GCSAA

Photo courtesy of Gulf South Solar

Golf Course Environmental Profile

Phase II, Volume V
Energy Use and Environmental Practices on U.S. Golf Courses

EIFG GCSAA USGA

Funded by the USGA through the Environmental Institute for Golf, the philanthropic organization of the GCSAA.

Golf Course Superintendents Association of America

Golf Course Environmental Profile

Phase II, Volume V

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The second phase of the Golf Course Environmental Profile was conducted by
the Golf Course Superintendents Association of America through
the Environmental Institute for Golf and funded by
the United States Golf Association.

Though the initial investment is expensive, more efficient hybrid or electric turf maintenance equipment and vehicles can yield energy savings, particularly if green energy alternatives are available. **Photo courtesy of Paul L. Carter**

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Foreword

Golf course energy use has declined since 2008

The final survey in Phase II of the Golf Course Environmental Profile, Energy Use and Environmental Practices, relays some positive news: since 2008, annual energy use from all sources by U.S. 18-hole golf courses has decreased 8.3%. Less than half of the energy used at the facility is for turfgrass maintenance, and electricity use for the entire facility has decreased by more than 31%.

Throughout the survey series, the results have portrayed professional land management and resource stewardship by GCSAA members. Reductions in golf course use of water, nutrients and energy provide a significant story that GCSAA can use to advocate for the golf course management profession.

Thank you to those who participated in the second phase of surveys including GCSAA members and non-member superintendents. We also extend our appreciation to USGA, the Environmental Institute for Golf, PACE Turf LLC, the National Golf Foundation and GCSAA staff for creating, analyzing and promoting the surveys. Your investment of time and effort has provided key data that is essential to ensuring the future success of our industry.

We appreciate the funding provided by USGA and EIFG and the efforts of our allies within the industry. As we strive to maintain high-quality golf courses while conserving resources and protecting the environment, we should all communicate the results of these surveys and the professional management and value of our golf course landscapes to golfers, the public, our legislators and the media. Future generations of superintendents and golfers will benefit from the leadership and accomplishments of today.

On behalf of your board of directors, I thank all superintendents for your support of the Golf Course Environmental Profile.

Bill Maynard, CGCS
2017 GCSAA President

Since 2008, golf facilities have made a number of changes to conserve energy, including switching to T8 lighting, which produces more light for less energy compared with older fluorescent lighting. **Photo by David Phipps**

Executive Summary

Objectives

Energy use and environmental practices on U.S. golf courses were documented for the first time in a 2008 survey conducted by the Golf Course Superintendents Association of America.

The objectives of the second Energy Use and Environmental Practices Survey were to compare results from 2015 to those from 2008 and to document, characterize, and/or quantify on a national scale the trends in energy use on U.S. golf courses, as well as trends in participation in energy conservation programs

Key results

Energy use

- Annual median energy use on U.S. 18-hole golf facilities has decreased 8.3%, from 2,623 million British thermal units (MMBtus) per facility in 2008, to 2,405 MMBtus in 2015.
- This decrease was primarily the result of a 31.4% decrease in consumption of electricity since 2008.
- Although gasoline use for the average facility has not changed since 2008, the use of diesel fuel increased slightly during that same time period.
- The usage of natural gas, propane and heating oil has not changed since 2008.
- Locations with higher average air temperatures consumed more total energy, electricity, gasoline and diesel than locations in cooler climates. This is due to the year-round operations that characterize warm-weather facilities, as well as the greater dependence of those facilities on air-conditioning and irrigation systems.
- Approximately 47% of all energy used on the golf course was used for turf maintenance, while the remaining 53% was used for other operations (clubhouse, tennis courts, swimming pools, etc.).
- Industry-wide, energy use has seen a projected 7.8% decrease since 2008. This decrease was due to the reduced energy use per facility reported above and a reduction in the number of golf facilities in the nation since 2008.

Environmental practices

Decreased energy use — on a per-golf-course basis — since 2008 can be attributed to a variety of energy conservation practices:

- Behavioral changes, such as lowering thermostats during winter, more timely filter replacement and non-peak equipment operation
- Design, physical or mechanical changes such as use of Energy Star-rated furnaces, programmable thermostats, efficient hot-water tanks, low-flow faucets, changes in irrigation controllers and use of more-efficient lighting.

Overall, individual 18-hole facilities decreased electricity use by 31.4% from 2008 to 2015, even though the amount of electricity used for pumping irrigation water did not change. **Photo by Jim Key**

Introduction: Why do we need a golf course environmental profile?

The Environmental Institute for Golf (EIFG) is sponsoring a long-range initiative to address the golf industry's lack of comprehensive national data on management practices, property features and environmental stewardship on the nation's golf courses. In the past, it has been difficult to document current practices or to track changes in the industry — information that would be valuable to golf course superintendents, golf industry leaders, turfgrass scientists and environmental regulators in their joint efforts to enhance environmental stewardship on the nation's golf courses.

