MINNESOTA DEPARTMENT OF COMMERCE
DIVISION OF ENERGY RESOURCES

Hotel Energy Efficiency

Market Potential for Minnesota's Hospitality Sector

Conservation Applied Research & Development (CARD)
FINAL REPORT

Prepared for: Minnesota Department of Commerce, Division of Energy Resources

Prepared by: Michaels Energy

MichaelsEnergy

COMM-20130501-73299 | June 2015

Prepared by:

Bryce Dvorak
Nancy Kelly
Carl Samuelson
Aaron Conger

Michaels Energy
400 Main Street, Suite 200
La Crosse, WI 54601
608) 785-1900
www.michaelsenergy.com
Project Contact: Nancy Kelly

© 2015 Michaels Energy. All rights reserved.

Contract Number: 73299

Prepared for Minnesota Department of Commerce, Division of Energy Resources

Mike Rothman, Commissioner, Department of Commerce

Bill Grant, Deputy Commissioner, Department of Commerce, Division of Energy Resources

Laura Silver, Project Manager
651-539-1873
laura.silver@state.mn.us

ACKNOWLEDGEMENTS

This project was supported in part (or in whole) by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development (CARD) program, which is funded by Minnesota ratepayers.

The authors would like to thank: the University of Minnesota Tourism Center, the Clean Energy Resource Teams, the Minnesota Technical Assistance Program, vendors who supported this project with information and time (especially Premier Lighting, EcoLab, HeatSavr, Amana, and Pentair), the hotels and their management that participated in the study (in particular Carlson Companies and Three River Hospitality for their early support), and the utilities who supported this project with rebates, recruitment, and attention to our questions (in particular CenterPoint Energy, Ottertail Power, Xcel Energy, and Dakota Electric).

DISCLAIMER

This report does not necessarily represent the view(s), opinion(s), or position(s) of the Minnesota Department of Commerce (Commerce), its employees or the State of Minnesota (State). When applicable, the State will evaluate the results of this research for inclusion in Conservation Improvement Program (CIP) portfolios and communicate its recommendations in separate document(s).

Commerce, the State, its employees, contractors, subcontractors, project participants, the organizations listed herein, or any person on behalf of any of the organizations mentioned herein make no warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this document. Furthermore, the aforementioned parties assume no liability for the information in this report with respect to the use of, or damages resulting from the use of, any information, apparatus, method, or process disclosed in this document; nor does any party represent that the use of this information will not infringe upon privately owned rights.

Abstract

Michaels Energy piloted an energy efficiency program for 38 hotels in Minnesota during 2014-2015. Components of this pilot, discussed in this research report, include: 1) use of ENERGY STAR portfolio manager to benchmark and certify high performers, 2) field audits and documentation of energy conservation measures, 3) implementation support by contractor partners, 4) surveying of hotel guests regarding the impact of energy efficiency on comfort, and 5) field testing of new technologies, in particular a liquid pool cover. Results show that hotels have significant opportunities to reduce their energy usage and guests are unlikely to notice the measures. Excellent cost savings are available and measure paybacks are quite attractive (frequently 2 years or less), especially when non-energy benefits such as water and maintenance savings are included in the calculation. Recommendations for utilities, hotels, contractors, and regulators to better serve this market sector are shared in this report.

Table of Contents

List of Figures

List of Tables

This page intentionally left blank

Executive Summary

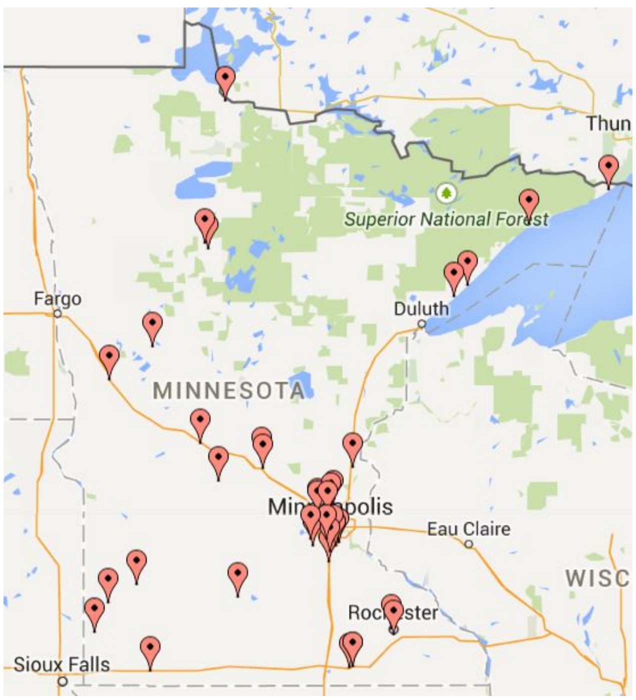
Hotels use energy in diverse and intensive ways, driven by demands of comfort, cleanliness, safety, and recreation. Through field assessments of 38 hotels, this research provides an exploration of energy use in the hotel sector. Findings from this study should be used to inform utility conservation program design and incentive offerings, technical reference manual development, energy audit recommendations, and to encourage end users to adopt efficient technology.

Specific elements of the pilot program include:

1) ENERGY STAR benchmarking and certification
2) Field audits, measure identification and energy analysis
3) Implementation support by contractor partners
4) Surveying of hotel guests regarding the comfort and energy efficiency
5) Innovative measure exploration, including pilot testing of a liquid pool cover

Market Characterization and Pilot Design

Figure 1: Map of Participating Hotels



There are approximately 1,250 hotels in Minnesota (ReferenceUSA). Hotels included in this study ranged from an eight room hotel in a rural town in southwest Minnesota to an extremely large hotel near the airport in Bloomington, Minnesota. However, there was a selection bias toward the mid-scale hotel, with 50-150 guest rooms, a pool and limited food service. By focusing the study away from the extremes, the objective was to develop more useful results describing typical opportunities. During participant recruitment, attention was paid to achieving geographic and brand distribution; see Figure 1 for a map of the participating hotels. Twenty-one hotel brands participated.

The knowledge of how hotels use energy (their "end use"), helps utilities identify the biggest opportunities and prioritize programs. The University of Minnesota Technical Assistance Program's (MnTAP) 2011 study on hotel energy use in Minnesota calculated end use extensively in 27 hotel properties. To update and confirm that research, this study's authors calculated end use for a smaller sample (6 hotels). End use diagrams are shown in Figure 2 and Figure 3.

Figure 2: Electricity End Use

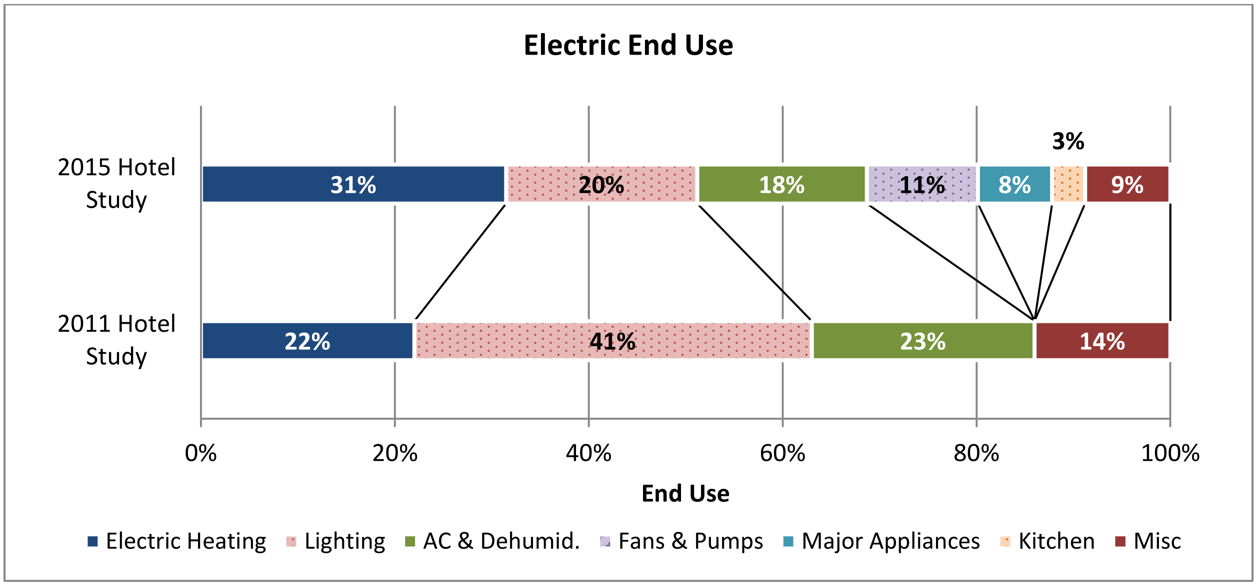
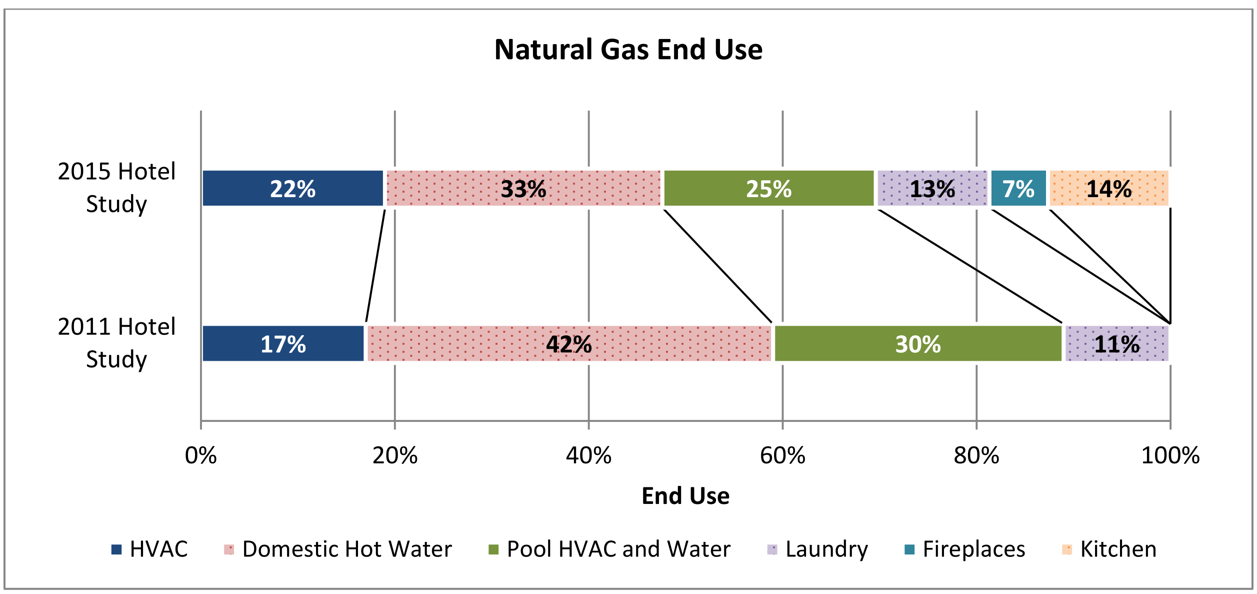


