



Golf Course Environmental Profile

Volume IV

Energy Use and Energy Conservation
Practices on U.S. Golf Courses

With a Foreword by
Sandy G. Queen, CGCS
2012 GCSAA President



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



Golf Course Superintendents Association of America

Golf Course Environmental Profile

Volume IV

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Practices on U.S. Golf Courses

Funded by



The Environmental Institute for Golf
and



The Toro Giving Program

On the cover

Left: Photo by Andy Jorgensen, Center: Photo by David Phipps, Right: Photo by Montana Pritchard

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Our Mission



The Golf Course Superintendents Association of America is dedicated to serving its members, advancing their profession, and enhancing the enjoyment, growth and vitality of the game of golf.



The Environmental Institute for Golf fosters sustainability through research, awareness, education, programs and scholarships for the benefit of golf course management professionals, golf facilities and the game.

Acknowledgments

The Golf Course Superintendents Association of America and The Environmental Institute for Golf wish to thank

The Toro Giving Program for helping to fund this research

The thousands of golf course superintendents who took the time and effort to complete the survey

— and —

Golf's allied associations for their support in this endeavor.

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Foreword

Sandy G. Queen, CGCS



Another Important Step

We are proud to present the fourth installment of GCSAA's Golf Course Environmental Profile report, *Energy Use and Energy Conservation Practices on U.S. Golf Courses*. This report represents the first attempt to measure golf course energy use on a national scale, and the information it provides will be useful for the golf industry in a variety of ways. Managers, owners, scientists and other industry professionals will all benefit by gaining a better understanding of how the industry uses energy and where current conservation practices are being implemented. The data collected may also spark future industry improvements.

I thank the golf course superintendents who participated in this survey. More than 1,500 facilities shared details about their energy use for the entire operation — clubhouse, golf course maintenance and other amenities. This was a challenging task and, in many cases, required input from several individuals at each facility. This level of commitment is a positive reflection on the golf industry.

The report indicates that energy use by golf facilities varies widely across geographic regions of the United States. The information in this report will allow managers to compare their energy use to that of similar-sized facilities within the same region and of other facilities across the country. The survey results also show that many energy-saving practices already have been implemented at golf facilities. Technology upgrades and positive management changes are widespread within the golf industry. And yet, there is room for improvement. The report recommends that more golf course facilities implement specific techniques such as energy audits and written energy conservation plans. The industry has much to gain as becoming more energy-efficient has a direct and positive effect on the bottom line of the business.

Changing technology will continue to expand our energy options in the future, especially for renewable energy sources. Given the land space available on golf courses, we will likely see energy being generated directly on the property to augment our energy needs. This report presents a holistic view of energy use for the golf industry and offers recommendations for continued progress. Through a commitment to continual progress and innovation, individual golf facilities can employ sustainable practices that will allow future generations to enjoy the game of golf.

Sincerely,

A handwritten signature in black ink, appearing to read 'Sandy G. Queen'.

Sandy G. Queen, CGCS
2012 GCSAA President

Executive Summary

GCSAA's Golf Course Environmental Profile is a data collection project that provides new insight into the property features, management practices and inputs associated with golf courses across the United States.

Energy Use and Energy Conservation Practices on U.S. Golf Courses is the fourth report produced from the project. The first, *Property Profile and Environmental Stewardship of Golf Courses*, was released in November 2007. The second report was *Water Use and Conservation Practices on U.S. Golf Courses* (2009), and the third report was *Nutrient Use and Management on U.S. Golf Courses* (2009).

The objectives of this survey were to quantify electricity used, fuel used for heating and other purposes, fuel used for equipment and vehicles, and conservation practices at golf facilities in the U.S. and its agronomic regions.

This report provides an accurate portrayal of energy use and conservation practices on golf courses in the U.S. It establishes a baseline that can be compared to data from future surveys to identify change over time.

Methodology

Superintendents at all golf facilities (16,285) were invited to participate in the survey. A total of 1,563 golf facilities participated in the survey accounting for 9.6% of the total. Analysis of the completed surveys indicated a representative sample of the golf facilities in the U.S. had been received with the exception of facility type (daily fee, municipal or private). Private facilities accounted for 39% of the returned surveys but made up approximately 30% of golf facilities. Therefore, proportions of the collected sample were weighted to resemble known golf course demographics. The data were analyzed and compared across facility types, maintenance budgets and agronomic regions.

Results

Respondents were asked to report energy use for the entire facility including the clubhouse, pump station, maintenance facility and other buildings and amenities. In addition, they were asked to identify their energy conservation practices. Highlights of energy use and conservation practices are listed below.

Electricity

- Total electricity use in 2008 for all U.S. golf facilities was estimated at 6.714 billion kilowatt-hours (kwh).
- The average use was 448,123 kwh of electricity per 18-hole facility in 2008.
- An 18-hole golf facility in the U.S. has an average of five separate electric meters.
- The Southeast agronomic region accounted for the greatest total electricity use per agronomic region at 1.9 billion kwh. This is due to the large number of golf facilities and year-round golf.
- The Pacific region accounted for the lowest total electricity use at 0.2 billion kwh because of the lower number of golf facilities in this region.

Propane

- The estimated total use of propane for all U.S. golf facilities was 17 million gallons in 2008.
- Forty-five percent of 18-hole golf facilities used propane in 2008. The average use was 2,528 gallons per 18-hole golf facility.
- The Northeast region used the greatest amount of propane at 5.9 million gallons.
- The Southwest region used the least amount of propane at 0.4 million gallons.

Natural gas

- The estimated total use of natural gas for all U.S. golf facilities was 17.5 million Mcf in 2008 (1 Mcf = 1,000 cubic feet).
- Forty-one percent of 18-hole golf facilities used natural gas in 2008. The average use was 2,856 Mcf per 18-hole golf facility.
- The North Central region used the greatest amount of natural gas at 5.9 million Mcf in 2008.
- The Pacific region used the least amount of natural gas at 0.5 million Mcf.

Heating oil

- The estimated total use of heating oil for all U.S. golf facilities was 4.4 million gallons in 2008.
- Nine percent of average 18-hole golf facilities used heating oil in 2008, and they used an estimated 2,273 gallons per facility.
- The Northeast region used the most heating oil (2.8 million gallons) in 2008.

- Survey participants in the Southwest region did not use heating oil.
- The Pacific, Upper West/Mountain and Southeast regions consumed less than 100,000 gallons of heating oil per region in 2008.

Fuel for equipment and vehicles

- The estimated total use of gasoline for all U.S. golf facilities was 77 million gallons in 2008.
- The estimated total use of diesel for all U.S. golf facilities was 50.4 million gallons in 2008.
- Nearly all 18-hole golf facilities used gasoline; average consumption was 5,192 gallons.
- Ninety-seven percent of average 18-hole golf facilities used diesel; average consumption was 3,467 gallons.
- Golf facilities in the Southeast region used the greatest amount of gasoline (21.7 million gallons) and diesel (12.9 million gallons) in 2008. Golf facilities in the Pacific region used the least amount of gasoline (2.3 million gallons) and diesel (2.0 million gallons) in 2008.

Written plans and energy audits

- Six percent of 18-hole golf facilities had a written energy conservation plan.
- Between 2004 and 2009, 15% of 18-hole golf facilities conducted an energy audit.
- As the maintenance budget or number of holes increased, the likelihood of having a written energy conservation plan or conducting an

energy audit also increased.

- Average 18-hole golf facilities in the Pacific region (10%) were more likely to have a written energy conservation plan than facilities in the other regions.
- Average 18-hole golf facilities in the Southwest (23%) were more likely to have conducted an energy audit than facilities in the other regions (9%–17%).

Behavioral, design and other conservation changes

- Three percent of 18-hole golf facilities had at least one building that was certified through LEED or a similar green building program.
- Seventy-seven percent of 18-hole golf facilities had incorporated one or more behavioral changes to conserve energy. Examples include turning down thermostats in winter, replacing filters in a timely manner and charging equipment during non-peak hours.
- Seventy-one percent of 18-hole golf facilities had incorporated one or more design, physical, or mechanical changes to conserve energy. Examples of design, physical, or mechanical changes include the use of Energy Star-rated furnaces, programmable thermostats, efficient water heater, low-flow faucets, irrigation controller updates and T-8 lighting. Changes to enhance energy conservation were most common in the heating and cooling system and the golf course irrigation system.



The pump station for the Chiricahua Course, The Desert Mountain Club, Scottsdale, Ariz. The golf course has saved on its energy costs by reducing the total number of horsepower used to pump water. Photo by Jim Key, CGCS

Renewable energy use

- Less than 5% of golf facilities purchased green electricity or energy credits, mainly because they were unaware of programs that offer them.
- Less than 2% of facilities were generating power on-site with alternative or renewable resources such as solar or wind technologies. Solar for electricity was the most common source used followed by wind, hydro and geothermal.