To respond to this need, the Golf Course Superintendents Association of America (GCSAA) and the EIFG in 2006 initiated a project to conduct a series of surveys to document water use, fertilizer use, pest management practices, energy use, environmental stewardship and property profiles. Collectively known as the Golf Course Environmental Profile, the results were released from 2007 to 2012 and provided baseline information for use in the management of golf facilities. The profile also offered an opportunity to communicate golf's environmental efforts to the public.

Results were published in the peer-reviewed scientific journal Applied Turfgrass Science (recently renamed Crop, Forage and Turfgrass Management), as well as in Golf Course Management and online documents. All reports from phase one of the Environmental Profile project are available online (www.gcsaa.org/environment/golf-course-environmental-profile).

In fall 2014, the second phase of the Golf Course Environmental Profile began, with a follow-up set of surveys that mirrors the previous series. The surveys were conducted by the GCSAA through the EIFG and funded by the United States Golf Association (USGA). The fifth and final survey released in the second phase focuses on energy use and environmental practices, and explores trends, changes and progress that have been made since the initial energy use survey was conducted in 2008.

A listing of the published articles from both the first and second phase of the Environmental Profiles appears in the "Further Reading" section of this report.

The objectives of the current energy use and environmental practices survey were to compare results from 2015 to those from the initial 2008 survey, in an attempt to document, characterize and/or quantify, on a national scale:

- Trends in energy use on U.S. golf courses, including:
  - o electricity
  - o gasoline
  - o diesel fuel
  - o natural gas
  - o propane
  - o heating oil
- Trends in participation in environmental conservation programs.

Results

Total energy use

When all sources of energy (electricity, gasoline, diesel, natural gas, propane and heating oil) were combined for each location, total energy use decreased for individual 18-hole facilities, as well as for the industry as a whole from 2008 to 2015. Individual 18-hole facilities showed an 8.3% decrease in median energy use (Table 1, Figure 1). This decrease in energy use was based primarily on reductions in electricity use, as explained in further detail below.

When industry-wide energy use projections were estimated for 2008 vs. 2015, a 7.8% decrease was observed (Table 2, Figure 2). The difference between this value and the 8.3% decrease reported above occurred because the projection takes into account both the reduced energy use on individual 18-hole facilities, which accounted for 39% of the decrease, as well the net loss of 768 facilities (from 15,972 in 2008 to 15,204 in 2015), which accounted for 61% of the decrease (Table 2). Electricity was the most heavily used energy source in both years, while gasoline and diesel fuel were the second and third most heavily used (Table 2, Figure 2).

Per-facility medians vs. industry-wide projections

Two types of measurements are reported in this article: medians and projections. The median data reported describes the energy use of the average 18-hole facility for both 2008 and 2015. For example, the average (median) annual energy use for an 18-hole U.S. golf facility in 2008 was 2,623 million British thermal units (MMBtu), whereas in 2015, it was 2,405 MMBtu.

The projection data reported in Table 2 is an estimate of how the entire golf course industry behaves. This broadened analysis takes into account both the energy use behavior on individual golf courses and the total number of facilities in the U.S. For example, the projected energy use for the entire golf industry in 2008 was 39,503 billion British thermal units (BBtu), whereas it decreased to 36,411 BBtu in 2015.

Each type of analysis yields different and equally useful insights, as highlighted in this article.

Measuring energy use

There are gallons of gas, diesel, heating oil and propane, cubic feet of natural gas, and kilowatt-hours (kWh) of electricity. In other words, different energy sources are measured with different sets of units.

This becomes a problem only when there's interest in evaluating total energy use — the sum of all energy sources used at a given facility, or for the entire industry. In order to accurately measure total energy use, it's necessary to convert all energy measurements to a single unit of measure — the British thermal unit, or Btu — so that they can be summed up. The conversions for each energy source are shown below.

British thermal unit (Btu) conversions

Energy source	Btu
1 gallon gas	120,405
1 gallon diesel	137,381
1 gallon heating oil	138,500
1 gallon propane	91,333
1 cubic foot natural gas	1,032
1 kWh electricity	3,412

Conversions supplied by the U.S. Department of Energy (10).