Figure 3: Gas End Use

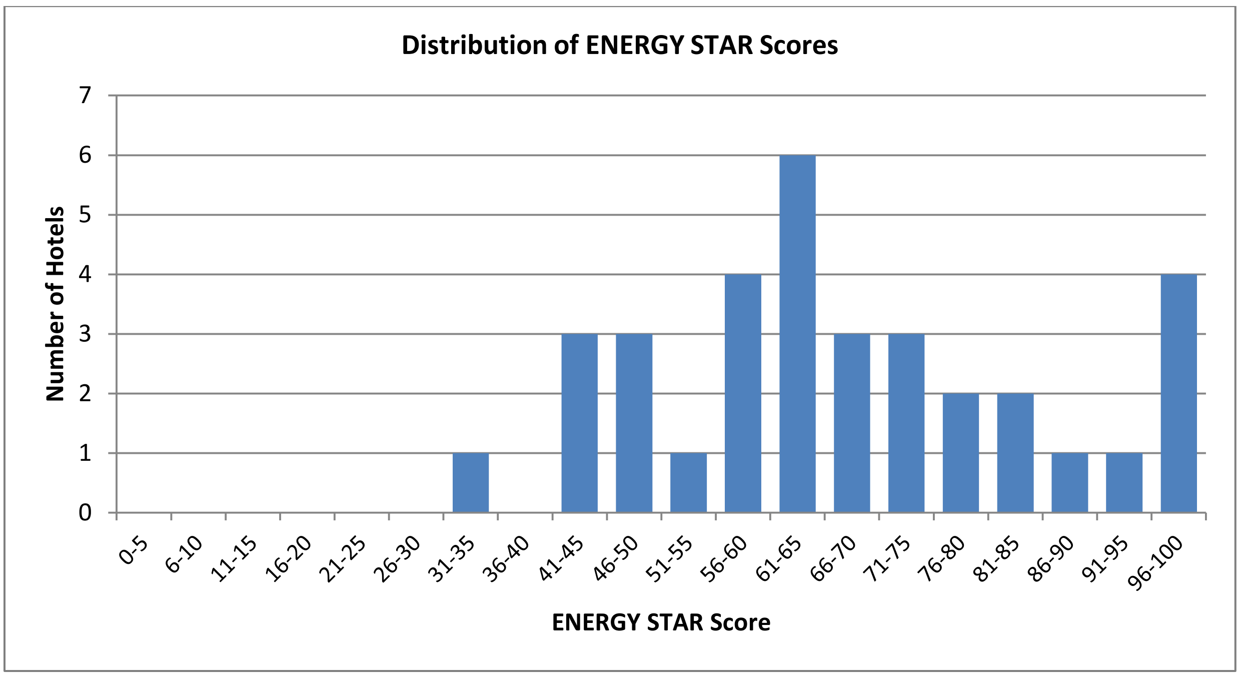


The data between the two studies compares favorably, although there are some differences. One such difference is that more electricity was allocated to lighting in the MnTAP study. This is most likely due to improved efficiency in lighting as hotels moved away from T12 and incandescent lighting.

ENERGY STAR

ENERGY STAR's Portfolio Manager was used to benchmark each participating hotel. The intent of using this tool, in addition to providing a comparison benchmark for the hotel, was to identify the top performing hotels and the poorest performing hotels. For the top portion (those who scored above 75), the team would assist those hotels to become certified as an ENERGY STAR building. For the poorest performers (those below 25), the team would offer additional support and assistance. The actual distribution of hotel ENERGY STAR scores is shown in Figure 4.

Figure 4: Hotel ENERGY STAR Score Distribution



An ENERGY STAR score of 50 designates a hotel is in the 50th percentile in terms of energy performance, so the expected distribution would be flat. The median score of the pilot hotel group in this study was 64.5, and the mean score was 68, with no hotels scoring below 25. According to this data, in Minnesota, as in Lake Wobegon, it's possible for nearly all the hotels to be above average. During this study, the team aided one hotel in obtaining ENERGY STAR certification and hotels that scored below 50 were given additional attention and support.

Eight of the hotels included in this graph have occupancy rates below 55%, a factor which appears to heavily influence the benchmark. ENERGY STAR recognizes the impact of low occupancy and requires that a hotel have an occupancy rate above 55% in order to qualify for ENERGY STAR building certification. Of those eight, six would have qualified if not for the occupancy requirement, and all four of the hotels that scored between 96 and 100 had low occupancy rates. This high scoring of low-occupancy hotels results in misleading benchmarks and compromises the ability for ENERGY STAR to be used as a screening tool.

Study Results

Guest Comfort Survey

For hotel management, guest comfort trumps energy efficiency; however, what is less clear is whether energy efficiency actually impacts the quality of a guest's stay. To explore this relationship, the project team contracted University of Minnesota Tourism Center researchers to design and conduct a survey of hotel guests. The survey responses were analyzed for statistical significance, and compared with a set of technical data gathered in the field during the audits. A full report of the findings of this research can be found in Appendix 1. Key conclusions from this effort include that guest's primary concerns are room cleanliness and bed comfort, followed by quietness and friendly staff. In reflecting on the comfort of their stay, very few of the guests' responses aligned with technical data in a way that would be helpful in making program recommendations. On the whole, hotel managers can feel comfortable investing in energy efficiency, because it's unlikely that guests will notice positively or negatively.

Recommended Measures

In a business environment, energy saving measures need to be justified with energy savings or other cost savings such as reductions in water use or maintenance. The project team only presented measures that had a simple payback of less than 10 years to hotel participants. Each measure recommended to a hotel was tracked and aggregated to describe the average impact of each measure and how deep the market penetration reached. Table 1 lists the opportunities that were frequently identified (40% or more of the hotels audited needed the measure). Measure costs of all the hotels in need of that measure were averaged. For example, 42% of the hotels needed to replace PTACs, the number of units needed in each hotel varied, but on average the incremental cost of upgrading to heat pumps was $6,000. Note that the payback was calculated after the utility rebate and included annual energy, water, and maintenance savings. This chart accounts for variation in utility rebate amount and variation in utility cost. When measures were recommended at the end of equipment life, incremental cost was used to calculate payback. Finally, note that for several measures, non-energy savings constituted more than 50% of the savings. Inclusion of these ancillary benefits can greatly improve a measure's outlook.

Some of the strongest measures identified in this sector include LED lighting installation, use of low temperature laundry products, replacing packaged terminal air conditioners (PTACs) with heat pumps (PTHPs), and installing a liquid pool cover. Replacing PTACs with heat pumps is an excellent measure for hotels that need it. However, unexpectedly, heat pump penetration is already quite high. 42% of hotels use heat pumps only. 20% use PTACs alone, while 28% use a combination of the two. The remaining 10% of hotels are heated and cooled in some other way.

Table 1: Energy Savings Measures

Energy Saving Measure	% of Hotels in need of Measure	Average Measure Cost ($)	Average Electrical Savings (kWh)	Average Monthly Demand Savings (kW)	Average Gas Savings (therms)	Average Annual Energy Savings ($)	Average Non-Energy Savings ($)	Average Utility Rebate ($)	Average Payback (Years)
Replace Exterior Lights with LED Fixtures	92%	$14,000	27,000	-	-	$1,700	$740	$2,200	4.8
Retrofit T8 and T12 Fixtures with LED Tubular Lamps	92%	$6,600	12,000	2.3	-	$1,100	$330	$1,500	3.9
Replace Pool Area Lighting with LED Lamps	74%	$3,500	11,000	1.7	-	$940	$340	$470	2.3
Replace Common Area Lights with LED Lamps	76%	$3,900	17,000	2.5	-	$1,500	$1,500	$1,400	0.9
Install Occupancy Sensors on Lighting in Public Spaces	74%	$730	3,400	0.1	-	$260	$-	$130	3.0
Replace PTACs with Heat Pump Units	42%	$6,000*	54,000	3.5	-	$4,200	$-	$4,800	0.3
Install Liquid Pool Cover	79%	$920	2,100	0.1	690	$740	$30	$-	1.6
Install Efficient Showerheads in Guestrooms	84%	$5,700	-	-	710	$640	$690	$380	4.6
Install Efficient Faucet Aerators in Guestrooms	92%	$600	-	-	140	$120	$190	$70	2.4
Replace Standard Water Heaters with High Efficiency Units	66%	$5,800*	-	-	840	$690	$-	$1,000	7.0
Implement Low Temperature Laundry System	82%	$1,000*	-	-	1,100	$1,000	$1,100	$-	0.5
Install Occupancy Controller for Vending Machines	66%	$590	2,600	-	-	$170	$-	$120	2.9
TOTALS		**$49,340**	**129,100**	**10.2**	**3480**	**$13,060**	**4920**	**$12,070**	**2.1**

*Incremental cost

Liquid Pool Cover

Physical pool covers provide well documented energy and water savings; however, they are labor intensive and rarely installed. An alternative technology, a liquid pool cover, was evaluated at four hotel test sites during this research. To form a liquid pool cover, an alcohol based chemical is added in small daily amounts to the pool. This chemical, which is lighter than water, floats to the top of the pool forming a layer which inhibits evaporation. Safety testing has been performed on the product and none of the test sites registered any bather complaints.

Liquid pool covers were determined to be about 68% as effective as a solid pool cover and a typical hotel could save $700-$1,200 per year. Since the equipment required is only a standard feed pump and the chemicals are readily available for purchase, any pool supply/maintenance company could install the liquid pool cover. Even with the expense of a feed pump this technology may have less than a one year payback, which could present a challenge to some utility cost-benefit calculations. This technology is especially appropriate for the hotel sector since they have long "open swim" hours, but infrequent guest use on weekdays. A solid pool cover would be removed most of the day, but a liquid pool cover can form whenever the pool surface is still.

Program Design and Recommendations

An energy efficiency program that could reach 25% of Minnesota's hotels would have an impact of nearly 27 million kWh and 840,000 therms annually, which is a total cost savings of $4.1 million dollars for hotels. Minnesota has a total hotel population of 1,250 hotels. Reaching all of them with a program would be unrealistic, so 25% was used as a conservative estimate. Total savings, shown in Table 2, are based on the expected savings, on average, for each property. The expected savings are weighted to account for the likelihood any given measure would or would not be required in a specific property.

Table 2: Minnesota Savings Potential

Savings Potential		Electrical Savings (kWh)	Monthly Demand Savings (kW)	Gas Savings (therms)	Annual Energy Savings ($)	Non-Energy Savings ($)
Weighted Single-Property Savings		85,600	6.9	2,700	$9,000	$4,100
MN Savings Potential	10% Impact 125 Hotels	10,700,000	860	340,000	$1,100,000	$510,000
	25% Impact 310 Hotels	26,800,000	2,200	840,000	$2,800,000	$1,300,000
	50% Impact 625 Hotels	53,500,000	4,300	1,700,000	$5,600,000	$2,600,000

Program design elements worth consideration include energy audits, accommodation of brand standards, partnerships with contractors, and rebates. High energy use, combined with complicated end-uses, pools in particular, results in a small business sector that merits a professional audit of the facility. The resulting report would also help hotel management justify recommendations in their budget. If pre-screening participants for savings potential is a desired strategy for insuring the cost-effectiveness of audits, use total dollars spent on energy or total number of rooms instead of ENERGY STAR.