Future research

To compare gasoline and diesel use on golf courses, researchers at the University of California-Irvine (10,11) estimated fuel use on a per-acre basis for the maintenance of a city-owned park in Irvine, Calif. According to that research, an average 18-hole golf course uses approximately 30% more gasoline and diesel fuel per acre on a national basis than the Irvine city park. This difference is likely

due to the higher maintenance requirements of specific areas of the golf course, maintenance of other landscape plants, more diverse equipment types, different mowing heights and patterns, and other varying agronomic practices on golf courses.

To address the issues raised by the Irvine research, additional national and regional research should be conducted to segregate the use of energy within different facets of the golf course facility, including irrigation pumping stations, maintenance buildings, equipment, specific turfgrass and landscape maintenance practices, clubhouse and amenities.

Recommendations and conclusions

This survey is the first attempt to examine energy use on golf courses on a national basis. The objective was to investigate energy use on a macro level for all energy inputs for the entire facility. The following recommendations address areas of improvement for the golf course industry highlighted by the survey results.

- Golf facilities should routinely document energy use across all operations and identify opportuni-

ties for conservation.

- All golf facilities should conduct an energy audit.
- Using the results of the energy audit and documentation about energy use, all golf facilities should develop a written energy conservation plan and implement the plan.
- At the time of this study, few golf facilities used energy from renewable sources or purchased green energy credits. Golf facilities should strive to purchase energy from renewable sources when available.
- Few golf facilities generated energy from on-site sources, but this may be a viable option in the future. The land space and natural resources available on golf course properties could lend themselves to energy generation as technology becomes available and costs decrease.
- Additional national and regional research should be conducted to segregate the use of energy within different facets of the golf course facility, including irrigation pumping stations, maintenance buildings, equipment, specific turfgrass and landscape maintenance practices, clubhouse and amenities.



The land space and natural resources available on golf course properties could lend themselves to energy generation as technology becomes available and costs decrease. Photo by David Phipps

Introduction

Energy Use and Energy Conservation Practices on U.S. Golf Courses is the fourth report in the Golf Course Environmental Profile. This report includes data about energy use at golf course facilities including clubhouses, maintenance facilities, equipment and amenities. It includes the total amount of electricity, propane, natural gas, heating oil, gasoline and diesel. Respondents also reported information about their energy conservation practices. These data complement the three previous reports that provide information on property features, land-use acreage, turfgrass species, water use, water conservation practices, nutrient use and nutrient management practices.

In 2006, GCSAA initiated a project, funded by the Environmental Institute for Golf through a grant from The Toro Giving Program, to collect data nationally on the property features, management practices and inputs associated with golf courses and golf course maintenance.

Since 2004, golf course superintendents, golf industry leaders, golf association leaders, environmental advocates, university turfgrass scientists and environmental regulators have participated in meetings, symposiums and conferences hosted by the Golf Course Superintendents Association of America (GCSAA) and The Environmental Institute for Golf to discuss environmental issues facing the golf industry and to identify future research, education and outreach opportunities. The group reached several important conclusions about the environmental aspects of golf including:

- The golf industry lacks comprehensive national data on the property features, management practices and inputs associated with golf courses and golf course maintenance.
- Although many individual golf courses are environmentally proactive, no systematic process was in place to document current practices or track changes that the golf industry nationwide has made to protect and enhance the environment.

In 2006, GCSAA initiated a project, funded by the Environmental Institute for Golf through a grant from The Toro Giving Program, to collect data nationally on the property features, management practices and inputs associated with golf courses and golf course maintenance. To collect the data, five surveys were conducted from 2006 through 2009. The surveys are expected to be repeated to measure changes on golf courses and in golf course maintenance practices over time.

The first survey was conducted in 2006 and its

manuscript, "Golf Course Profile Describes Turfgrass, Landscape and Environmental Stewardship Features," was published in November 2007 in *Applied Turfgrass Science*, a peer-reviewed scientific journal (2). Its companion report, "Property Profile and Environmental Stewardship of Golf Courses," was also produced in November 2007. The second survey of the series was conducted in late 2006 and its manuscript, "Golf Course Environmental Profile Measures Water Use, Source, Cost, Quality and Management and Conservation Strategies," was published in *Applied Turfgrass Science* in 2008 (8). Its companion report, "Water Use and Conservation Practices on U.S. Golf Courses," was also produced in 2008.

In 2007, the third survey of the series was completed and its manuscript, "Golf Course Environmental Profile Measures Nutrient Use and Management and Fertilizer Restrictions, Storage and Equipment Calibration," was published in *Applied Turfgrass Science* in 2009 (9). Its companion report, "Nutrient Use and Management on U.S. Golf Courses" was also published in 2009. The fourth survey was conducted in 2009 and collected data from 2008. The resulting article, "Golf Course Environmental Profile Measures Energy Use and Energy Management Practices," was published in *Applied Turfgrass Science* in 2012 (3). Its companion report, *Energy Use and Energy Conservation Practices on U.S. Golf Courses*, was produced in 2012.

All of the published Golf Course Environmental Profile reports and journal articles are available on the Environmental Institute for Golf's website, www.eifg.org. For more information on the Golf Course Environmental Profile, please contact the Environmental Institute for Golf at 800-472-7878.

Summary of Methodology

Input on the survey questions was collected from golf, environmental, academic and regulatory sources. GCSAA staff drafted survey questions, which were reviewed and revised by a group of golf course superintendents, golf association leaders and environmental advocates.

The National Golf Foundation (NGF) was contracted to conduct the survey, manage the recruitment of participants and complete the analysis of data in collaboration with GCSAA. The NGF adheres to The Code of Marketing Research Standards developed by the Marketing Research Associ-

ation (4). The NGF refined and formatted the survey instrument for online and paper versions. The same survey procedures were used for this survey as were used in the previous three surveys (2,8,9). An attempt was made to recruit 16,285 superintendents at golf facilities in the U.S. to complete the energy survey. Surveys were sent beginning Feb. 24, 2009 by e-mail or mail and accepted until May 19, 2009. Several reminders to complete and submit the survey were sent by e-mail and mail.

Of the 16,285 superintendents contacted, 1,563 completed and returned surveys, yielding a

Completed surveys



Figure 1. Percentage of the total number of completed surveys by agronomic region. Red dots indicate locations of golf facilities responding to the survey.



(Top) According to the energy survey results, gasoline and diesel were used more than any other fuels for equipment and vehicles. Photo by Montana Pritchard

(Bottom) Candler Hills GC in Ocala, Fla., installed solar panels on its golf maintenance building in 2011. In the first three and a half months of use, the facility saved roughly \$4,000. Once it has accrued \$1,200 in credits from selling excess power (expected to occur in February 2012), the facility will maintain a running credit and should have no power charges for the next 30 to 40 years. Photo by Andrew J. Jorgensen

9.6% return rate. The analysis classified the golf courses by agronomic region, course type (daily fee, municipal or private) and number of holes. Agronomic regions were determined by grouping geographic areas with similar climatic and agronomic characteristics, and boundaries were drawn using county borders (1,7). Analysis of the returned surveys indicated a representative sample of golf facilities was received with the exception of facility type. Responses from private facilities accounted for 39% of the returned surveys, but made up 30% of golf facilities. Therefore, proportions of the collected sample were weighted to resemble the known golf course demographics. Weighted data are presented in this report (Figure 1, Table A1).

Data were analyzed to run descriptive statistics and explore relationships among the variables such as agronomic region, course type and number of holes. The words “significant” and “significantly” are used frequently in the report to describe statistical differences. For example, “Average electricity use increased significantly with the number of holes and maintenance budgets.” In the mathematical sense, “significant” means that differences are important, distinct and too great to be caused by chance. The energy use data have been analyzed and compared across facility types, maintenance budgets and agronomic regions.

The facility type was characterized as private or public. Private facilities require a membership, and public facilities allow anyone to play for a fee. Golf facilities were divided into three annual maintenance budget categories: more than \$1 million, \$500,000 to \$999,999 and less than \$500,000.

The final major comparison was by agronomic region. The continental U.S. was divided into seven agronomic regions: Northeast, North Central, Transition, Southeast, Southwest, Upper West/Mountain and Pacific. The regional analysis identifies variation in energy use and conservation across the U.S. Where 18-hole equivalent data are presented, data within a region were averaged over facility type and budget. The number of 18-hole equivalents in the U.S. is 14,983, and was determined by taking the total number of golf holes and dividing by 18 (5).