Median energy use for 18-hole facilities

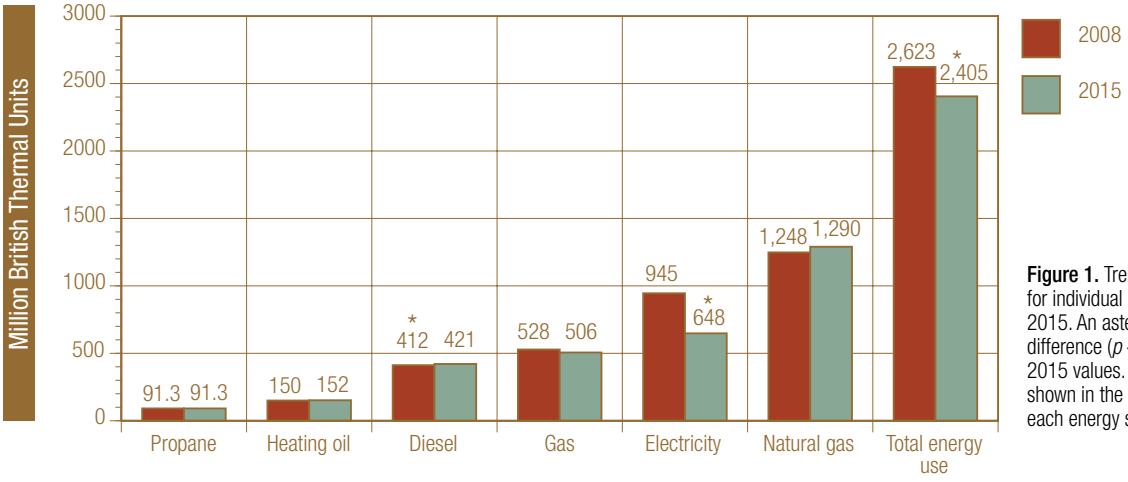

Figure 1. Trends in median energy use for individual 18-hole facilities in 2008 vs. 2015. An asterisk indicates a significant difference ($p < 0.10$) between 2008 and 2015 values. See Table 1 for energy use shown in the units conventionally used for each energy source.

Trends in energy use for individual 18-hole facilities

Energy source	2008	2015	% change
Gasoline			
Gallons	4,385	4,200	-4.2
MMBtu	528	506	
Diesel			
Gallons	3,000*	3,063	+2.2
MMBtu	412*	421	
Electricity			
kWh	276,949	190,000*	-31.4
MMBtu	945	648*	
Natural gas			
Mcf	1,209	1,251	+3.5
MMBtu	1,248	1,290	
Propane			
Gallons	1,000	1,000	0
MMBtu	91.3	91.3	
Heating oil			
Gallons	1,083	1,100	+1.6
MMBtu	150	152	
Total energy use			
MMBtu	2,623	2,405*	-8.3

Abbreviations: MMBtu, million British Thermal Units; Mcf, thousand cubic feet; kWh, kilowatt hours.

Table 1. Trends in median energy use for individual 18-hole facilities in 2008 vs. 2015. An asterisk indicates a significant difference ($p < 0.10$) between 2008 and 2015 values. For each energy source, consumption is shown in British thermal units (Btu) as well as in the units conventionally associated with each energy source.

Electricity use

Between 2008 and 2015, electricity use for individual 18-hole facilities decreased 31.4% (Table 1, Figure 1). Of all the energy sources analyzed in this survey, the reduction in electricity use was the largest — and likely the result of behavioral and/or design changes made since 2008 (see "Adoption of conservation practices," Page 10). Of all electricity used, approximately 28.9% in 2008 and 31.2% in 2015 was used for pumping irrigation water. These figures are based on responses from facilities that have separate electrical meters for pump stations.

Although the electricity used per 18-hole facility for irrigation pumps did not change from 2008 to 2015, there was a reduction in electricity used for all other purposes, which were primarily non-turf maintenance activities (clubhouse operations, equipment and other buildings and amenities) (Table 3). The significant proportion of electricity used for irrigation pumps has previously been documented in by Qian et.al. (5), who indicated the greatest use of electricity occurs at clubhouses (including electrical charging for golf carts) and for pumping irrigation water.

When industry-wide electricity use projections were estimated for 2008 vs. 2015, a 12.5% decrease was observed. The decrease in the number of golf facilities in the nation since 2008 contributed to this reduction, but approximately 63% of the reduction was due to reduced energy use on individual golf courses (Table 2, Figure 2).