Hotel managers navigate a three-legged management structure: the hotel owner, a management company, and a brand standard. All three parties have the potential to influence energy efficiency. For instance, some brands have been using their standards to implement greening programs. Utilities should seek to become a strategic partner for any hotel that is required to participate in an energy-oriented brand standard program.

Partnering with contractors was another successful aspect of this study that should be considered in program design. By involving a contractor in the auditing process, the hotels were left with improved cost estimates for the work they were considering and more up-to-date information about the technology being considered (typically lighting). There may be regulatory barriers to creating such partnerships, but whenever possible pursue the relationship. Hotels ultimately benefited from the convenience.

Finally, rebates need to be more fully utilized in this sector. Rebates are utilities' primary tool for driving implementation and market penetration. Many of the participating hotels expressed that they were unaware rebates existed for technologies being considered. LED lighting was the technology for which hotels and their contractors most actively sought rebates. Rebates for heat pump upgrades were the most generous. On average, rebates for PTHP units equaled the incremental cost but many hotels were unaware of the rebate. Another opportunity for rebate growth is domestic hot water heaters which were rebated less generously than many other technologies. Finally, utilities have an opportunity to rebate consumable products such as the liquid pool cover and low-temperature laundry products. The energy savings for those products are real, but customers are still wary. A utility rebate would serve as an endorsement that these products do save energy.

Introduction/Background

Hotels use energy in diverse and intensive ways, driven by demands of comfort, cleanliness, safety, and recreation. This research aims to document the uses and opportunities for efficiency in the hotel sector. In addition to the market assessment, this study also seeks to understand new technologies available and the demands guest comfort place on decision makers. Finally, this research will discuss ways to package these elements into a program that a utility could offer its hotel customers.

This research effort drew on past research done in the state of Minnesota and on program examples from around the country. In addition, a number of national and international hotel chains are headquartered in Minnesota, so their experience was sought to contribute to this research. Finally, new research partnerships were created with the University of Minnesota Tourism Center researchers, and with vendors and product suppliers.

There are approximately 1,250 hotels in Minnesota (ReferenceUSA). Hotels included in this study ranged from an eight room hotel in a rural town in southwest Minnesota to an extremely large hotel near the airport in Bloomington, Minnesota. However, there was a selection bias toward the mid-scale hotel, with 50-150 guest rooms, a pool and limited food service. By focusing the study away from the extremes, the hope was to develop more useful results describing typical opportunities.

Literature Review

Academic Literature

An extensive review of academic literature, conducted by the University of Minnesota Tourism Center research team, can be found in Appendix 1 as a part of the guest comfort survey report. The literature reviewed focused on the hotel guest experience and in particular sought to determine amenities of primary concern to guests and the value of sustainability and "going green" to both guests and hoteliers. It appears that to date, few studies have focused narrowly on establishing links between guest comfort, as a facet of customer satisfaction, and energy efficiency, as a facet of hotel sustainability.

The literature reveals that guests prioritize cleanliness, quietness and friendly service above other amenities when evaluating their stay (Barsky, 1992; Cadotte, 1988). Guests do not differentiate when they stay in a room with an energy efficient television or lighting upgrade (Susskind, 2011). Additionally, in a study that grouped guests by preference for green lodging, the group with the strongest preference for green lodging cited price savings and improved environmental quality as the primary benefits of choosing a green option (Barber, 2014).

From hotel management's perspective, sustainability improvements are regarded as imperative (Tierney, 2011). However, one study documented that management was often unaware of the economic benefits of sustainability measures, which presented a barrier to implementation (Zhang, 2012). In a Minnesota-specific study exploring the benefit of a "green hotel" certification program for the state, it was determined that such a program would be too expensive and time consuming. However, greater promotion and awareness of hotels using green practices would be beneficial for the state (Explore Minnesota Tourism, 2008).

Technical Studies and Technology Review

ENERGY STAR provides foundational background information on hotel energy use and opportunities. Energy costs represent the second greatest portion of annual operating costs, after labor costs. Hotels can find significant cost and maintenance savings by implementing energy efficiency measures (ENERGY STAR, 2007). Lighting, plug load, air distribution systems, and heating and cooling systems are identified as opportunities for energy efficiency upgrades. In particular, hotels are encouraged to consider benefits in areas such as maintenance, guest comfort, security, air quality, and sound reduction as valuable ancillary benefits to energy efficiency improvements (ENERGY STAR, 2007).

In Minnesota, University of Minnesota's Minnesota Technical Assistance Program (MnTAP) conducted a study in 2011 of hotel properties. The study provides data for 27 hotels including their energy intensity per square foot and occupied room, and potential savings estimates. The average hotel, according to MnTAP's study, spends approximately $95,000 on energy annually, using approximately 900,000 kWh and 30,000 therms. Unlike many commercial building sectors, hotels use electricity and gas in approximately even amounts, making gas savings opportunities significant in this sector. The MnTAP study estimates that overall, the participating hotels have a savings potential of 27% annually (MnTAP, University of Minnesota, 2011).

Additional information for this study was gained by contacting suppliers of some hotel-specific technologies. Vendors consulted include: Ecolab (low-temp laundry); Premier Lighting (LED lighting); HeatSavr and Horizon Pool Supply (liquid pool cover); InnCom and Telkonet (guest room occupancy systems); Rinnai (water heaters); Pentair and Blue Fin Pool and Spa (variable speed pool pumps); and Amana (package terminal heat pumps and guest room occupancy systems).

Utility Programs

There are very few utility programs that target the lodging sector. A national review of utility programs conducted by E Source on behalf of the project team, revealed that nationwide only 4 of 3,000 utility programs target the lodging sector. None of these targeted programs exist in Minnesota and only two programs, both offered by California utilities, are providing a comprehensive program (more than just targeted rebates).

One program, provided by a third party firm on behalf of both Southern California Edison and San Diego Gas & Electric, provides additional support and solutions specific to the hotel sector. The project team interviewed the program manager to better understand the program offering. The program, called Lodging Energy Efficiency Program, offers free turn-key support including an energy audit, incentive payments, assistance with contractor selection, savings validation, and on-bill financing. Savings, according to E Source's DSM Insights tool for SoCal Edison were 2.25 Million kWh in 2013 at a cost of $0.47 per kWh saved.

Pacific Gas & Electric (PG&E) offers an alternative program called Lodging Savers. . This program offers a similar suite of services, but includes a direct-install package of measures for hotels. Not all of the direct-install measures are free, but many are. The list of measures comprehensively covers the hotel opportunity list including: lighting, guest room energy management systems, packaged terminal heat pumps, vending machine controllers, and refrigeration repair and controls. The savings for this program in 2013 were 7.47 million kWh at a cost of $0.39 per kWh saved.

Some utilities not offering a comprehensive program are offering rebates that target key technologies. One such technology is the guest room energy management systems (or GREMS). According to DSIREusa.org, prescriptive rebates for GREMS are available from 10 Minnesota utilities, all of them municipals and most of them part of the Minnesota Municipal Utility Association. It's likely this is a general offering, not reflective of the municipal utility clientele or demand given the hotel population in these municipalities. Other utilities would rebate this technology through their custom rebate program.

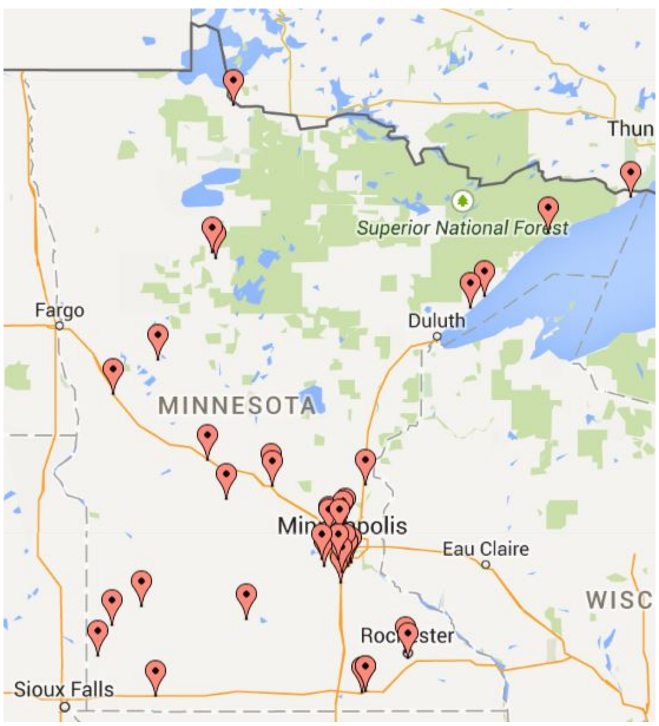
Methodology

This research pilot consisted of two phases: a small initial pilot with five hotels and a large pilot with 33 additional hotels.

The initial pilot of five hotels provided learning experience for the project team to better understand the opportunities in this sector, refine the audit and data collection practices, and develop the necessary energy calculations. All five hotels were located in the Twin Cities metro area. In addition, the initial five hotels agreed to participate in a survey of their guests regarding comfort and energy efficiency. This survey was conducted by University of Minnesota Tourism Center staff.