Survey Results

In the first portion of the survey, respondents were asked to report their total energy use for the entire facility including the clubhouse, maintenance facility, pump station, equipment and other amenities such as swimming pools. In the second portion of the survey, respondents reported information about their energy conservation practices. Survey categories for energy use included electricity, propane, natural gas, heating oil, gasoline and diesel fuel. During the development of the survey questions, it was apparent that many facilities would have difficulty segregating their various energy sources by building, function or department. In order to simplify the data collection, survey participants were asked to report total energy use for all functions at the facility.

Btu conversion

A popular way to offer perspective and compare energy use patterns is to convert the various energy sources into British Thermal Units (Btu). This method produces a common unit of measurement across all energy sources and allows for easier comparisons. By using conversions provided by the U.S. Energy Information Administration, Btu have been calculated using data from this report. The Btu estimate does not include production, delivery or other inputs for the energy source. For instance, the total Btu for an average 18-hole golf facility in the U.S. is 6.134 billion. The total Btu estimates for average 18-hole golf facilities for all energy sources (electricity, gasoline, diesel, natural gas, propane and heating oil) can be found in Table A2.

For perspective, one automobile that is driven 12,000 miles per year and gets 20 miles per gallon will use approximately 600 gallons per year. Simply calculated, that is 74,542,800 Btu annually (12).

In general, energy use varied by region and size of golf facility. Variance among agronomic regions is due in part to the differences in climate, length of the golf/growing season and the availability of

energy sources. For example, the Pacific has the lowest average Btu consumption at 4.299 billion per facility, while the Southwest region has the highest average Btu consumption at 8.472 billion Btu per facility (Table A2). Higher energy use in the Southwest is primarily due to a 12-month golf season and greater demands for electricity to run irrigation systems and cool buildings.

Listed below are the results for electricity, propane, natural gas, heating oil, gasoline and diesel use on U.S. golf facilities in 2008, followed by energy conservation practices.

Electricity

In 2008, total estimated electricity use for all U.S. golf facilities was 6.7 billion kilowatt-hours (kwh). The average use was 448,123 kwh (1,529 million Btu) per 18-hole golf facility (Tables A3, A4).

Average electricity use increased significantly depending on the number of holes, facility type or maintenance budgets. Private facilities used significantly more electricity than public facilities, and facilities with higher budgets spent significantly more on electricity than facilities with lower budgets (Figure 2).

Electricity use by facility size, type and budget

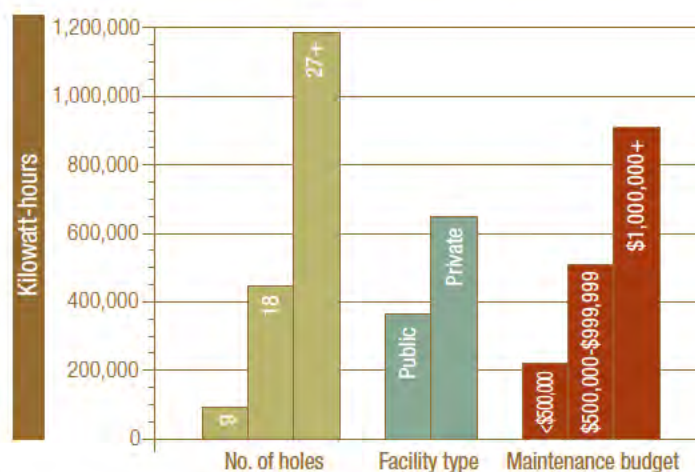


Figure 2. Electricity use by the average 18-hole golf facility in the U.S. in kilowatt-hours by number of holes, facility type and maintenance budget in 2008.



(Left) In 2008, the average 18-hole golf facility had five electric meters. Photo by Ted Freeman
 (Right) To save energy costs at the Desert Mountain Club, Scottsdale, Ariz., the irrigation lakes were filled later in the day or earlier in the evening before the irrigation cycle began. Photo by Jim Key, CGCS

Electric meters

Survey participants were asked to indicate the number of individual electric meters in use at their facility. If a separate meter was used at the irrigation pump station, they were asked to identify the total amount of electricity used for irrigation. Eighteen-hole facilities with separate electric meters for their pump stations reported an average use of approximately 113,000 kwh. The average 18-hole golf facility used five electric meters.

Non-peak hours

Survey participants were asked to state whether electricity was used to power or charge equipment during non-peak hours. Electric power providers reduce prices as an incentive to use power when demand is low, usually at night. The majority of 18-hole facilities ran their irrigation pumps and approximately two-thirds of them charge their golf cars during non-peak hours (Figure 3).

Non-peak energy use

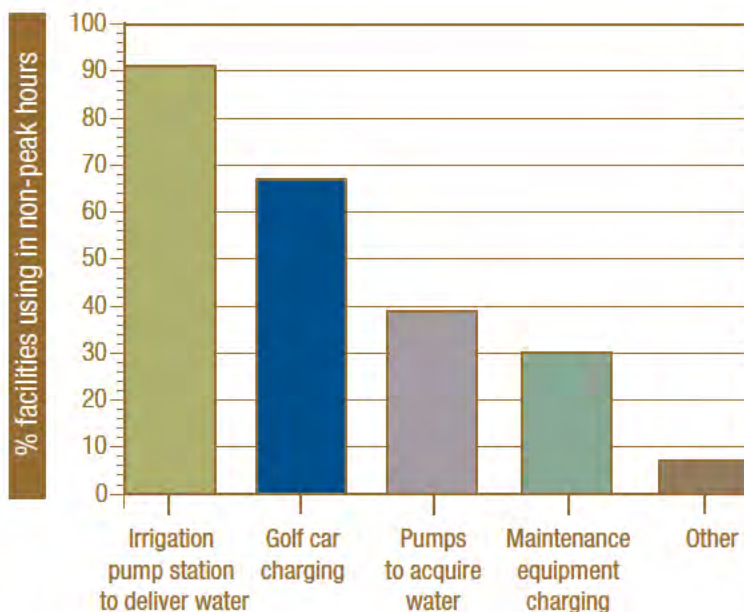


Figure 3. Operations conducted primarily during non-peak hours by the average golf facility in the U.S.

Average electricity use within regions

Eighteen-hole golf facilities in the Southwest used significantly more electricity than 18-hole facilities in other agronomic regions. Eighteen-hole golf facilities in the Northeast region averaged the least amount of electricity per facility when compared to other regions (Figure 4, Table A3).

Higher electricity use at golf facilities in the Southwest is likely due to the warmer, arid climate and year-round golf season. Using electricity to power irrigation pumps is likely to add to the higher electricity use in the Southwest. The Southwest region had the highest number of irrigated turfgrass acres and highest water use per 18-hole golf facility when compared to other agronomic regions (8).

Total electricity use

In 2008, total estimated electricity use for all U.S. golf facilities was 6.7 billion kilowatt-hours (kwh). The average use was 448,123 kwh (1,529 million Btu) per 18-hole golf facility (Table A3).

The Southeast region accounted for the greatest use of electricity at 1.9 billion kwh, and the Pacific accounted for the least electricity used at 221 million kwh (Table A4). Variance in electricity use among the agronomic regions is due in part to the differences in the climate, length of the golf season and the total number of golf facilities within each region (Figure 5).

Propane

In 2008 45% of 18-hole golf facilities used propane, and their average use was 2,528 gallons (231 million Btu). The estimated total use of propane for all U.S. golf facilities was 17 million gallons in 2008 (Tables A3, A4).

The percentage of public (45%) and private (44%) golf facilities using propane was nearly equal. Private 18-hole golf facilities used an average of 3,590 gallons of propane, which was significantly more than the 2,127 gallons used at public golf facilities.

The percentage of 9-hole, 18-hole and 27+-hole facilities using propane was nearly equal, ranging from 41% to 45%. Average annual propane use was 7,510 gallons at 27+-hole facilities; 2,528 gallons at 18-hole facilities; and 1,591 gallons at 9-hole facilities.

Average propane use within regions

The highest percentage of 18-hole golf facilities using propane was in the Northeast (61%), Transition (50%) and Pacific (50%) regions. The lowest percentage of use was in the Southwest (34%), Southeast (35%) and Upper/West Mountain regions (42%).

The highest average use of propane at 18-hole facilities was in the Northeast (4,040 gallons), Southeast (2,960 gallons) and Upper/West Mountain regions (2,390 gallons). Facilities in the Southwest region had the lowest average consumption of propane at 1,023 gallons (Figure 6, Table A3).