Projected industry-wide energy use

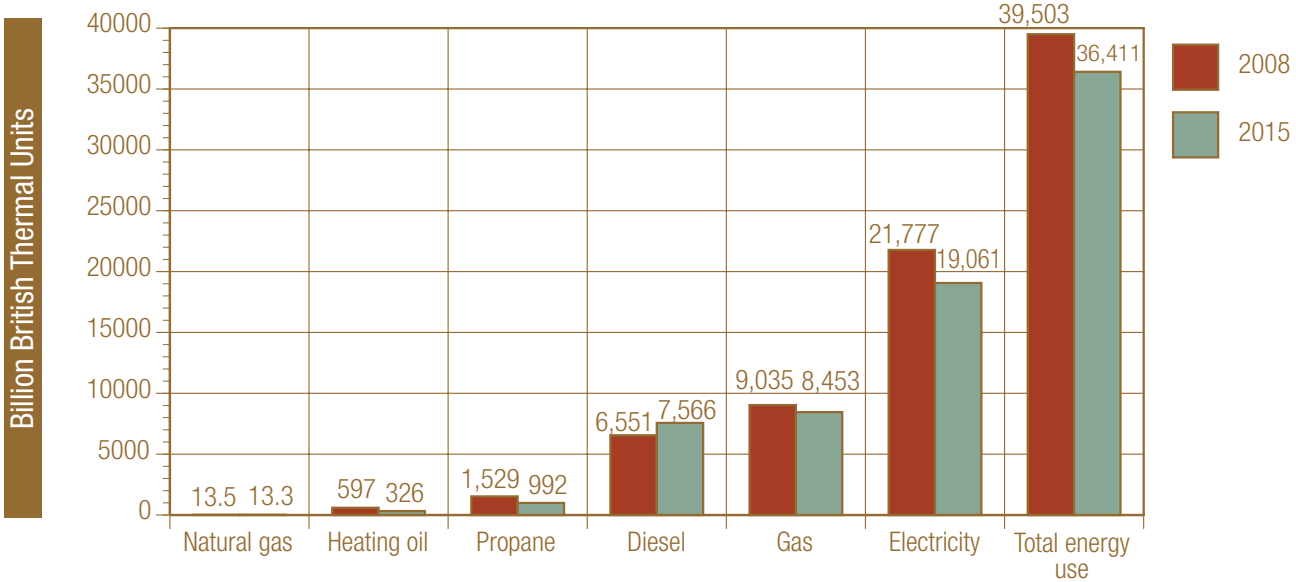

Figure 2. Trends in projected industry-wide energy use, 2008 to 2015. See Table 2 for energy use shown in the units conventionally used for each energy source.

Gasoline and diesel use

Although median gasoline use for individual 18-hole facilities did not change from 2008 to 2015, there was a small increase in the use of diesel fuel during that period (Table 1, Figure 1). At the same time, an increase in the use of diesel was also observed when industry-wide fuel use projections were estimated (Table 2, Figure 2), despite the net decrease of 768 facilities in the U.S. during those years. No concrete explanations are available for the observed increase in diesel use, especially because there was no concomitant decrease in gasoline use. However, one possible explanation could be the increase in the adoption of diesel equipment-intensive cultural practices for use on fairways, even though such practices had previously been restricted to greens. These practices include increased mowing and rolling frequency, increased applications of plant growth regulators, and sand topdressing.

Other fuels

Natural gas, propane and heating oil are used primarily for heating and other purposes, but are not used universally as gasoline and diesel fuel are (Table 4). There were no changes in the use of these fuels for individual 18-hole facilities between 2008 and 2015 (Table 1, Figure 1). When industry-wide projections were estimated, decreases in the use of propane and heating oil were observed. Decreases in heating oil were due to the reduced number of facilities in the nation, and the propane decrease was due to a combination of the decrease in facility numbers and changes in behavior at individual golf courses (Table 2, Figure 2).

Trends in projected industry-wide energy use

				% decrease due to:	
Energy source	2008	2015	% change	Change in facility numbers*	Reduced energy use
Gasoline					
BBtu	9,035	8,453	-6.4	73	27
MMga	75.0	70.0			
Diesel					
BBtu	6,551	7,566	15.5	no decrease	no decrease
MMga	47.7	55.1			
Electricity					
BBtu	21,777	19,061	-12.5	37	63
MWh	6,383	5,586			
Natural gas					
BBtu	13.5	13.3	-1.5	100	0
Bcf	13.1	12.9			
Propane					
BBtu	1,529	992	-35.1	31	69
MMga	16.7	10.9			
Heating oil					
BBtu	597	326	-45.4	100	0
MMga	4.3	2.4			
Total energy					

Abbreviations: BBtu, billion British thermal units; MMga, million gallons; Bcf, billion cubic feet; MWh, megawatt-hours.

*Values were determined by multiplying the change in 18-hole equivalents between 2008 and 2015 (694) by the average energy use per 18-hole equivalent

Table 2. Trends in projected industry-wide energy use, 2008 to 2015, and the impact of changes in number of facilities and changes in energy use patterns. Energy use values are expressed in billions of British thermal units (BBtu) to make direct comparisons more feasible, as well as in conventional units.

Median electrical use for irrigation pump stations vs. other uses

	2008		2015	
	Median amount used (kWh)	% of total electrical use	Median amount used (kWh)	% of total electrical use
Irrigation pump	75,680	28.9	65,000	31.2
All other uses	186,533	71.1	143,484*	68.8

Table 3. Median electrical use for irrigation pump stations vs. all other uses (clubhouse operations, other buildings and amenities, equipment) for individual 18-hole facilities. An asterisk indicates a significant difference ($p < 0.10$) between 2008 and 2015 values.

% facilities using various fuel sources

Fuel source	2008	2015
	% of facilities	
Gasoline	99	100
Diesel	96	99
Propane	43	39
Natural gas	31	31
Heating oil	10	6

Table 4. Percent of facilities using various fuel sources on a course-wide basis in 2008 vs. 2015.