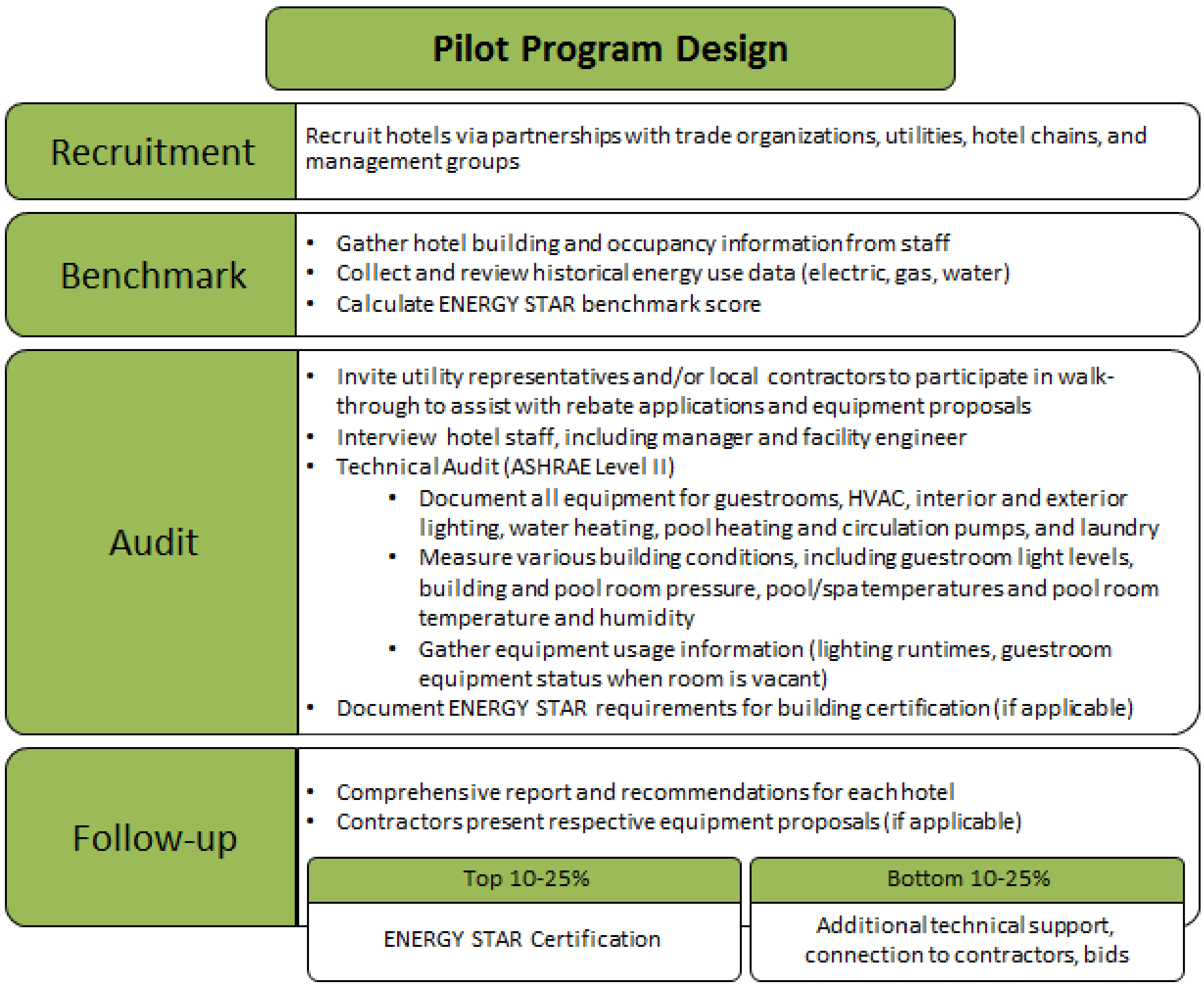
The hotels in the second phase were geographically diverse, with 30% located in the metropolitan area and 70% located in Greater Minnesota. See Figure 5 for a map of participating hotel locations. Priority was given to diversity among brands, and overall 21 brands were included in the study. Hotels were recruited to participate in this study through a variety of channels, but primarily through local utilities, hotel management groups, or brand contacts. The Clean Energy Resource Teams also supported identification of some participant hotels. A copy of the marketing brochure is included as Appendix 2.

Figure 5: Map of Participating Hotels



All of the hotel audits covered guestrooms, HVAC, interior and exterior lighting, water heating, pool heating and circulation pumps, and laundry systems. The reports provided energy history, building description, measure recommendations including savings, payback, potential rebates, and non-energy savings including water and maintenance, as well as total energy savings impact for the hotel. One particularly useful practice was to invite a utility representative and/or a local contractor along during the audit and the report out to leverage that local expert's knowledge and ability to help drive projects. In addition, hotels that received an ENERGY STAR score of 75 or higher were offered assistance in submitting their application for ENERGY STAR certification. Hotels that scored in the bottom quartile of the participating hotels were offered extra support and attention from the project team during the report out and subsequently in order to help them improve. Figure 6 below shows the steps of the pilot program. A sample of the audit report is included in Appendix 3.

Figure 6: Pilot Program Design Schematic



Findings

Guest Comfort

For hotel management, maintaining a high standard for guest satisfaction and comfort is a paramount consideration. Energy projects that compromise guest comfort are unlikely to be implemented. However, there may be opportunities to enhance guest comfort by energy efficiency. For instance, improvements to ventilation, lighting, room temperature, water pressure and noise levels may all result from efficiency upgrades. To explore that potential relationship, the project team was interested to find out if a hotel with more efficient technology would be rated as more comfortable by guests than a hotel with less efficient technology.

To conduct this research, University of Minnesota Tourism Center researchers were contracted to design and conduct a survey of hotel guests. The results were analyzed for statistical significance, and compared with a set of technical data gathered in the field by an engineer. A full report of the findings of this research can be found in Appendix 1.

Survey Methodology

Each of the five initial pilot hotels agreed to have their guests surveyed as part of this study. The surveys were conducted in the breakfast room in the morning. Guests who completed the questionnaire received a five-dollar gift card to a coffee shop as incentive. In one hotel the survey was administered over two mornings, a Saturday and Thursday, otherwise all surveys were administered in one session per hotel on weekday mornings.

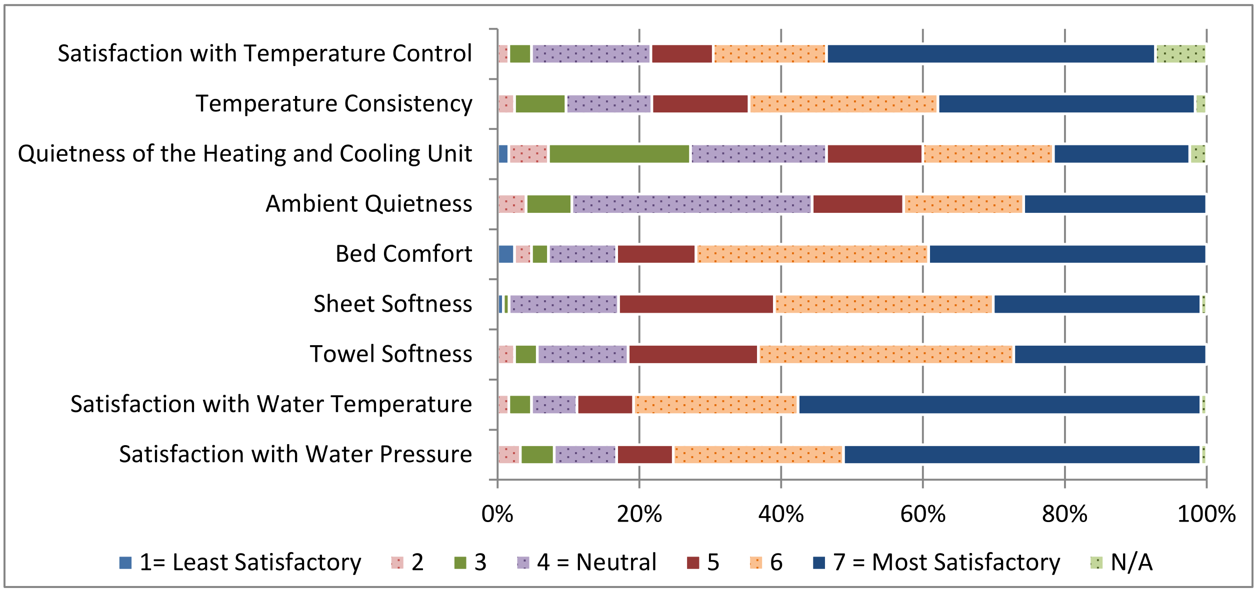
The Tourism Center research team developed the survey based on previous research conducted in the industry (the survey can be found in Appendix 1). The guests were asked to rate from 1-7 (higher scores reflected greater satisfaction) items such as: temperature control and consistency, noise level of the heating and cooling unit, ambient noise, water temperature and pressure, lighting, and air quality.

Various technical data for each property was also provided by the field engineer This data characterized the building and energy usage, the efficiency of the equipment, and measurement of the building's performance (i.e. lumens of light output, CFM of exhaust air, temperature of the water etc.). This field data was assigned, as best as possible, to describe a specific comfort characteristic.

Survey Results

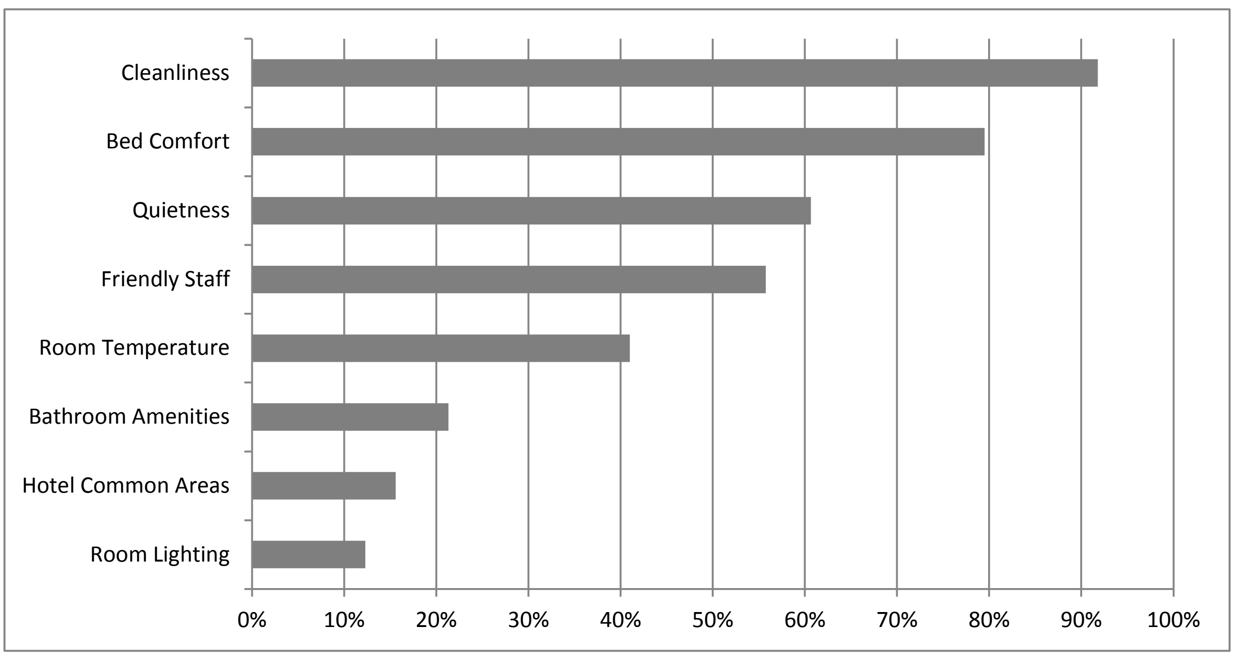
Overall, the level of satisfaction with various aspects of the guest room was high, as shown in Figure 7. The median response was a 6 or above for all categories except ambient quietness and quietness of heating and cooling unit, which received median ratings of 5.

Figure 7: Guest Ratings of Perceived Room Amenities (n=125)



When asked what factors influence choice of hotel, guests most commonly identified location, room comfort, and cost. When asked what factor contributed to a comfortable stay, guests responded that cleanliness and bed comfort were most influential, followed by quietness (Figure 8). The majority of the respondents (60%) defined their travel as for business purposes.

Figure 8: Hotel Amenities Important to a Comfortable Stay – Multiple Responses Allowed (n=122)



The importance of room cleanliness and bed comfort was further reinforced by comparing these responses with overall stay satisfaction. Only guests who perceived the room as clean or perceived the bed as comfortable were more likely to rate the overall room experience highly. None of the other 10 factors had significant effect on overall room experience.

Comparing the survey data to the technical data yielded mixed results. Statistical significance was found in relationships between a few variables; however, interpretation of that significance is not easy. One conclusion is that the technical data poorly represented all the interactive effects that create the perception of a comfort quality. For instance, the study showed a relationship between bath exhaust flow and perception of air quality in the room. In reality, bath fan air flow is not sufficient to describe room air quality. Other influencing factors include fan system design, window operation, common space ventilation, and presence of mold or mildew. These unaccounted-for interactive effects limit the meaningfulness of this data.