Total propane use

Based on the average consumption per 18-hole facility and the number of facilities, the total consumption was estimated for each region. The Northeast region used the greatest amount of propane at 5.9 million gallons. The Southwest (0.4 million gallons), Pacific (0.6 million gallons) and Upper West/Mountain (0.9 million gallons) used the least amount of propane in 2008 (Figure 7, Table A4).

Natural gas

Approximately 41% of 18-hole golf facilities used natural gas in 2008. The average use was 2,856 Mcf (2,933 million Btu) per 18-hole golf facility (1 Mcf = 1,000 cubic feet). The estimated total use of natural gas for all U.S. golf facilities was 17.5 million Mcf in 2008 (Tables A3, A4).



In 2008, average electricity use for golf facilities varied significantly depending on the number of holes, facility type or maintenance budget. Photo by Montana Pritchard

Key to regions in figures:

US - United States	SE - Southeast
NE - Northeast	SW - Southwest
NC - North Central	UW/Mtn - Upper West/Mountain
Trans - Transition	Pac - Pacific

Average electricity use

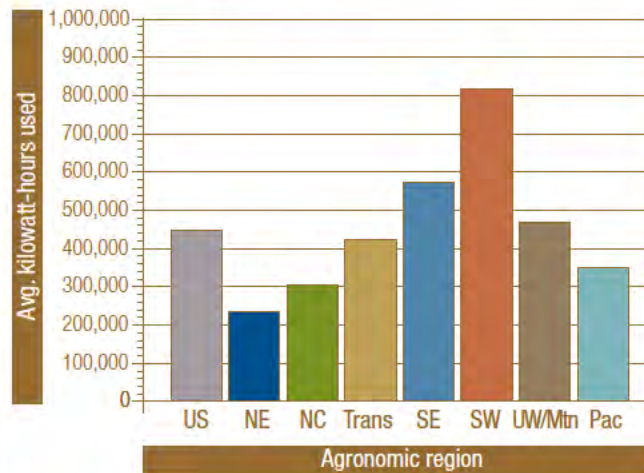


Figure 4. Average electricity used at 18-hole golf facilities in the U.S. and its agronomic regions in kilowatt-hours.

Total electricity use

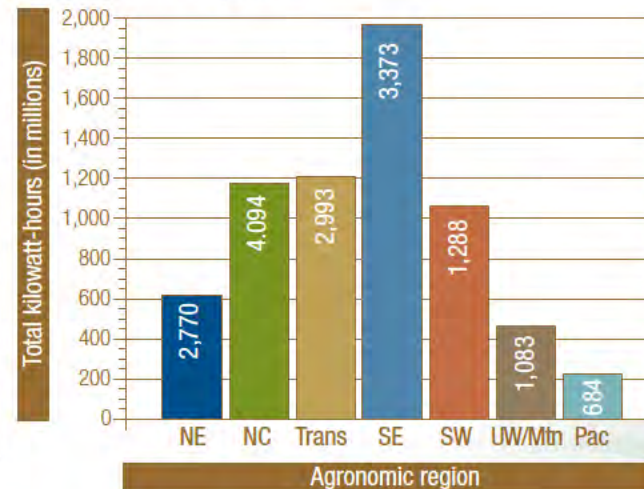


Figure 5. Golf facilities (numbers shown in bars) reporting from each agronomic region and the total millions of kilowatt-hours they used 18-hole in 2008.

Average propane use

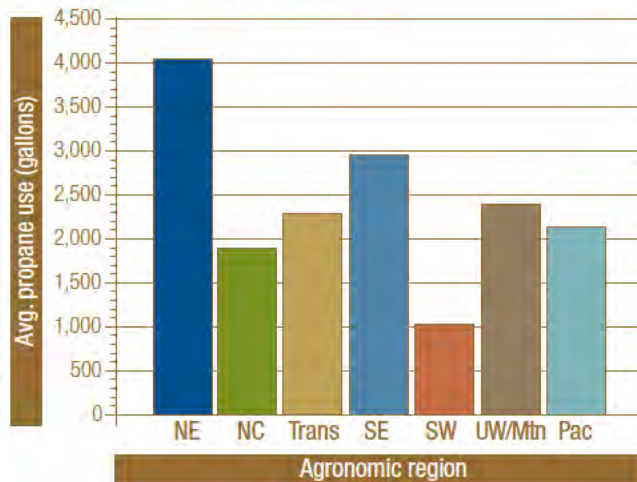


Figure 6. Average 2008 propane use in gallons at 18-hole golf facilities by U.S. agronomic region.

Total propane use

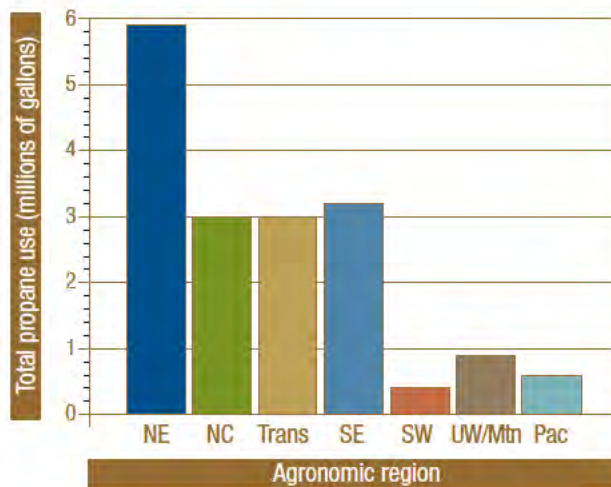


Figure 7. Total propane use in millions of gallons at 18-hole golf facilities by U.S. agronomic region in 2008.

Average natural gas use

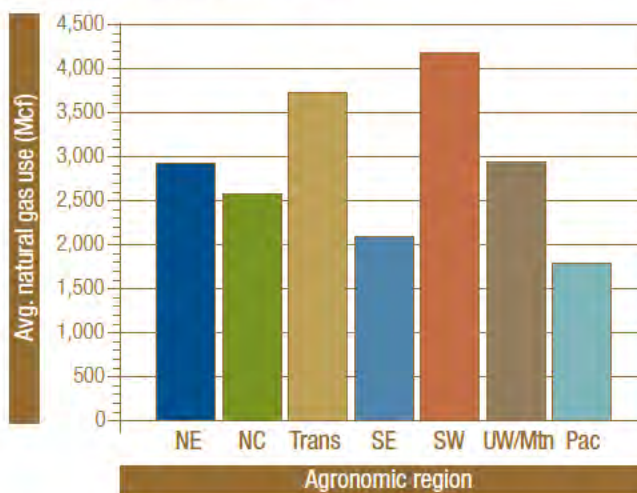


Figure 8. Average natural gas use in Mcf at 18-hole golf facilities by U.S. agronomic region in 2008.

Natural gas was used at more private 18-hole golf facilities (48%) than public 18-hole facilities (39%). Private facilities used significantly more natural gas (an average of 4,221 Mcf) than public 18-hole golf facilities (an average of 2,044 Mcf).

More 27+ -hole golf facilities (44%) and 18-hole golf facilities (41%) used natural gas than 9-hole facilities (24%). Facilities with 27+ holes and 18 holes used significantly more natural gas than 9-hole facilities. On average, golf facilities with a maintenance budget of more than \$1,000,000 used significantly more natural gas than facilities with lower maintenance budgets.

Average natural gas use within regions

A higher percentage of facilities in the North Central (64%) and Upper West/Mountain (63%) regions used natural gas. The lowest percentage of facilities using natural gas is in the Southeast region (19%).

The highest average use of natural gas for 18-hole facilities was in the Southwest with 4,172 Mcf. The Pacific region had the lowest average consumption at 1,789 Mcf (Figure 8, Table A3).

Total natural gas use

The estimated total use of natural gas for all U.S. golf facilities was 17.5 million Mcf in 2008 (Table A4). Based on the average consumption per 18-hole facility and the number of facilities, total consumption of natural gas was estimated for each region. The North Central region used the greatest amount of natural gas (5.9 million Mcf), and the Pacific region used the least amount of natural gas (0.5 million Mcf) (Figure 9, Table A4).

Variance in natural gas consumption among the agronomic regions is due in part to the differences in the climate, the total number of golf facilities within each region and the availability of natural gas as a fuel source.

Heating oil

Approximately 9% of average 18-hole facilities used heating oil in 2008. The average use was 2,273 gallons (315 million Btu) per 18-hole facility in 2008. The estimated total use of heating oil for all U.S. golf facilities was 4.4 million gallons in 2008 (Tables A3, A4).

Nearly equal percentages of private facilities (8%) and public facilities (9%) used heating oil in

2008. Private 18-hole golf facilities used an average of 4,242 gallons of heating oil, which was significantly higher than the 1,619 gallons of heating oil used at public facilities.