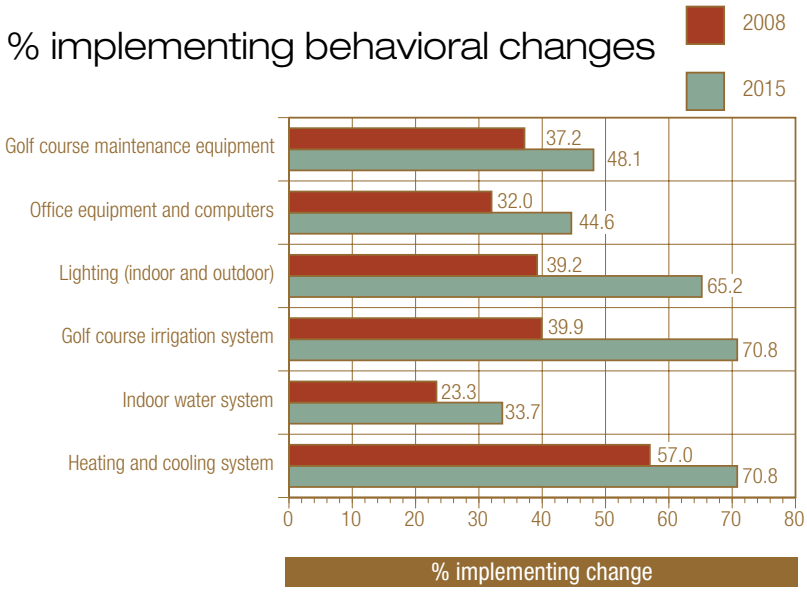

Figure 3. Percent of respondents implementing behavioral changes to conserve energy in 2008 vs. 2015.

Energy use for turf maintenance vs. other operations

Although most energy sources are used for multiple purposes on a golf facility, it is possible to approximate the relative amounts of energy used in turf maintenance operations vs. all other operations (clubhouse, other buildings, tennis courts, swimming pools, etc.) on the golf course. Assuming that gas and diesel fuels are used almost exclusively for turf maintenance, and considering that approximately 28.9% of electricity was used for irrigation pumps in 2008 and 31.2% of electricity in 2015 (Table 3), energy used for turf maintenance accounted for approximately 46% of all energy used in 2008 and 47% in 2015.

Role of climate in energy use

Because survey participation in 2015 was lower than that in previous years, it was not possible to subdivide the responses into agronomic regions in order to determine regional trends in energy use. However, by comparing 30-year normal climate data for each location with the energy use for that location, the influence of climate on energy use could be analyzed. As might be expected, locations with higher average air temperatures consumed more total energy, electricity, gasoline and diesel than locations in cooler climates. This is because warmer locations have climates that allow year-round turf maintenance and golf facility activities, they use air conditioning more heavily, and they use irrigation systems more frequently.

The relationship between warmer temperatures and greater energy use was not observed for propane, natural gas or heating oil, however. This may be mostly due to the limited amount of data available for analysis, since these fuels are used less frequently in general and are also used most heavily in the cooler regions of the country (2). As a result, the range of temperatures available for analysis is limited, thus limiting the power of a regression analysis.

Adoption of conservation practices

- The percentage of facilities adopting behavioral changes that conserve energy has increased since 2008 (Figure 3). Examples included heating and/or cooling system changes such as lowering thermostats during the winter and replacing filters in a timely manner, as well as operating equipment during non-peak hours.
- The percentage of facilities that have incorporated design, physical or mechanical changes to equipment in order to conserve energy has also increased since 2008 (Figure 4). Examples provided included heating/cooling system changes such as use of Energy Star-rated furnaces, programmable thermostats and efficient hot-water

tanks, indoor water system changes such as low-flow faucets, changes in irrigation controllers, and lighting changes such as a switch to T-8 lighting.

- Since 2008 there has been a small increase– from 2.3% to 4.2% (data not shown) — in the percentage of respondents who say their facilities generate energy on-site, with solar electricity being the predominant power-generating source.
- Another potential source of energy savings comes from the replacement of vehicles and equipment that burn fossil fuels with electric or hybrid substitutes. Results from the 2015 survey indicated that since 2011, 25.5% of respondents have made these replacements. This question was not asked in the 2008 survey, so no trends can be established for adoption.
- The percentage of facilities that have a written energy conservation plan (a document that identifies energy conservation goals and strategies for achieving those goals) has increased slightly since 2008, from 5.2% to 6.6%, and the percentage that have conducted an energy audit (by a professional auditor or self-assessment) in the past four years has also increased slightly, from 14.0% to 17.9% (Figure 5).
- Special programs that allow golf facilities to purchase green electricity (produced from renewable, or non-polluting and non-hazardous technologies such as wind, solar, water or geothermal) from a verified renewable energy source is an energy conservation option. In 2008, only 1.5% of respondents participated in such programs, with participation growing to 5.4% in 2015. Lack of awareness and/or unavailability of green energy were the most common barriers to lack of participation (Figure 6).

