation | Premium Efficiency Motor | Annual kWh 2000 Hours Operation | Energy Savings kWh/Year | Energy Savings $/Year |
|---|---|---|---|---|---|---|
| 25 | 90 | 31,080 | 93.9 | 29,800 | 1,280 | $143 |
| 50 | 91.2 | 61,357 | 94.8 | 59,044 | 2,313 | $254 |
| 100 | 92.7 | 120,679 | 95.4 | 117,271 | 3,408 | $375 |
| 150 | 93.1 | 180,331 | 95.8 | 175,136 | 5,195 | $571 |

*Cost per kilowatt hour = $0.11.

**Table 2.** Premium efficiency-rated motors pay for themselves within a short period of time.

15- to 25-horsepower range designed to handle small watering demands) to larger pumps run on a variable frequency drive. The thinking behind this change is that smaller-sized pumps would no longer be necessary because the variable frequency drive on a larger pump would take care of both lower and higher pumping and energy demands.

This solution is not energy efficient because the larger pump operates at low flow rates for extended periods of time for smaller applications such as hand-watering or running a few sprinkler heads. Because the flow rates are not at maximum capacity, the pump is not operating at its BEP on the pump curve, causing an inefficient use of energy (Figure 2).

To determine whether energy is being used efficiently, measure kilowatt hours against the overall amount of water being pumped (usually measured in acre-feet). The lowest amount of kilowatt hours used per acre-foot of water pumped will be measured when a pump is operating at the highest point on the pump curve. When flow rates are low for long periods of time, it takes more kilowatt hours to pump the same amount of water, and the variable frequency drive causes the pump to run inefficiently. If this happens continually, the inefficiencies become greater over time and increase energy costs even more.

In areas like Southern California, golf courses can use a smaller jockey pump for hand-watering and syringing at peak rate times and lock out larger pumps from being used to eliminate the higher charges incurred by the larger pumps. The extra cost of a jockey pump with a variable frequency drive will increase the initial upfront costs of a new pump station. However, for the 15 to 20 energy assessments in our program where a jockey was an option, it was estimated that these costs would often be recovered in less than five years.

*Premium efficiency-rated motors*

Upgrading to National Electrical Manufacturers Association's (NEMA) Premium efficiency-rated pump motors is probably the easiest shovel-ready project any golf course can undertake. The investment is straightforward: install electric motors having the highest electrical energy efficiency commensurate with your needs. (Make sure the motors are actually NEMA-rated Premium efficiency motors because classifications can be misleading.) Premium efficiency motors can pay for themselves within a few years and sometimes in as little as a few months (Table 2). These motors will continue to save in energy costs well beyond their purchase cost. Understanding true operating costs and not just initial investment costs should be the motivating factor when making energy-efficient upgrades.

## Efficient pumping system operation

Managing pump performance is critical to realizing maximum energy savings. One of the easiest ways to use energy efficiently is to maximize the output of the pump station to match the exact output of each pump. In other words, if a 75-horsepower pump's maximum output is 750 gallons/minute, then the irrigation program for that pump should be designed for 750 gallons/minute. It is surprising how often this simple concept has been overlooked. Each pump used during each irrigation program should be designed to reach maximum flow or the pump will not optimize its energy use. Since this is not always feasible, the idea is to design the irrigation program to push each pump to the maximum capacity as much as possible. For pumps with a variable frequency drive, maximizing the output of each pump minimizes the potential of running the pumps at low flow rates for extended periods of time and optimizes the energy needed to pump water.

Operating individual pumps is only part of the equation. Making sure all the pumps on the system are working in sequence with each other maximizes the full potential for saving energy. For example, at the Chiricahua course at The Desert Mountain Club (see the sidebar), maximizing the time each pump was operated, while balancing the total output to the system, saved the course thousands of dollars. Some pumps were taken offline during certain times during the year, and the course used a lower gallon-per-minute output. In addition, because some well pumps were on the same meter as the pump station, the use of these wells was shifted to different times of the day. The local utility company charged additional fees for increased amounts of demand on the system, making it more cost-effective to use the well pumps when the golf course was not irrigating. This meant the irrigation lakes were filled a little later in the day or earlier in the evening before the irrigation cycle began.

Accurate and up-to-date irrigation system programming together with proper hydraulics is critical for optimizing energy use. In particular, the flow and pressure output of the pump station must match the size of the mainline piping system. Experts suggest a majority of pumping systems on golf courses are designed incorrectly for the irrigation system they operate. Either the pump flow or pressure is too high or the main lines are too small. All these factors should be con-

## Cost savings: A case study

In some instances, it may be advantageous for a course to reduce the overall kilowatt demand on the system by taking pumps offline and lengthening the watering window cycle to yield additional savings.

In 2006, energy costs on the Chiricahua Golf Course at The Desert Mountain Club, Scottsdale, Ariz., had risen 40% from 2004, an increase of $110,000.