Significantly more 9-hole facilities (14%) used heating oil than 18-hole (9%) or 27+-hole facilities (10%). Average annual heating oil use differed significantly among 27+-hole (9,625 gallons), 18-hole (2,273 gallons) and 9-hole (1,532 gallons) facilities. Golf facilities with an annual maintenance budget greater than \$1,000,000 used significantly more heating oil than facilities with lower maintenance budgets. Maintenance budget had no significant effect on the percentage of facilities using heating oil.

Average use of heating oil within regions

The highest percentage of facilities using heating oil was in the Northeast region (44%) followed by the Transition region (6%). Survey participants within the Southwest region did not report any use of heating oil.

The highest average use of heating oil was in the Northeast region with 2,733 gallons (379 million Btu) per facility. Average use in the Transition region was 1,769 gallons (245 million Btu) (Figure 10, Table A3).

Total heating oil use

The estimated total use of heating oil for all U.S. golf facilities was 4.4 million gallons in 2008 (Tables A3, A4). The Northeast region used the greatest amount of heating oil at an estimated 2.8 million gallons in 2008. Less than 100,000 gallons of heating oil was consumed by facilities within the Pacific, Upper West/Mountain and Southeast region (Figure 11, Table A4).

Fuel for equipment and vehicles

Respondents were asked to indicate the amount of fuel (gasoline, diesel, propane, natural gas or other) used by vehicles associated with the operation of the facility. Approximately 99% of 18-hole facilities used gasoline and 97% used diesel in 2008. Gasoline and diesel were used more than any other fuels for equipment and vehicles. Data for propane, natural gas and biodiesel by number of holes, facility type, maintenance budget and agronomic region are not presented because the response rate/sample size for those materials was small. A small percentage of 18-hole facilities used

Total natural gas use

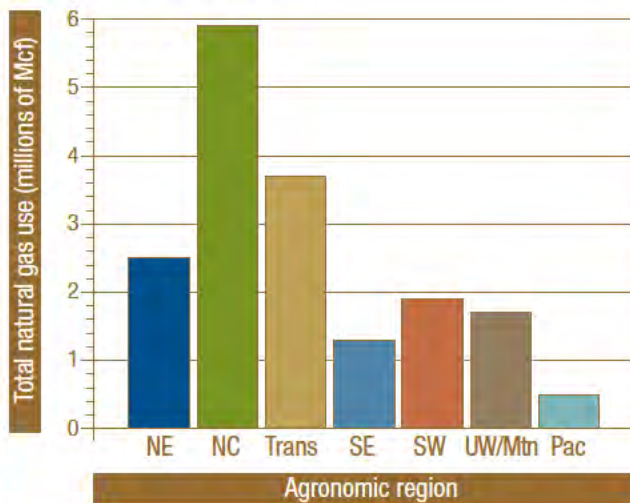


Figure 9. Total natural gas use in millions of Mcf at golf facilities by U.S. agronomic region in 2008.

Average heating oil use

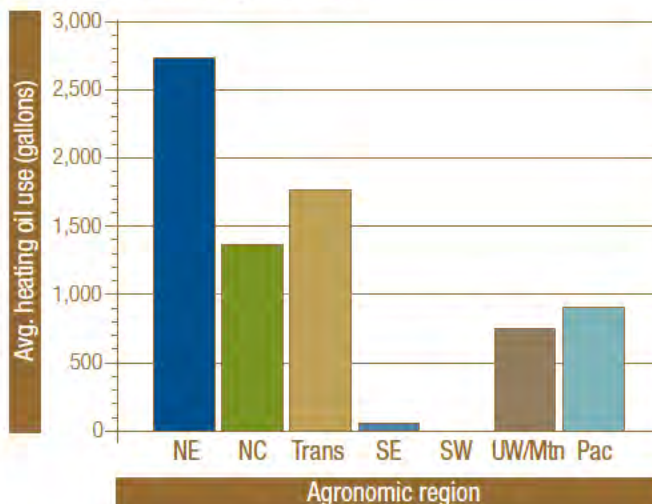


Figure 10. Average heating oil use in gallons at 18-hole facilities by U.S. agronomic region in 2008.

Total heating oil use

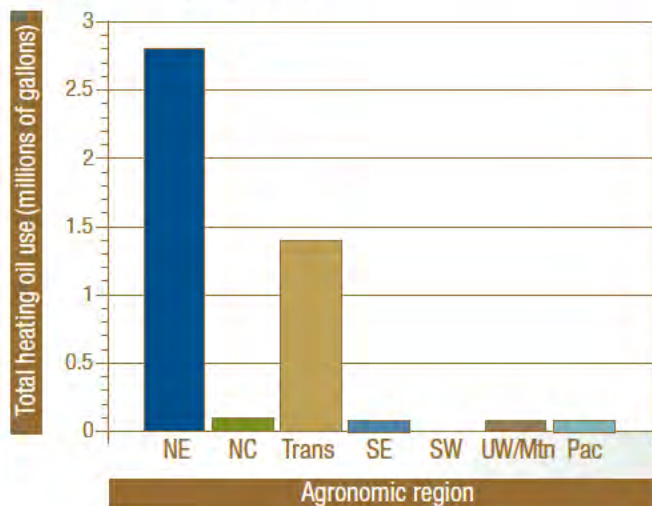


Figure 11. Total heating oil use in millions of gallons at golf facilities by U.S. agronomic region in 2008.

Gasoline and diesel use by budget

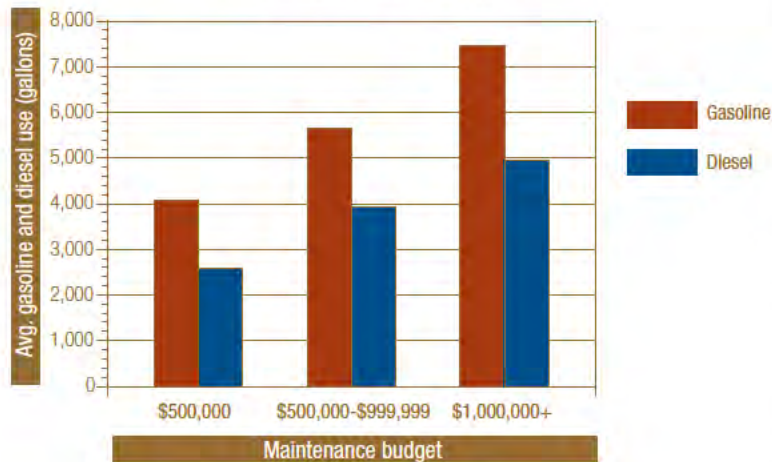


Figure 12. Gasoline and diesel use in gallons by 18-hole golf facilities in the U.S. by maintenance budget in 2008.

Average gasoline and diesel use

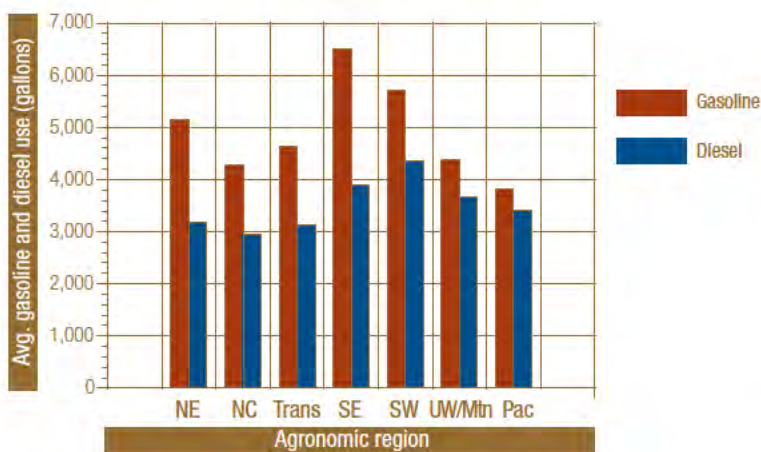


Figure 13. Average gasoline and diesel use in gallons at 18-hole facilities by U.S. agronomic region in 2008.

natural gas and propane for licensed/registered vehicles, facility power generation or other undetermined uses (Table A5).

The estimated total use of gasoline for all U.S. golf facilities was 77 million gallons. The estimated total use of diesel for all U.S. golf facilities was 50.4 million gallons (Table A4).

Forty-one percent of the average 18-hole golf facilities used gasoline blended with alcohol.

Gasoline consumption increased significantly with the number of holes: 27+-hole facilities consumed an average 11,713 gallons; 18-hole facilities consumed an average 5,192 gallons (645 million Btu); and 9-hole facilities consumed an average 1,703 gallons. Private facilities consumed significantly more gasoline (5,944 gallons) than public golf facilities (4,852 gallons).