In other areas covered by the survey, change in energy conservation practices since 2008 has been limited.

- In both 2008 and 2015, fewer than 5% of facilities reported participation in renewable energy programs that allow purchase of energy credits.
- Conducting operations during non-peak hours may also result in financial savings, as energy companies provide lower pricing for electricity used during times of day when demand is low. In both 2008 and 2015, the most common off-peak operations were irrigation and golf cart charging (Figure 7). However, the frequency of non-peak usage has changed little during that time period.

% implementing design, physical or mechanical changes

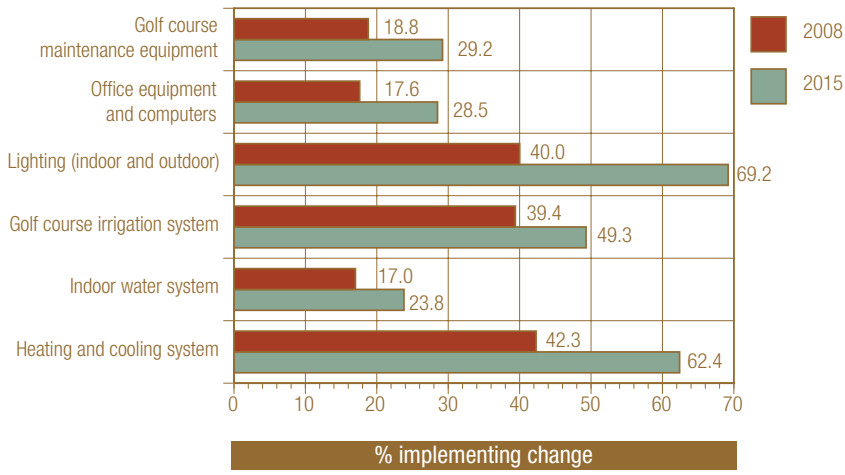

Figure 4. Percent of respondents implementing design, physical or mechanical changes to equipment to conserve energy in 2008 vs. 2015.

% writing an energy plan or conducting energy audit

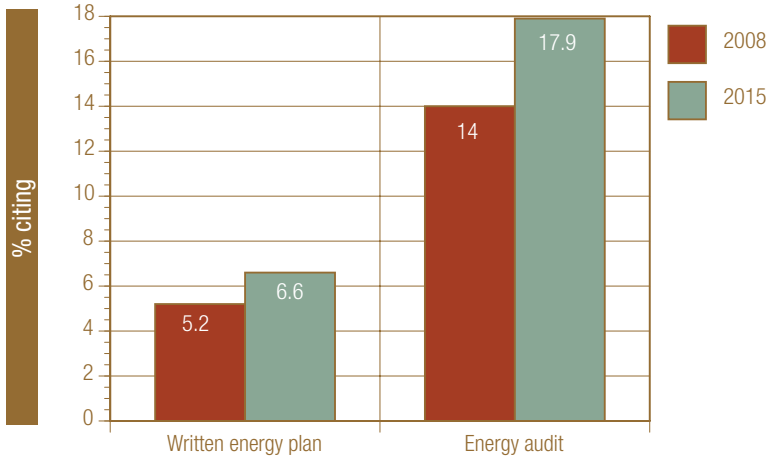

Figure 5. Percent of facilities that have a written energy conservation plan or that have conducted an energy audit in 2008 vs. 2015.

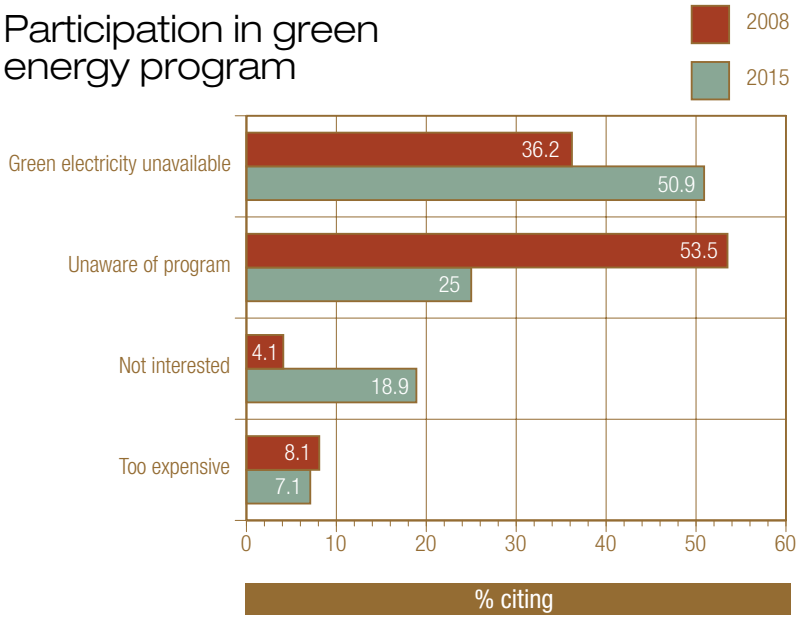

Figure 6. Reasons for lack of participation in green energy programs in 2008 vs. 2015.