Two pieces of evidence are easier to interpret. Heating and cooling units with a high energy efficiency ratio (EER) did positively affect guests' perception of temperature control. This does not mean the high EER units will increase guest satisfaction with temperature, but it does indicate the hotels can invest in the upgrade without fear of negatively impacting comfort. Additionally, no relationship was found between water pressure and temperature and guests' satisfaction with their shower. Nor did guests indicate any preference for 2.0 or 2.5 gallon per minute (gpm) showerheads. This indicates that the fear that guests may dislike water efficiency measures in the shower is most likely unsubstantiated.

Hotel Management Impressions of Comfort and Efficiency

Regardless of guest's preference, the hotel management's preferences and past experience weigh heavily on the decision making process. Although the evidence is anecdotal, pre-audit interviews with general managers offer perspective on management's view of energy efficiency.

Nearly all hotel managers had favorable opinions of implementing energy-saving technology in their hotels. Most managers cited saving money as an incentive to implement energy efficient measures. Environmental justifications were cited much less frequently.

Guest comfort is a priority for all hotels, but larger nationally branded hotels were more sensitive to potential negative impacts on the guest experience than hotels in smaller markets or ones competing primarily on price. More than any other quality, hotel management's personality and corporate culture influence receptivity to exploring emerging or developing technologies, such as LED lights, guest room energy management systems, and low temperature laundry. Like in any business, some managers were very keen on trying new approaches and others adept at identifying barriers.

ENERGY STAR

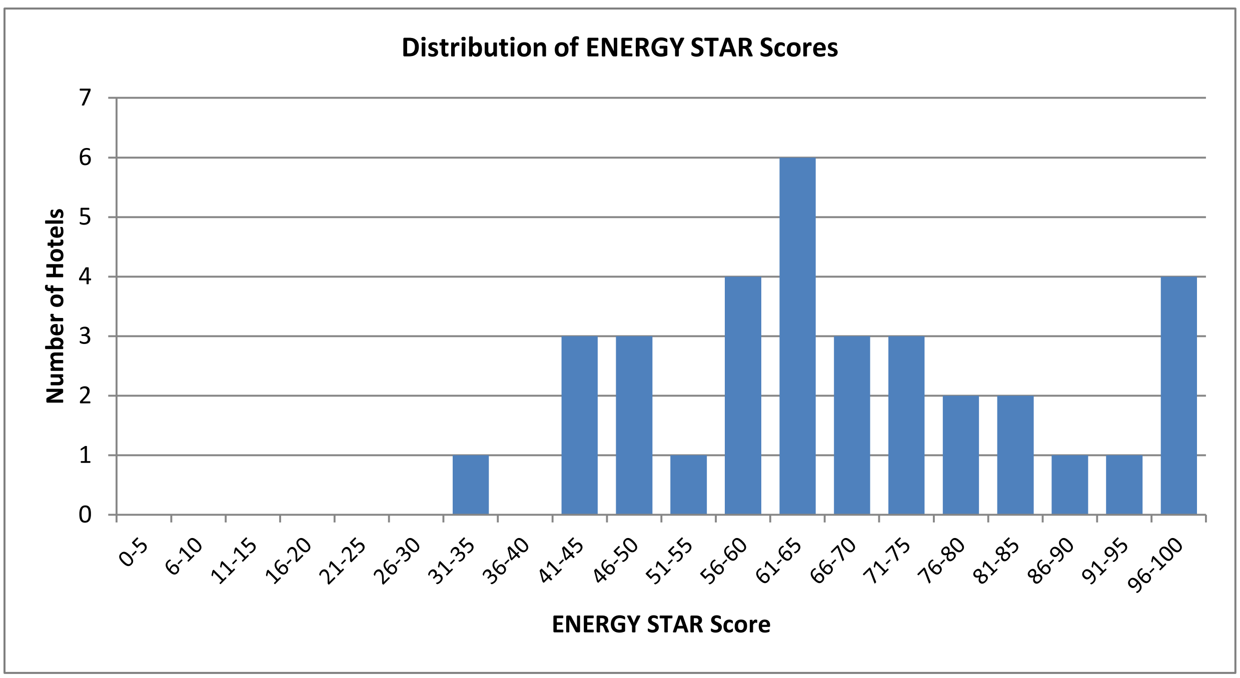
The project team benchmarked the participating hotels using ENERGY STAR Portfolio Manager. Each hotel with at least 12 months of energy data available, received a performance score between 1 and 100, based on the energy use and building operations. A hotel can apply to become an ENERGY STAR certified building if it scores 75 or higher, has more than 55% guest room occupancy, and does not compromise guest comfort. Certification requires a Professional Engineer to review to verify that basic standards of occupant comfort have been maintained. Barriers to certification in the hotel sector include low occupancy, low guestroom light levels and inadequate bath exhaust flow rate.

The project team benchmarked each building in ENERGY STAR prior to the site visit. This served to inform the auditor of the hotel's efficiency in advance and to add a benchmarking component to the audit report. Hotels that scored 75 or higher were evaluated specifically for the ENERGY STAR building certification and offered assistance with the application process if they met all requirements.

Pilot Results

An ENERGY STAR benchmark score was generated for 34 out of the 38 hotels audited. Four hotels were removed from the analysis; these hotels were either too small, included too much non-hotel space (conference center or casino), or had incomplete energy use history. The distribution of scores for all benchmarked hotels is shown in Figure 9. An ENERGY STAR score of 50 designates a hotel is in the 50^{th} percentile in terms of energy performance. The median score of the pilot hotel group in this study was 64.5, and the mean score was 68. These factors indicate that the pilot group skewed towards higher-scoring hotels. Reasons for this discrepancy could include: a small sample size (34 hotels versus ENERGY STAR's sample of 142 hotels); a regional sample versus a national sample; and finally, ENERGY STAR is based on 2003 data, so baseline efficiency has likely improved, particularly in lighting, heating and cooling.

Figure 9: Distribution of ENERGY STAR Scores

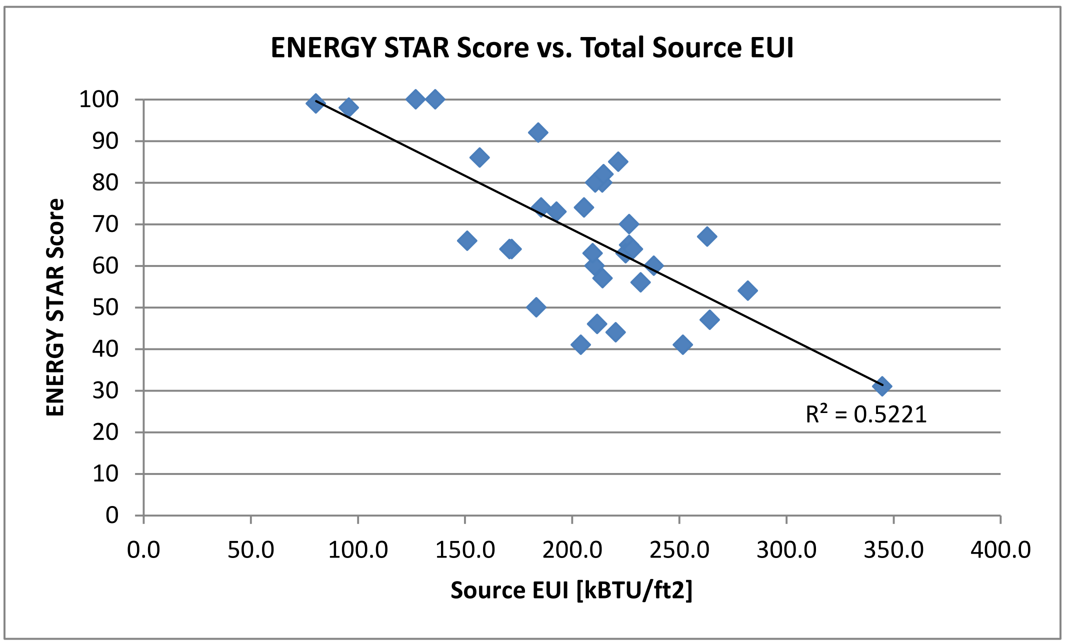


Seven hotels with ENERGY STAR scores of less than 50 received additional assistance from the project team. A primary strategy was to involve third party experts. Utility account representatives were involved with three sites, and a lighting contractor assisted at one site. Other assistance included follow-up calls and referrals to contractors, and one hotel was provided with a free liquid pool cover.

There were 10 hotels with an ENERGY STAR score of at least 75. Six of these hotels had occupancy rates less than 55% and did not qualify for building certification. Of the remaining hotels, one hotel had inadequate light levels at the guestroom desk and another had bath exhaust fans that were not working, so they did not meet the required comfort conditions. Two hotels met the comfort requirements, one of which proceeded to obtain an ENERGY STAR building certification.

The source energy use intensity (EUI) of each hotel compared to the ENERGY STAR score is shown in Figure 10. This comparison is similar to how the EPA evaluated the accuracy of the ENERGY STAR hotel benchmark. The coefficient of determination (R^2) of 0.52 indicates a favorable correlation between EUI and ENERGY STAR score. This relationship is actually stronger in this study's data than in the original ENERGY STAR model dataset, which had an R^2 of 0.37 (ENERGY STAR, 2014).

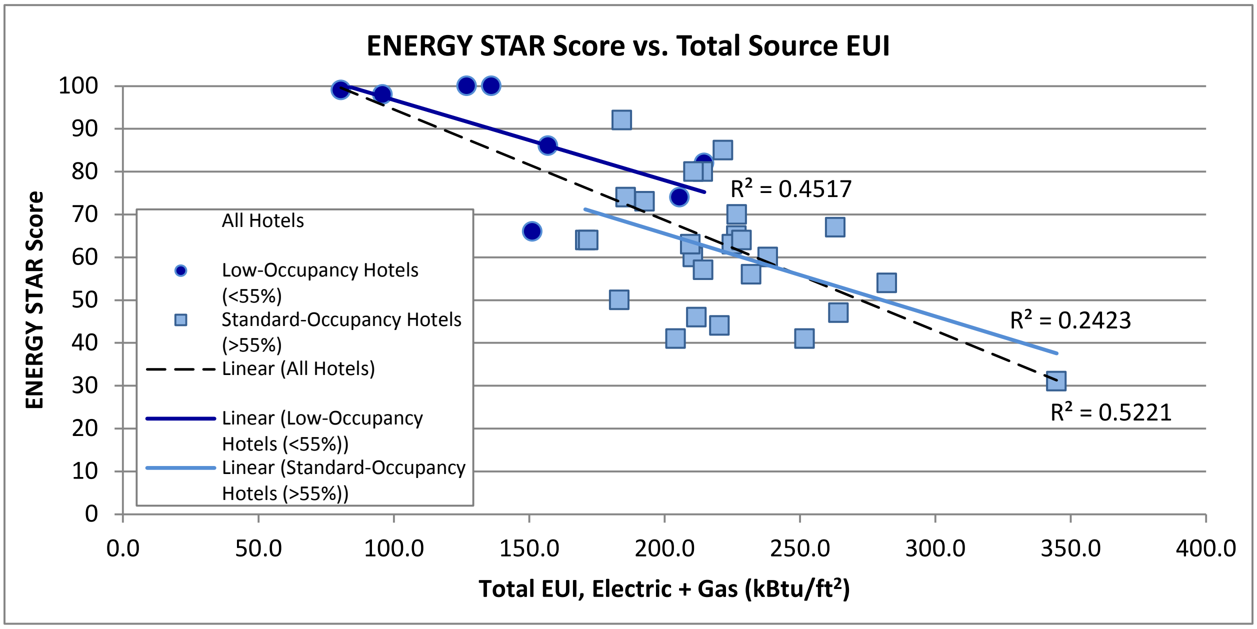
Figure 10: ENERGY STAR Score versus Source EUI, in Total kBTU Per Square Foot



This strong relationship between source EUI and the ENERGY STAR score misleads the user because hotel occupancy is not accounted for in the ENERGY STAR calculation. Hotels with low occupancy (under 55% average occupancy annually) are precluded from application for ENERGY STAR building certification, but the software interface still produces a score for those properties.