Diesel consumption also increased significantly with the number of holes: 27+-hole facilities consumed an average 7,258 gallons; 18-hole facilities consumed an average 3,467 gallons (481 million Btu); and 9-hole facilities consumed an average 1,181 gallons. Private facilities consumed significantly more diesel (4,150 gallons) than public facilities (3,151 gallons).

The consumption of gasoline and diesel significantly increased as the maintenance budget increased (Figure 12).

Average use of gasoline and diesel fuel within regions

Gasoline. Golf facilities in the Southeast region used significantly more gasoline than any other region (6,507 gallons [808 million Btu] per facility). Golf facilities in the Pacific region consumed the least gasoline (3,808 gallons [473 million Btu] per facility) (Figure 13, Table A6).

Diesel. Golf facilities within the Southwest region used significantly more diesel fuel per facility than in any other region (4,346 gallons [603 million Btu]). Golf facilities in the North Central region used the least diesel fuel per facility (2,943 gallons [408 million Btu]) (Figure 13, Table A6).

Total use of gasoline and diesel fuel within regions

Total consumption per region was estimated based on the average amount of fuel used per facility and the number of facilities in each region. Gasoline and diesel use varied across agronomic regions in part to the different length of growing seasons, agronomic practices and number of facilities per region (Figure 14).

Golf facilities in the Southeast region consumed

the highest amount of gasoline at 21.7 million gallons. Golf facilities in the Pacific region used the least amount of gasoline at 2.3 million gallons. Golf facilities in the Southeast region consumed the highest amount of diesel fuel at 12.9 million gallons. The Pacific region's facilities used the least amount of diesel at 2.0 million gallons (Figure 14, Table A4).

Energy conservation practices

Survey respondents were asked whether they had written an energy conservation plan, had conducted an energy audit between 2004 and 2009, had certified any of their buildings through the Leadership in Energy and Environmental Design (LEED) program, or had instituted any physical or behavioral changes to conserve energy at the golf facility. The survey listed six specific physical or behavior changes for respondents to choose: heating and cooling system, indoor water system, golf course irrigation system, lighting, office equipment and computers, and golf course maintenance equipment.

In addition, respondents were asked if they had purchased green electricity or energy credits as part of a renewable energy program. Some electricity providers generate power through wind, solar or hydroelectric technologies, and they often offer options for customers to purchase power from these sources. Other programs are available where customers can purchase a credit for power that is generated from renewable sources. Respondents were also asked whether they generated their own power on site through renewable technology such as wind, solar, geothermal, waste biomass or hydroelectricity.

Written energy conservation plans and energy audits

Six percent of 18-hole golf facilities had a written energy conservation plan. Of those that had a plan, 30% were required to do so by a federal, state, local or tribal authority.

Fifteen percent of 18-hole golf facilities conducted an energy audit at their facility during the time period of 2004-2009.

The larger the maintenance budget or number of holes, the greater the likelihood of the golf facility's having a written plan or energy audit.

Eighteen-hole golf facilities in the Pacific (10%) region were more likely to have a written energy conservation plan than facilities in the other regions (Figure 15).

Total gasoline and diesel use

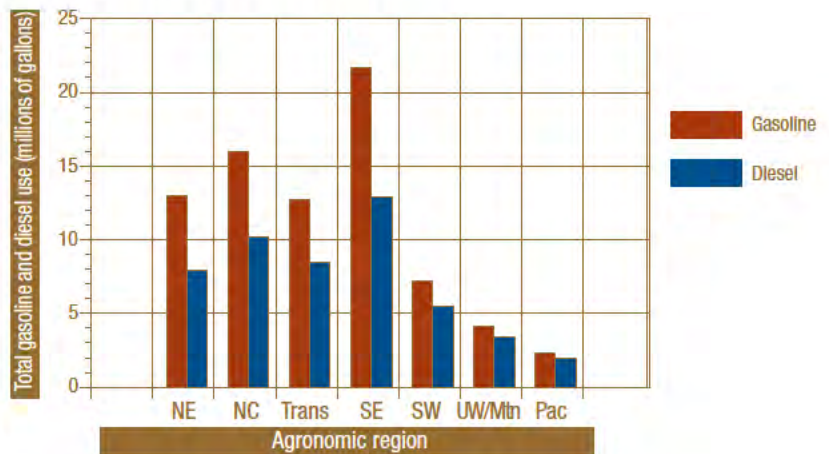


Figure 14. Total gasoline and diesel use in millions of gallons by golf facilities in U.S. agronomic regions in 2008.



Installing a solar power operating system is expected to significantly lower the electric bill at the Island CC in Plaquemine, La. Photo by David McCallum

Written energy conservation plans

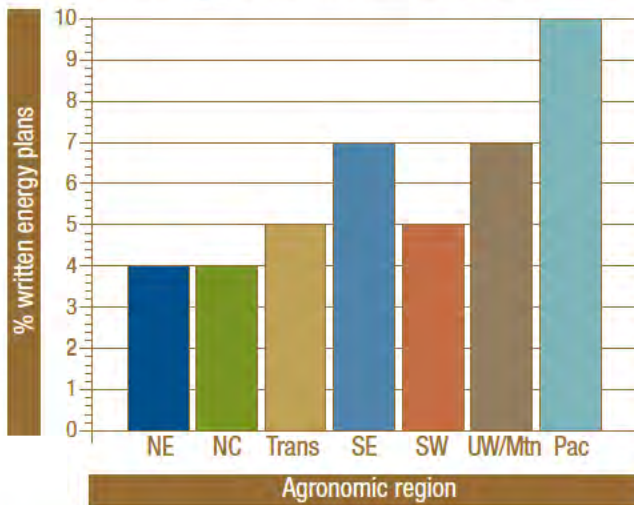


Figure 15. Percentage of written energy conservation plans for average 18-hole facilities in 2008 by U.S. agronomic region.

Energy audits

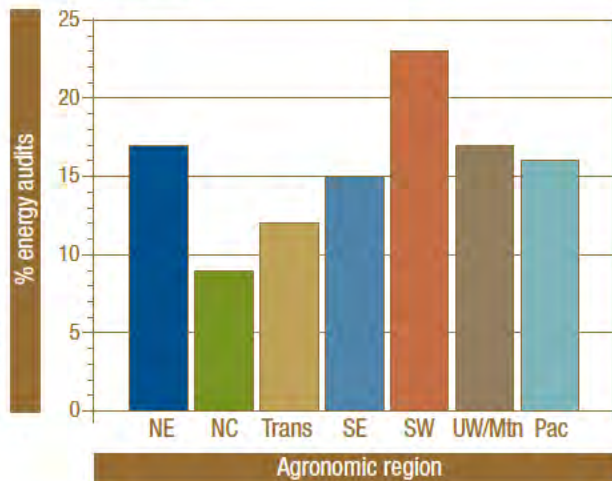


Figure 16. Percentage of energy audits for average 18-hole facilities in 2008 by U.S. agronomic region.



Country Club of Naples (Fla.) takes advantage of being in the Sunshine State by using solar-powered golf cars to conserve and reduce costs. Photo by Bill Davidson, CGCS

Eighteen-hole golf facilities in the Southwest had the highest percentage of energy audits, but were not significantly different from the Northeast (17%), Upper/West Mountain (17%) or the Pacific (16%) regions (Figure 16).

Behavioral, design, and other conservation changes

Three percent of 18-hole golf facilities had at least one building that was certified through LEED or a similar green building program.

Seventy-seven percent of 18-hole golf facilities had incorporated one or more behavioral changes to their procedures and practices to conserve energy. Examples of behavioral change include turning down thermostats in winter, replacing filters in a timely manner and charging equipment during non-peak hours.

Seventy-one percent of 18-hole golf facilities had incorporated one or more design, physical or mechanical energy conservation changes. Examples of design, physical or mechanical changes include the use of Energy Star-rated furnaces, programmable thermostats, efficient water heater, low-flow faucets, irrigation controller updates and T-8 lighting. Specific changes to enhance energy conservation were common in the heating and cooling system and the golf course irrigation system (Figure 17, Table A7).

Renewable energy use

Less than 5% of golf facilities purchased green electricity or energy credits. Thirty-five percent indicated that green electricity programs were not available. Where green electricity was available, the most common reason for not purchasing it was lack of awareness of the program. Fifty-six percent indicated that they were unaware of green electricity programs. Nine percent indicated that green electricity was too expensive. Five percent said that they had no interest in such programs, and 5% indicated that they did not believe these programs are truly "green."