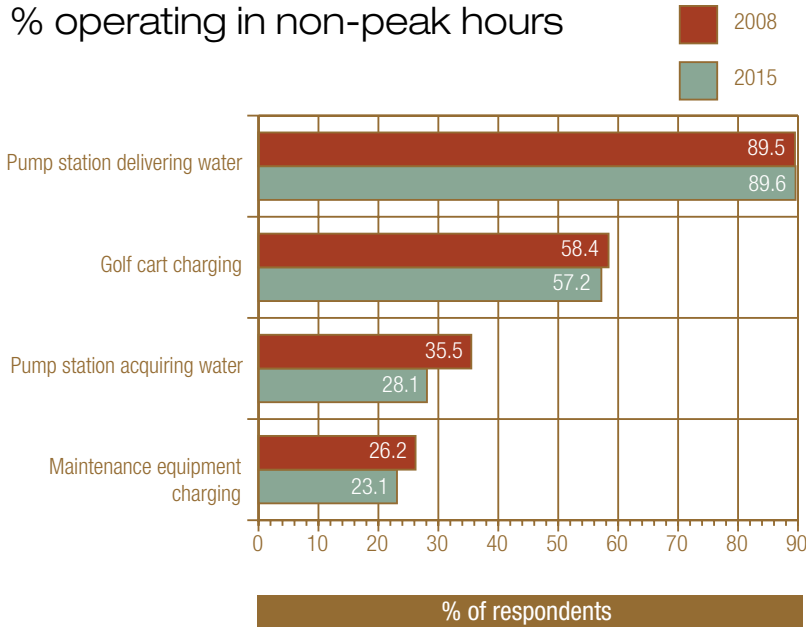

Figure 7. Percent of respondents conducting each operation primarily during non-peak hours in 2008 vs. 2015.

Conclusions and recommendations

Since 2008, energy use has decreased for individual U.S. golf facilities and for the industry as a whole. These reductions were brought about partly through a reduction in the number of golf facilities in the nation, but also by energy conservation practices whose greatest impact was on electricity use, which has been reduced by 31.4% since 2008. Most of the decrease in energy use took place in non-turf maintenance operations such as the clubhouse, tennis courts, swimming pool and other buildings, where practices such as programmable thermostats and more efficient lighting, furnaces or hot-water tanks made it possible for the reductions to occur. In contrast, no significant reductions in energy use took place for functions associated with turf maintenance, such as electricity for irrigation pumps and fuel for equipment and vehicles.

The following actions can promote progress in reducing energy consumption.

- Replace irrigation pumps with more-efficient systems. This purchase may ultimately result in lower electricity use, but some facilities may find it difficult to justify the immediate expense.
- Though the initial investment is costly, more-efficient hybrid or electric turf maintenance equipment and vehicles can provide energy savings, particularly when green energy alternatives are provided.
- Continued reductions in the acreage of maintained turf (1) will also have a major impact on energy use.
- The increase in median diesel fuel use since 2008 for 18-hole facilities was most likely caused by the recent adoption of cultural practices such as sand topdressing on fairways and other large acreages. Because these practices require diesel equipment, the benefits of these practices — reduced water, fertilizer and pesticide use — have to be weighed against the increased fuel use. In most situations, the benefits will outweigh the costs, but all input costs should be considered.
- Since 2008, small increases in the adoption of alternative or more-efficient energy sources have occurred in the form of on-site solar energy production, the purchase of green electricity from a renewable energy source, and the use of hybrid or electric vehicles and equipment. Adoption of these approaches will continue to contribute to future energy reductions, as will increased reliance on energy audits and written energy conservation plans.

Although diesel use increased slightly from 2008 to 2015, there was no corresponding decrease in gasoline use. One possible explanation could be an increase in the adoption of cultural practices (such as sand topdressing on fairways) that involve intensive use of diesel-powered equipment. ***GCM* file photo**

Methodology

Survey questions adhered as closely as possible to those in the 2008 survey. However, input from golf, environmental, academic and regulatory sources was integrated into the 2015 survey in order to clarify questions or to include information on new technologies and issues in golf course management.

PACE Turf was contracted to provide technical oversight of the survey, analyze and summarize the data, and to prepare reports for publication in peer-reviewed scientific journals, as well as in GCSAA publications and websites.

The National Golf Foundation (NGF) was contracted to refine and format the survey instrument for online use, conduct the survey, manage the recruitment of participants, collate the data and complete the analysis in collaboration with GCSAA and PACE Turf.