In this data set, eight hotels have occupancy less than 55%. Six of those hotels score high enough to qualify for ENERGY STAR certification, save for being disqualified for low occupancy, and four score above 95. This low-occupancy group inflates the overall distribution of scores and influences the predictive fit of the model. The project team conducted the analysis of source EUI versus ENERGY STAR and indicated the low-occupancy hotels. This data is presented in Figure 11.

Figure 11: ENERGY STAR Score versus Source EUI, Low and Standard Occupancy



ENERGY STAR's value relies on peers within a group being similar. In this case, given the stark divide in ENERGY STAR scores between the two groups, the inclusion of low-occupancy hotels worsens the comparability of the hotel peer group. Perhaps ENERGY STAR could not remove low occupancy hotels because they didn't have occupancy information in their data set. It is clear they recognize the issue because they preclude low-occupancy hotels from certification. An implication is that the top ENERGY STAR scores are pegged to hotels with low-occupancy. This creates an unfair goal for standard occupancy hotels to try to match.

Developing a method to account for occupancy would require further study. One option might be to exclude low-occupancy hotels from the sample. Another might be to analyze EUI as a function of occupancy rate in addition to building size. For instance, a better metric may be to analyze energy use intensity using the ratio of total source energy use to the average number of occupied rooms. This average would be calculated by multiplying the number of guestrooms by the annualized occupancy rate. ENERGY STAR may have explored this possibility and determined it a worse fit, but their documentation does not clarify the topic.

Energy Consumption and End Use

The 38 hotels that participated in this study varied in size, brand and geography, as well as installed equipment and amenities. However, despite this diversity, several common traits were identified within most of the hotels surveyed during this study.

The most common identifying trait among the hotels surveyed is the use of packaged terminal equipment in guestrooms for heating and cooling. Of the 38 hotels audited, 90% used either packaged terminal air conditioners (PTACs) (electric resistance heating), packaged terminal heat pumps (PTHPs), or a combination of both. Initially, project team assumed that PTACs would be the more prevalent technology; in fact, 42% of hotels used heat pumps alone, and only

20% used PTACs alone (28% used a combination). 10% of hotels used some alternative means to heat and cool guest rooms.

Another defining feature of the pilot hotels involved in this study is the inclusion of a pool on the premises, with 32 of the hotels audited having at least one pool or spa on site. Nearly all hotels used 80% efficient non-condensing boilers when heating hot water for the pool and spa. This also included water heating for other sources like domestic and laundry hot water. Pool rooms were largely dehumidified by outdoor air dilution with no mechanical cooling (49%). Remaining hotels dehumidified by outdoor air with some direct expansion cooling for summer months or mechanical dehumidification with heat recovery to the pool water or pool room air.

Finally, most of the hotels surveyed in this study utilized similar equipment for lighting the interior and exterior of the building. Nearly all hotels used CFL lighting for the common areas like lobby and hallways, and these lights were on 24 hours per day. Mechanical and storage rooms were typically lit with linear fluorescent fixtures. While T8 fluorescent fixtures were most common, some older hotels still relied on older T12 lighting or a combination of both. Nearly all exterior lighting was served by high intensity discharge lamps, such as metal halide or high pressure sodium.

Details of the data collected can be found in Appendix 4.

Hotel Energy Use

Annual electric and gas use for 37 hotels is displayed in Figure 12 and Figure 13[1]. Hotels are sorted by number of rooms along the X-axis. The average use is calculated and displayed as a black line. The average use identified by the 2011 University of Minnesota Technical Assistance Program (MnTAP) is included in each chart for comparison. The overall average monthly demand for these hotels was 156 kW. The overall average cost of energy for these hotels was $105,000 as compared to the initial assumption of $95,000.

The energy use of a few individual hotels stands out and merits some explanation. The clear outlier in the charts below is a casino resort. Its use of gas and electricity far exceeded the average gas and electricity use for the pilot study[2]. Other high energy-using hotels contained large conference centers, catering facilities, or both. These properties had a non-trivial effect on the average for the pilot study. Most of the hotels that have low gas use do not have laundry or pool facilities.

Based on the variety and geographic range of the hotels selected for this study, the project team anticipated receiving similar results to the MnTAP study. In fact, the MnTAP averages for electricity and gas use are both within 12% of the same averages for the pilot group hotels. Specific edge case hotels could account for some discrepancy, as the MnTAP group of hotels ranged from 40 to 136 rooms, whereas this study's group of hotels ranged from 8 to 233. The average usage between the two datasets is close enough to not be alarming.

---

[1] One hotel only provided 6 months of gas data, so it is excluded from this analysis.

[2] The casino resort heated with a combination of wood chips and #2 fuel oil. This was converted into equivalent therms for the purpose of analysis.

Figure 12: Hotel Annual Electricity Usage

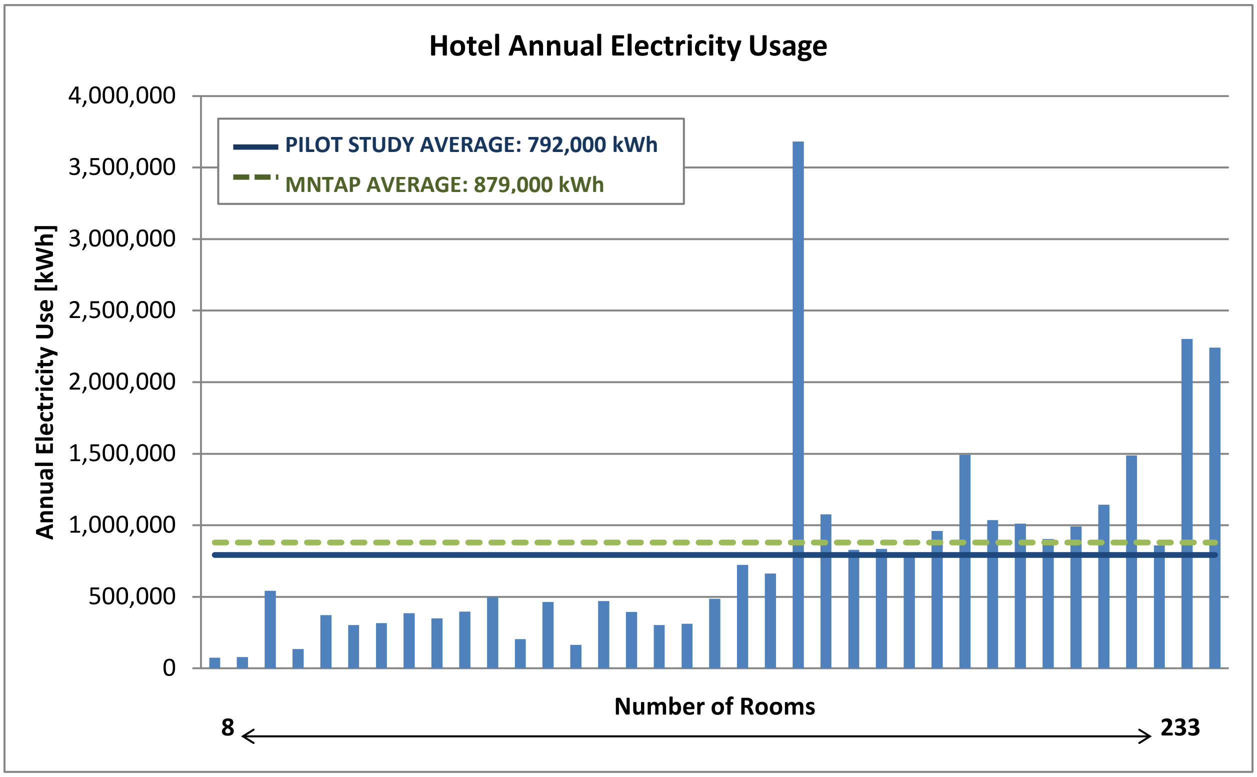
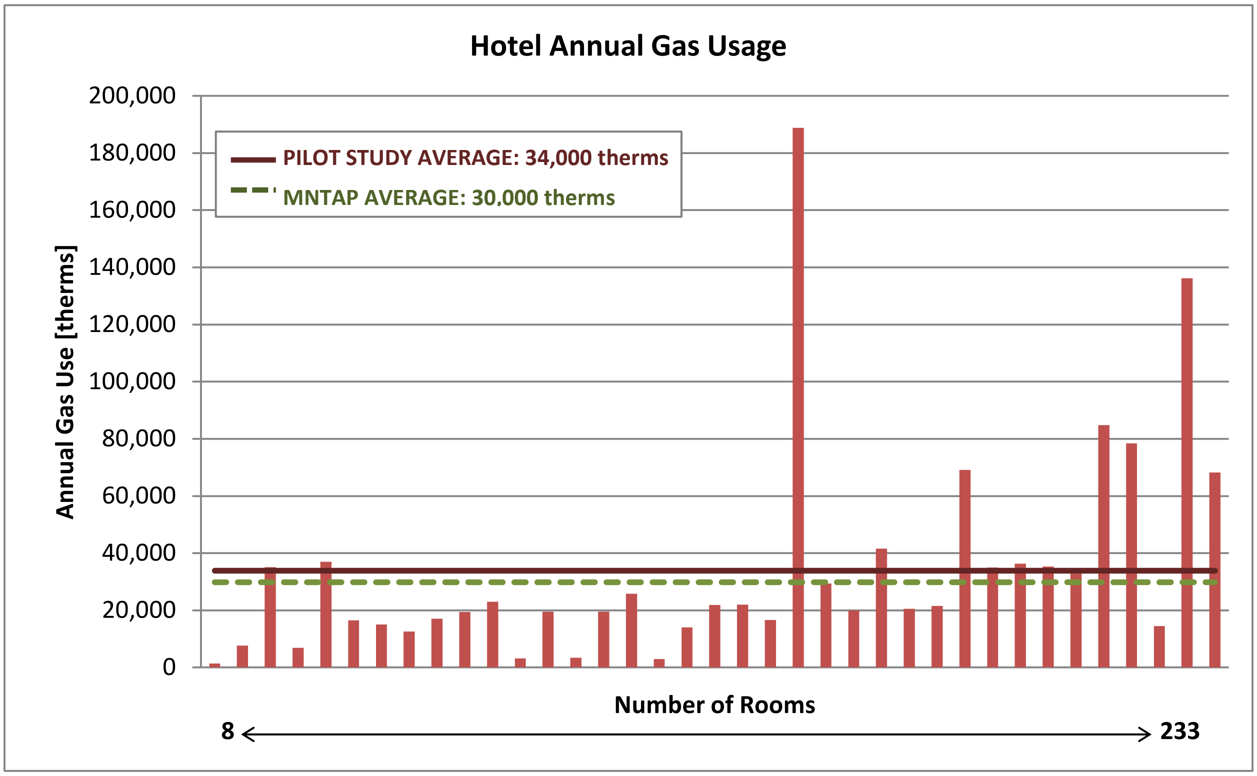


Figure 13: Hotel Annual Gas Usage



Hotel End Use

Hotels have an energy end use profile that is distinct from other sectors, due to the amenities that hotels offer including a pool and spa, laundry, guest room showers, common spaces, and some amount of kitchen equipment. Additionally, a large portion of the energy-using equipment installed in hotels is on 24 hours per day, which can significantly alter the overall end use. Such equipment includes lighting and pool water heating and circulating pumps.