The most common reason 18-hole facilities did not purchase energy credits was that they were unaware of energy credits within a renewable energy program. Eighty-three percent indicated they were unaware of energy credit programs, and 8% were not interested. Another 8% indicated that the programs are too expensive. Five percent indicated that other managers or owners make these decisions, and 1% percent indicated they purchase energy credits.

Changes to conserve energy

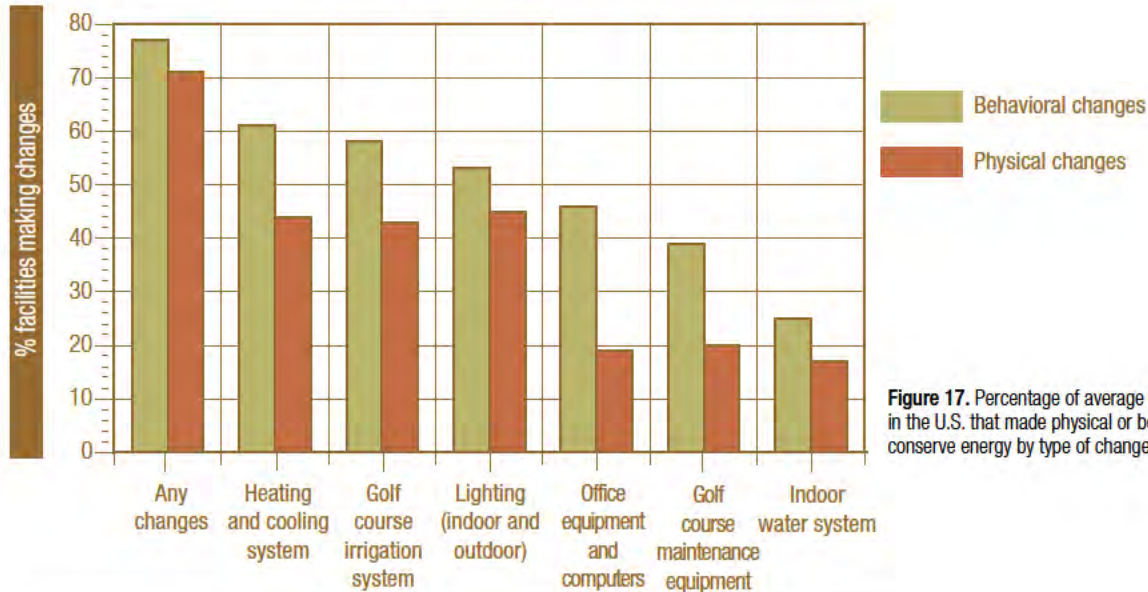


Figure 17. Percentage of average 18-hole golf facilities in the U.S. that made physical or behavioral changes to conserve energy by type of change.

Approximately 2% of facilities were generating power on-site with alternative or renewable resources such as solar or wind technologies. This accounts for 23 of the 18-hole golf facilities in the sample. Solar energy for electricity was the most common renewable energy (71%), followed by wind (16%), hydro (10%) and geothermal (9%).

Recommendations

These results provide an overall portrayal of golf facility energy use and establish a reference point for comparison with results from future surveys to monitor industry change over time. Additional national and regional research should be conducted to segregate the use of energy within different facets of the golf course facility, including irrigation pumping stations, maintenance buildings, equipment, specific turfgrass and landscape maintenance practices, clubhouse and amenities.

The following recommendations address areas of improvement for the golf course industry highlighted by the survey results:

- Golf facilities should routinely document energy use across all operations and identify opportunities for conservation.
- All golf facilities should conduct an energy audit.
- Using the results of the energy audit and doc-

At the time of this study, few golf facilities used energy from renewable sources or purchased green energy credits. According to the U.S. Energy Information Administration, only 11% of the total primary energy production in 2009 was from renewable energy sources and only 8% of the total energy consumed by end-users was from renewable energy (14). Golf facilities should strive to purchase energy from renewable sources when available.

umentation about energy use, all golf facilities should develop a written energy conservation plan and implement the plan.

- At the time of this study, few golf facilities used energy from renewable sources or purchased green energy credits. Golf facilities should strive to purchase energy from renewable sources when available.
- Few golf facilities generated energy from on-site sources, but this may be a viable option in the future. The land space and natural resources available on golf course properties could lend themselves to energy generation as technology becomes available and costs decrease.
- Additional national and regional research should be conducted to segregate the use of energy within different facets of the golf course facility, including irrigation pumping stations, main-



In 2008, all U.S. golf facilities used an estimated total of 77 million gallons of gasoline and 50.4 million gallons of diesel to operate equipment and vehicles. Photo by Montana Pritchard

tenance buildings, equipment, specific turfgrass and landscape maintenance practices, clubhouse and amenities.

Conclusions

The use of energy for all activities in society is of great interest worldwide. This report indicates that golf courses in the United States use energy from a variety of sources; primarily electricity, gasoline, diesel, natural gas, propane and heating oil. Information from this survey provides basic insight into how golf facilities consume energy and will be useful in a variety of ways. First, this data will allow the golf industry to document changes in energy use over time. This effort is the first attempt to estimate energy use on golf courses in the U.S., and it will allow subsequent surveys to track how use patterns and management practices change in the future. Second, golf course managers can use this information to compare their facility with similarly sized operations within their region and in other areas of the country. Next, the survey data will be helpful in comparing energy use in the golf industry with use in other sectors, particularly

other commercial, agricultural or turfgrass management operations. Finally, scientists will be able to use this information to refine carbon footprint calculations. Carbon calculators will be useful tools for golf course managers as they strive to understand energy use and carbon sequestration at their facilities.

Electrical consumption

The U.S. Energy Information Administration estimates that total electricity consumption in the U.S. was nearly 3,741 billion kwh in 2009. The major sectors using this electricity were residential (38%), commercial (37%), industrial (25%) and a small percentage for transportation, mostly for trains and electric cars (13). From these figures, total commercial use of electricity is approximately 1,384.7 billion total kwh.

Using the 2008 data from this energy use survey to compare golf facilities with the commercial sector shows that golf facilities accounted for approximately 0.5% of commercial electricity consumed. Although the percentage of energy used on golf courses is small compared to national totals, energy management, efficiency and conservation are important aspects of sustainable golf course operations. Many opportunities exist for golf facilities to conserve energy. Although few have done so, all golf facilities should conduct an energy audit and document energy use across all operations. This is a vital step in identifying options for conservation and cost savings.

Carbon calculators

Information from this survey will be helpful in refining carbon use calculations on golf courses. The use of various sources of energy can be directly related to a release of carbon as carbon dioxide into the atmosphere. Carbon calculators are used to create a balance sheet comparing the total amount of carbon expended through the use of various energy sources with the amount of carbon accumulated in plants or soil through natural processes including photosynthesis.

Carbon footprint calculators are available to the public in many forms for personal and business use. They are also being developed specifically for the golf industry and golf course managers who may find them useful for further examining their energy use, carbon sequestration capacity and conservation practices in the future.

Scientists are currently investigating the ability of turfgrasses grown on golf courses to sequester carbon into the soil for long-term storage (6). Information from this survey can be useful in refining the energy use component of carbon footprint calculations. Researchers at the University of California-Irvine estimated fuel use on a per-acre basis for the maintenance of a city-owned park in Irvine, Calif. (10,11). According to that research, an average 18-hole golf course uses approximately 30% more gasoline and diesel fuel per acre on a national basis than the Irvine city park. This difference is likely due to the higher maintenance requirements of specific areas of the golf course, more diverse equipment types, different mowing heights and patterns, maintenance of other landscape plants, and other agronomic practices on golf courses.

Future surveys

This survey was designed to investigate energy use patterns for the entire facility including the maintenance facility, irrigation pumping station, clubhouse and amenities, such as swimming pools. Future surveys should be designed to further segregate these segments of the facility. Specifically identifying energy use associated with irrigation, turf maintenance, buildings, clubhouse operations and other amenities will be helpful for managers who seek to conserve energy. Further, understanding the energy associated with turfgrass management will provide more insight for carbon calculations and could lead to a better awareness of the amount of energy required to meet the market demands of golfers.