To evaluate the impact of climate on energy consumption, average temperature for each survey location were determined by matching each respondent's ZIP code to 30-year average temperature data (4). This climate data was compared, via linear regression, against the energy use per acre for each energy source, at each survey location.

Survey response

Of the 15,204 golf facilities in the U.S. at the time the survey was completed, 12,530 U.S. golf courses managed by superintendents with available email addresses were identified by integrating GCSAA and NGF databases.

An initial email invitation, which included a link to the online survey, was sent to prospective participants in October 2016, followed by three email reminders, sent in October or November 2016. A total of 528 (or 3.5% of all U.S. facilities) completed surveys were received (Figure 8). This is lower than the 9.8% response coverage from the initial survey (3), which also included a mail survey campaign. While both surveys targeted the same population, respondents in the 2016 survey were not identical to those in the initial survey.

To ensure that the data was representative of the broad spectrum of golf facilities in the nation, responses were weighted so that the diversity in golf course size, type and geographic location were accurately reflected in the survey data.

2015 survey responses

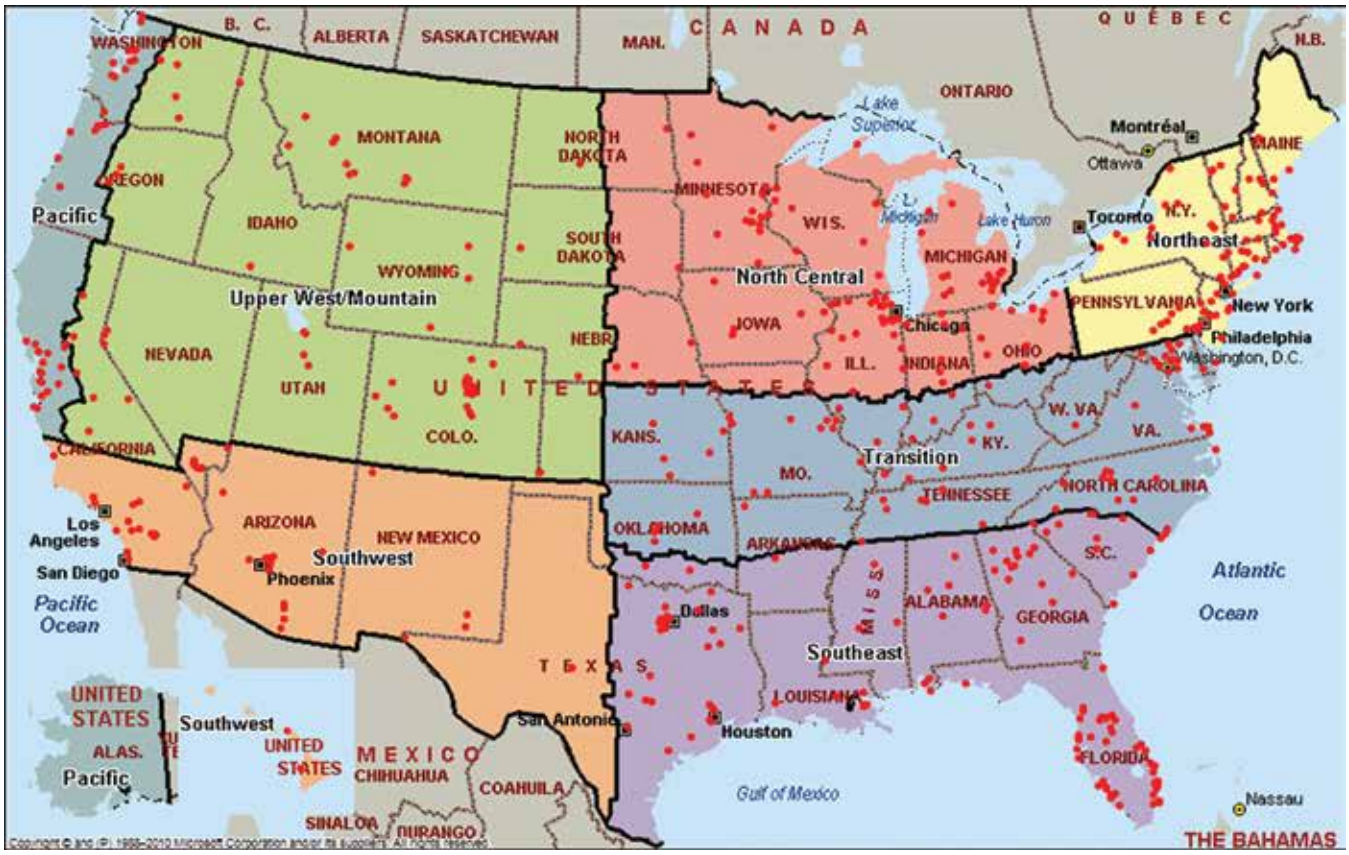

Figure 8. Distribution of 2015 survey responses received in seven different agronomic regions.

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