The 2011 MnTAP hotel study conducted an end use analysis on all 27 hotels studied. In an effort to not duplicate, but verify and update that work, the project team analyzed energy end use for six hotels. Figure 14 and Figure 15 compare the results of both analyses.

Figure 14: Electric End Use

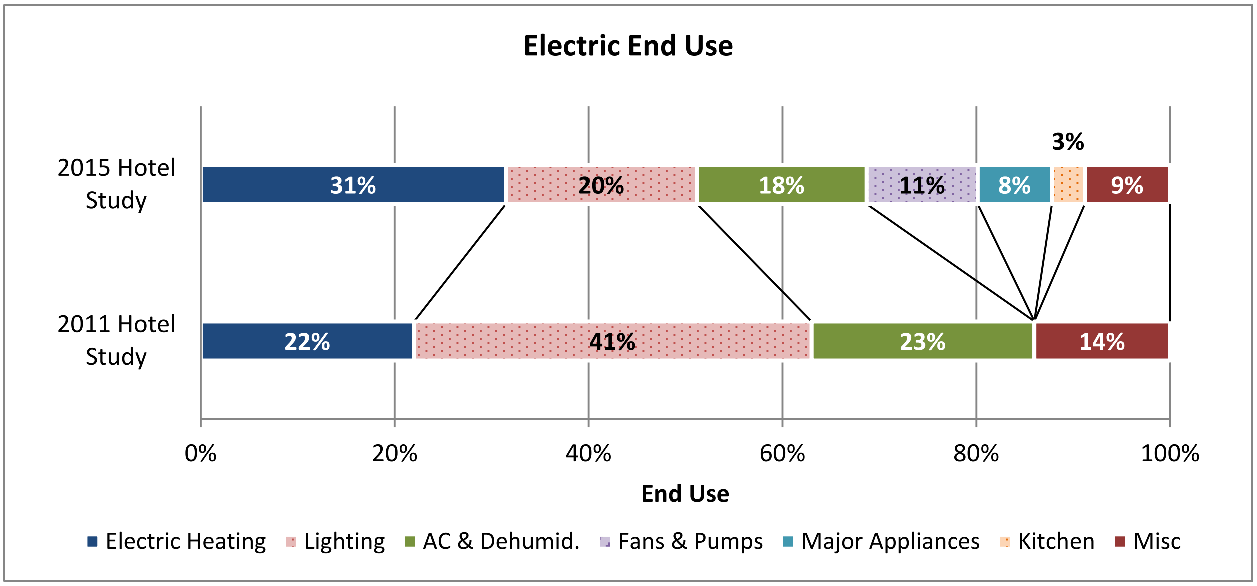
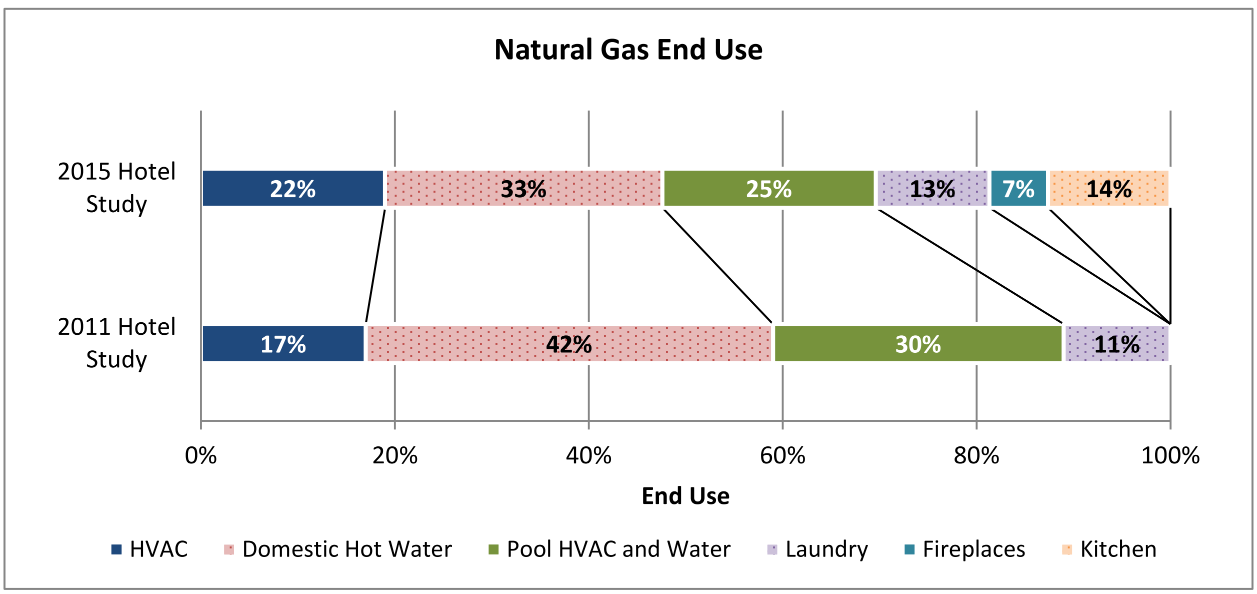


Figure 15: Natural Gas End Use



Although the end use breakdowns differ slightly, they are comparable. In both studies, lighting and electric heating constitute the majority of electricity use. Electric heating was the greater of the two for the hotels the project team analyzed, while the MnTAP study attributed the highest use to lighting. Part of this discrepancy could be credited to the fact that four of the six hotels in this study used PTAC units to heat guestrooms, which rely solely on electric resistance heat. However, a large number of hotels in the overall pilot group used heat pumps to deliver guestroom heating, which use less energy than electric resistance heat alone. MnTAP's study population could have included more heat pumps and thus documented lower electricity use for heating. Additionally, the end use for pilot hotels was subdivided into several additional categories that were not included in the MnTAP study; it is possible that with fewer categories the percentage of energy would more closely match ("miscellaneous" electricity constitutes 9% for the pilot hotels, while MnTAP attributes 14% electricity to the category). Finally, the MnTAP data was collected between 2008-2010 and lighting efficiency gains since may account for the different between end use in the lighting categories.

Description of Measures

The following section describes common measures recommended to hotels in this study. In particular, measures that have an innovative, misunderstood, or complicated component are explained in more details. Some frequent measures, like lighting occupancy sensors, are not discussed at all, despite being a frequent recommendation, because they are widely understood and easy to implement.

Pools

Description of Equipment and Operation

The pool room must maintain its own unique and isolated operating environment. Typical settings are 82°F for air temperature, 80°F for water temperature and relative humidity levels of 50-60%. These conditions provide a good balance between bather comfort, minimal energy consumption and maintaining integrity of building components. Exhaust fans are used to maintain the area at a slightly negative pressure to control chemical odors.

Most hotel indoor pool rooms in Minnesota are conditioned by one of two types of heating, ventilation and air conditioning (HVAC) systems.

1. Gas heat with outdoor air dilution to control room humidity. Some of these systems have mechanical cooling to provide supplementary cooling and dehumidification.
2. Electric heat with mechanical cooling to control room humidity with hot gas heat recovery to heat pool water.

The majority of energy loss in an indoor pool is due to evaporation of the pool water [3]. In addition the ventilation system has to work harder than normal to heat and dehumidify the indoor air to keep humidity levels between 50% and 60% and the temperature around 82°F.

The typical hotel pool seen in this study had constant speed pool pumps. The water was cleaned by sand filters that were backwashed about once per week. Heat was provided by 80% efficient gas-fired pool water heaters.

Potential Measures

Operations and Maintenance

There is no technology that can replace good equipment maintenance. Energy waste occurs whenever pool water and room air temperatures are excessive, the desired relative humidity is lower than 50%, or too much outdoor air must be conditioned. If the relative humidity levels are too high, significant damage can occur to the building structure.

[3] U.S. Department of Energy web site on pool covers.

Outdoor air dilution HVAC systems have an outdoor air damper that modulates between 20% and 100% open depending on how much outdoor air is required.

Figure 16 shows the outdoor air intake for the pool room with an outdoor air dilution system. Upon closer inspection, the damper was 100% open on a day when the outdoor temperature was about 10°F. Another hotel was maintaining room temperature at 79°F, relative humidity between 75-85%, and the pool log showed that pool water temperature was maintained at 86°F. This indicates there were problems with the sensors or control set points. All these issues need to be addressed to maintain energy efficiency.

Figure 16: Outdoor Air Damper at 100%

Variable-Speed Pumps for Pools and Spas

Depending on the system setup and flowrate, some hotels were candidates for replacing existing pumps with variable-speed equipment. The state of Minnesota requires a minimum recirculation rate for pools and spas (typically 75 gpm and 35 gpm respectively). All but two hotels surveyed used constant speed pumps and the project team identified several hotels that had circulation rates higher than the state requirement, due to oversized equipment or efficient plumbing. A variable-speed pump allows the recirculation rate to be reduced closer to the minimum required flowrate.

This opportunity, found in a limited amount of hotels, presents significant energy savings. The affinity law states that pump power is the cube of pump speed, so a speed reduction of 10% can lead to a 27% reduction in power draw. Additionally, due to lax certification requirements many constant speed pumps draw far higher power than their nameplates suggest. Among the hotels identified, the average payback was calculated to be 1.8 years, with an average annual energy savings of $900 on an estimated cost of $1,600. However, the overall number of hotels where this measure was identified as appropriate during the study was relatively low (24%). Most hotels surveyed had equipment that appeared to be properly sized and either met or slightly exceeded the minimum required recirculation rate, with not enough energy savings for the project to pay back in a reasonable amount of time.

Liquid Pool Covers

Physical pool covers provide well documented energy and water savings; however, they are labor intensive and rarely installed. An alternative technology, a liquid pool cover, was evaluated at four hotel test sites during this research. The goal of this test was to evaluate the effectiveness of the liquid pool cover as compared to a traditional solid pool cover. A complete measurement and verification report on the HeatSavr™ liquid pool cover testing is included in Appendix 5.