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Appendix

Superintendents and surveys

	Golf facility superintendents		Completed surveys [†]			Margin of error (%)
	No. [‡]	% of total no.	No. rec'd	% of total	Response rate (%) [§]	
Region						
Northeast	2,770	17.0	220	14.1	7.9	5.3
North Central	4,094	25.1	336	21.5	8.2	4.3
Transition	2,993	18.4	274	17.5	9.2	4.7
Southeast	3,373	20.7	341	21.8	10.1	4.2
Southwest	1,288	7.9	146	9.3	11.3	6.4
Upper West/Mountain	1,083	6.7	160	10.2	14.8	6.0
Pacific	684	4.2	86	5.5	12.6	8.3
Type						
Daily fee	9,024	55.4	679	43.5	7.5	3.0
Municipal	2,444	15.0	277	17.7	11.3	4.7
Private	4,817	29.6	606	38.8	12.6	3.1
No. of holes						
9	3,948	24.2	188	12.0	4.8	5.9
18	10,286	63.2	1,106	70.8	10.8	2.3
27+	2,051	12.6	269	17.2	13.1	4.7

[†]The total number of completed surveys was 1,563.

[‡]The total number of golf facility superintendents was 16,285.

[§]Response rate is the percentage of the total number of completed surveys received for each region, course type and course classification (9, 18, or 27+ holes).

^{||}At 90% confidence interval.

Table A1. Number of golf facility superintendents, percent of total number of golf facility superintendents, number of completed surveys received, percent of the total completed surveys received, response rate within the category, and margin of error by agronomic region, course type, and number of holes.

Total Btu on U.S. golf courses

Energy source	Millions of Btu [†]							
	US	NE [‡]	NC	Trans	SE	SW	UW/Mtn	Pac
Electricity	1,529	797	1,041	1,441	1,957	2,781	1,598	1,196
Propane	231	369	173	208	270	93	218	195
Natural gas	2,933	3,007	2,642	3,862	2,154	4,285	3,018	1,837
Heating oil	315	379	189	245	7	0	104	126
Gasoline	645	639	532	574	808	710	543	473
Diesel	481	441	408	436	539	603	507	472
Total	6,134	5,632	4,985	6,766	5,735	8,472	5,988	4,299

[†]Btu are British Thermal Units, values are expressed as millions and conversions: 1 kwh of electricity = 3,412 Btu; 1 cubic foot of natural gas = 1,027 Btu; 1 gallon of heating oil = 138,690 Btu; and 1 gallon of propane = 91,333 Btu; from the U.S. Energy Information Administration, www.eia.gov (12).

[‡]Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

Table A2. Total Btu for average 18-hole facilities in the U.S. and its agronomic regions.

Electricity, propane, natural gas, and heating oil

Energy consumption	Agronomic regions [†]							
	US	NE	NC	Trans	SE	SW	UW/Mtn	Pac
Electricity								
Kilowatt-hours	448,123	233,614d [‡]	305,052cd	422,278bc	573,650b	815,105a	468,364b	350,568bc
Btu [§]	1,529	797	1,041	1,441	1,957	2,781	1,598	1,196
Propane								
Gallons	2,528	4,040a	1,894b	2,281b	2,960ab	1,023c	2,390ab	2,137b
Btu	231	369	173	208	270	93	218	195
% using	45	61a	45b	50ab	35c	34c	42bc	50ab
Natural gas								
Mcf	2,856	2,928ab	2,573b	3,731ab	2,097c	4,172a	2,939ab	1,789c
Btu	2,933	3,007	2,642	3,832	2,154	4,285	3,018	1,837
% using	41	35b	64a	37b	19c	38b	63a	48b
Heating oil								
Gallons	2,273	2,733a	1,364a	1,769a	51c	0c	750b	907b
Btu	315	379	189	245	7	0	104	126
% using	9	44a	3cd	6b	2cd	0d	2cd	4bc

[†]Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

[‡]Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

[§]Btu are British Thermal Units, values are expressed as millions and conversions: 1 kwh of electricity = 3,412 Btu; 1 cubic foot of natural gas = 1,027 Btu; 1 gallon of heating oil = 138,690 Btu; and 1 gallon of propane = 91,333 Btu; from the U.S. Energy Information Administration, www.eia.gov (12).

Table A3. Average consumption of electricity, propane, natural gas, and heating oil and the percentage using propane, natural gas and heating oil at average 18-hole golf facilities in the U.S. and its agronomic regions for 2008.

Estimated energy use in 2008

Energy source	Agronomic regions [†]							
	US	NE	NC	Trans	SE	SW	UW/Mtn	Pac
Electricity[‡]	6,714	614	1,175	1,208	1,970	1,063	463	221
Btu [§]	22,908	2,095	4,009	4,122	6,722	3,627	1,580	754
Propane	17.0	5.9	3.0	3.0	3.2	0.4	0.9	0.6
Btu	1,553	538	274	274	292	36	82	55
Natural gas[#]	17.5	2.5	5.9	3.7	1.3	1.9	1.7	0.5
Btu	17,973	2,568	6,059	3,800	1,335	1,951	1,746	513
Heating oil	4.4	2.8	0.1	1.4	<0.1	0	<0.1	<0.1
Btu	610	388	14	194	<14	0	<14	<14
Gasoline	77.0	13.0	16.0	12.7	21.7	7.2	4.1	2.3
Btu	9,566	1,615	2,000	1,578	2,696	895	509	286
Diesel	50.4	7.9	10.2	8.5	12.9	5.5	3.4	2.0
Btu	6,990	1,096	1,415	1,179	1,789	763	472	277

[†]Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

[‡]Estimated electricity use is expressed as millions of kilowatt-hours (kwh).

[§]Btu are British Thermal Units, values are expressed as billions, and conversions: 1 kwh of electricity = 3,412 Btu; 1 cubic foot of natural gas = 1,027 Btu; 1 gallon of heating oil = 138,690 Btu; 1 gallon of propane = 91,333 Btu; 1 gallon of gasoline = 124,238 Btu; and 1 gallon of diesel = 138,690 Btu; from the U.S. Energy Information Administration, www.eia.gov (12).

^{||}Estimated propane, heating oil, gasoline and diesel use are expressed as millions of gallons.

[#]Estimated natural gas use is expressed as millions of Mcf.

Table A4. Estimated energy use in 2008 for all golf facilities in the U.S. and its agronomic regions.

Fuel use in equipment and vehicles

Fuel type	Use by 18-hole golf facilities (%)	Avg. amount used (gallons; Mcf for natural gas) [†]	% used		
			Golf course maintenance equipment [‡]	Golf cars	All other uses [§]
Gasoline (all blends)	99	5,192	76	16	8
Diesel (on/off road)	97	3,467	98	0	2
Propane	16	2,070	21	0	79
Natural gas	5	2,145	6	0	94
Biodiesel (all blends)	4	2,528	90	6	4

[†]Natural gas use in 1,000 cubic feet (Mcf).

[‡]Mowers, portable pumps, portable generators, utility vehicles and tractors.

[§]Licensed/registered vehicles, facility power generation and other undetermined uses.

^{||}Fewer than 50 responses.

Table A5. Fuel usage in 2008 for equipment and vehicles at average 18-hole golf facilities in the U.S.

Gasoline and diesel

Fuel consumption	Agronomic regions [†]							
	US	NE	NC	Trans	SE	SW	UW/Mtn	Pac
Gasoline								
Gallons	5,192	5,147bc [‡]	4,285cde	4,622cd	6,507a	5,717ab	4,374cde	3,808e
Btu [§]	645	639	532	574	808	710	543	473
Diesel								
Gallons	3,467	3,181cd	2,943d	3,144d	3,889ab	4,346a	3,659bc	3,401bcd
Btu	481	441	408	436	539	603	507	472

[†]Agronomic regions: NE, Northeast; NC, North Central; Trans, Transition; SE, Southeast; SW, Southwest; UW/Mtn, Upper West/Mountain; Pac, Pacific.

[‡]Within a row, values followed by the same letter are not significantly different from one another. Letters denote significance at the 90% confidence level.

[§]Btu are British Thermal Units, values are expressed as millions and conversions: 1 gallon of gasoline = 124,238 Btu; and 1 gallon of diesel = 138,690 Btu; from the U.S. Energy Information Administration, www.eia.gov (12).

Table A6. Average consumption of gasoline and diesel in 2008 for equipment and vehicles at average 18-hole golf facilities in the U.S. and its agronomic regions.

Changes made to conserve energy

Change	Physical [†]	Behavioral [‡]
	% of golf courses	
Heating and cooling system	44	61
Golf course irrigation system	43	58
Lighting (indoor and outdoor)	45	53
Office equipment and computers	19	46
Golf course maintenance equipment	20	39
Indoor water system	17	25

[†]Examples of physical/mechanical/design changes include: Energy Star-rated furnace, programmable thermostats, efficient water heater, low-flow faucets, irrigation controller, T-8 lighting.

[‡]Examples of behavior/procedure/practice changes include: turning down thermostats in winter, replacing filters in timely manner, operating during non-peak hours.

Table A7. Physical and behavioral changes made to conserve energy for the average 18-hole golf facility in the U.S.



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