**Existing conditions**

- 2,225 total horsepower or 1,659 total kilowatts of demand
- three transfer pump stations
- six 200-horsepower pumps, three 250-horsepower pumps
- one golf course pump station
- seven 75-horsepower pumps, two boosters

**Solution**

- Instituted a kilowatt demand management plan for how and when the golf course pumped its water
- Reduced the kilowatt demand by taking some pumps completely offline during periods of the year
- Programmed system to stage pumping, minimizing multiple pumps being run at the same time
- Increased the length of the golf course watering window (Figure 3) [FIGURE3]

**Winter months**

4,000 gallons/minute – 4.5 hours
3,000 gallons/minute – 5 hours
1,800 gallons/minute – 6.5 hours

**Summer months**

4,000 gallons/minute – 7 hours
3,000 gallons/minute – 8 hours
1,800 gallons/minute – 10.5 hours

**Result**

A reduction of the cost of energy by 27% (billing rates increased 20% during the same period).

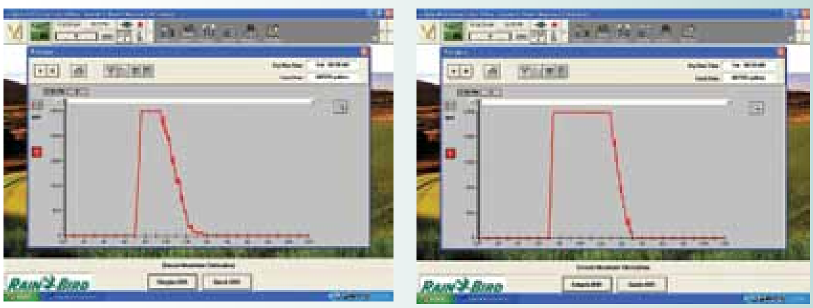

**Figure 3.** The diagram on the left shows how the station at Desert Mountain operated when the program was designed to pump the maximum amount of water over the shortest period of time. In the diagram on the right, total output of the station was reduced in order to reduce the total number of horsepower used to pump water. As a result, the water window was spread out, reducing overall kilowatt demand on the system over this period of time and reducing kilowatt demand charges from the utility.

To save energy costs, the irrigation lakes were filled later in the day or earlier in the evening before the irrigation cycle began.

## The research says

➔ A pump station is fundamental to the success of the golf course, and it consumes more energy than any other piece of equipment at the facility.

➔ To save energy and boost pump efficiency, install variable frequency drives on pumps, use a jockey pump for small watering jobs and use Premium efficiency-rated motors.

➔ To increase pumping efficiency, design the irrigation program to match the maximum output of each pump.

➔ Water less to reduce the amount of energy used; alter the layout or design of the course to reduce features that require a lot of water.

sidered when programming an existing irrigation system or upgrading and replacing a pump station. Every golf course should, whenever feasible, hire a qualified irrigation design consultant to assist in the final selection of pumping systems and overall irrigation system programming.

One of the biggest misconceptions found in the outreach program in Southern California is that a new pump station is automatically more efficient than the older existing pump station. The outreach program found that proper pump and irrigation system programming is essential to efficient pumping. In almost every case, the old pump station was replaced with a more-efficient and therefore larger-capacity system, but few, if any, modifications were made to the outflow pipe delivery system. The additional output coupled with the lack of programming caused the system to run less efficiently than it could have. As a result, the new system used the same or, in some cases, more energy than the old one.

## Watering less

A golf course has another option to reduce energy use – water less. Water use has been and will continue to be one of the major environmental concerns of golf courses. Factors such as location, design, layout and soil type all affect how much water a golf course requires, and the amount of water varies greatly from one course to another, even within the same region. Watering less reduces dependency on the maximum output of a pump station and places less priority on making sure a course is watered in the least amount of time possible. Reducing a pump's total output means that less energy is needed to apply the water to the golf course. Therefore, less watering equals less energy consumed.

Although watering less can be accomplished with little to no adjustment to the golf course design and layout, making adjustments to the course will have the greatest impact because turf acreage, bunker style, size and scale of mounding, etc., are directly related to the resources required to maintain the course to the standards necessary to attract and keep golfers. A course with severe slopes, large bunkers and greens or vast out-of-play irrigated areas increases maintenance costs. Therefore, adjusting the design of these features (without changing the way a course plays) can make a tremendous difference in all costs related to long-term management, including energy use.

## Conclusions

Understanding how a golf course uses energy can enable superintendents to use energy more efficiently and reduce overall kilowatt demand. Demand savings can be found in areas such as irrigation programming, pumping system hydraulics and staging of sprinklers as well as overall water management. Investigating these areas may increase upfront costs, but could also identify large savings opportunities. As resources become more scarce or more expensive or both, adjustments in overall management will become increasingly important.

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