A liquid pool cover is an alcohol based liquid that forms a transparent seal on a still pool surface and reduces evaporation. It is not effective when swimmers are using the pool. Typical hotel pools are open from 7 am to midnight, but are rarely used other than weekends. For hotel pools, the pool surface is still and the liquid pool cover can be effective about 14 hours per day or 60% of the day. This can be compared to a traditional pool cover that is only in place from midnight to 7 am or 30% of the day. Safety testing has been performed on the product and none of the test sites registered any bather complaints.

Monitoring equipment was installed in two of the four test sites. The other two sites received the pool cover and anecdotal observations were recorded. Baseline conditions for pool room air temperature and relative humidity for Hotel 1 is shown in Figure 17. The system seems to be operating relatively well other than the rise in humidity to 83% on September 5th when the HVAC system was shut down briefly. These conditions can be contrasted with the baseline conditions for Hotel 2 as shown in Figure 18. For Hotel 2, the average air temperature and relative humidity was 79°F and 79% respectively. The water temperature, which was manually logged, averaged 86°F. Comparing these to the typical settings for a pool room, it is clear there were problems with the sensors or control set points for Hotel 2.

Figure 17: Hotel 1 Baseline Indoor Conditions, Aug/Sept 2014

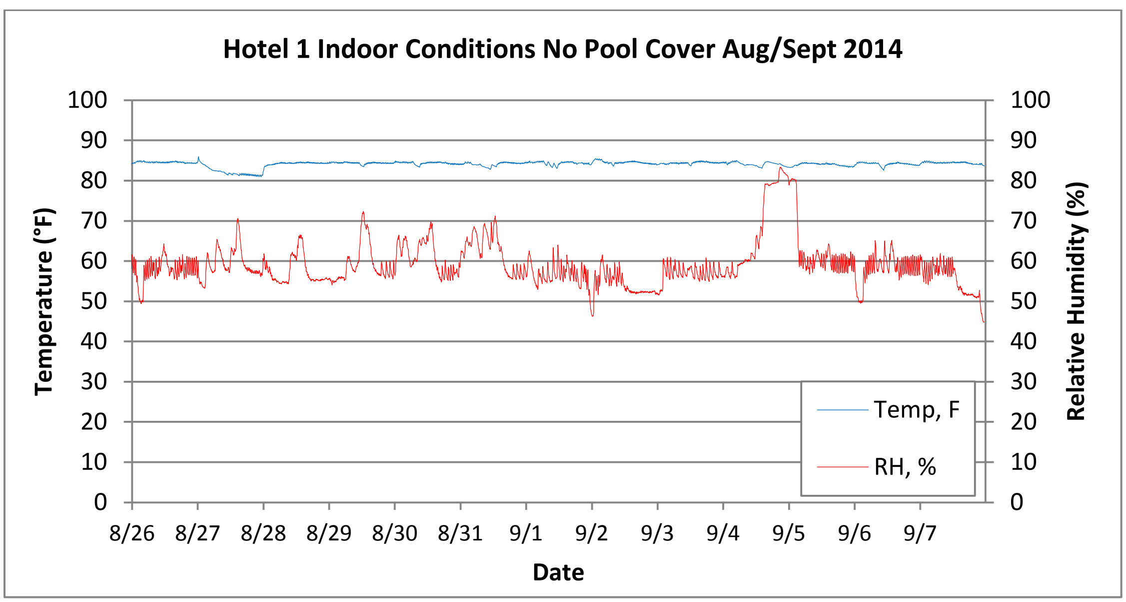


Figure 18: Hotel 2 Baseline Indoor Conditions, Aug/Sept 2014

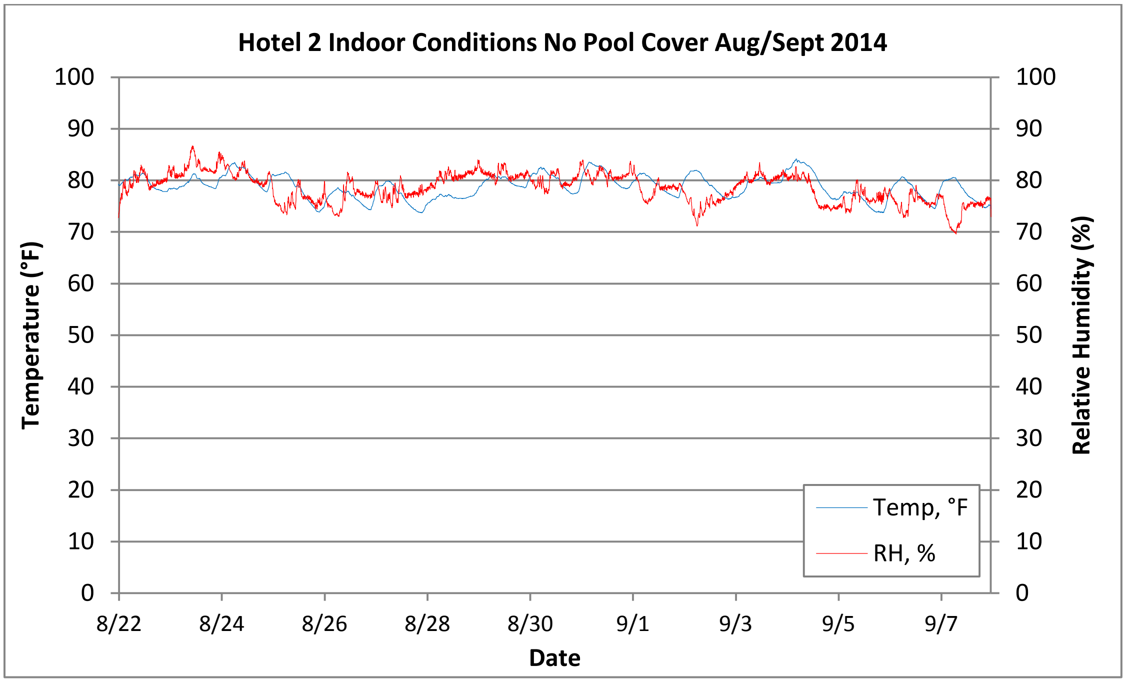


Table 3 and Table 4 show the water savings from the liquid pool cover for Hotel 1 and Hotel 2. In addition to the water lost by evaporation, water is lost when the sand filters are backwashed or if there is high swimmer activity. These water losses should be consistent over long periods of time but may affect the estimates of water evaporation rates over a short test period if they are not accounted for. If the data was available, the amount of water added after the filters were backwashed was recorded. It is interesting to note that at Hotel 1, where backwash amounts were tracked, the savings in evaporation was double that of Hotel 2 where backwash amounts were not tracked.

Table 3: Water Usage and Estimated Savings Hotel 1

Test Condition	Start	End	Duration, Days	Water Added, Gallons/Day	Back Wash, Gallons/Day	Evaporation, Gallons/Day
Base - No Pool Cover	8/20/14	9/29/14	40	6.83	3.44	3.40
Proposed - Pool Cover	9/30/14	11/3/14	34	5.56	3.53	2.03
Savings, %				**19%**	**-**	**40%**

Table 4: Water Usage and Estimated Savings Hotel 2

Test Condition	Start	End	Duration, Days	Water Added, Gallons/Day
Base - No Pool Cover	8/18/14	9/8/14	21	13.0
Proposed - Pool Cover	9/9/14	10/6/14	27	10.5
Savings, %				19%

Once the evaporation savings were determined for the liquid pool cover, a calculation spreadsheet was used to estimate annual energy savings. The energy savings calculation was based on determining a percent effectiveness for the liquid pool cover. Effectiveness is defined as how much equivalent area of pool surface would be covered by a solid pool cover. For each hotel, percent effectiveness value was adjusted until the evaporation rate reduction matched the values observed in the test. For Hotel 1 this resulted in an effectiveness level of 73% and for Hotel 2 the effectiveness level was 64%. Table 5 and Table 6 show the energy savings estimated for Hotel 1 and Hotel 2.

Table 5: Estimated Energy Savings for Hotel 1

Dectron System with Water Heat Recovery	Baseline	Proposed	Savings	%
Usage for HVAC and Water Heating, kWh	59,000	46,000	13,000	22%
Estimated Demand, kW	10.9	8.5	2.4	22%

Table 6: Estimated Energy Savings for Hotel 2

Titan System with DX Cooling Coil	Baseline	Proposed	Savings	%
Usage for HVAC and Water Heating, therms	2,200	1,600	600	27%
Usage for HVAC and Water Heating, kWh	4,400	1,300	3,100	70%
Estimated Demand, kW	1.2	0.4	0.9	71%

Table 7: Estimated Energy Savings Based on Reducing Evaporation by 30%

	Hotel 1	Hotel 2
HVAC System Type	DX with Water Heat Recovery	Outdoor Air Dilution with DX Cooling
kW Savings, at $9.43/kW	$300	$100
kWh Savings at $0.07/kWh	$900	$200
Therm Savings at $0.79/Therm	-	$400
Total Energy Savings, $	$1,200	$700
One Time Equipment Cost	$500	$500
Annual Chemical	$180	$320
Payback First Year, months	7	14
Payback After First Year, months	2	5
% Effectiveness	73%	64%

Table 7 summarizes the estimated energy savings from the liquid pool cover for these two hotels. Even though the savings is less for the Dectron system, electric energy costs more than gas, so the payback is still attractive. The chemical feed pump is a one-time cost and the initial investment would pay off in seven to eight months. Each following year the cost of chemicals would be recouped in two to three months.

Low Temperature Laundry

Description of Process and Equipment

The laundry process in hotels is highly automated. The washers typically are programmable and detergents and chemicals are provided by a chemical supplier on a regular basis. For the majority of hotels, the chemical supplier was either Ecolab or Proctor & Gamble (P&G). The capabilities of programmable washers include adjustments to water temperature, water level, extraction speed, wash time and amount of chemical added. As shown in Figure 19, the machines can have up to 10 different wash cycles, each programmed for a specific linen type.

Figure 19: Washer Programs

Hotel laundry consumes significant amounts of energy and water. The hot water is primarily heated by 80% storage tank heaters. The supply temperature averaged 130°F. The typical washer was a 60 pound capacity machine. Hotels use a rule of thumb that 13 pounds of laundry is processed per occupied room. For a typical 80 room hotel with occupancy rate of 65%, using this factor results in approximately 250,000 pounds of laundry processed per year or 11 loads of laundry per day.

Based on the end use analysis, approximately 10-15% of natural gas is used for laundry. For the average hotel, laundry consumes approximately 4,000 therms at a cost of $4,000 per year. This same hotel consumes about 400,000 gallons of water per year for laundry and at a cost of $2,000 annually.[4] This is approximately 15% of overall water usage. Based on costs provided by chemical suppliers, this same hotel will pay around $5,000 for laundry chemicals. The cost of replacing linens was not determined, but it is certainly significant as hotels value high quality, "soft and white" linens for their guests. The other significant factor in the laundry operation is

[4] The average cost of water in Minnesota, including sewer fees, is $0.005 per gallon.

water quality. If the water quality is poor, the chemicals must be adjusted to ensure linen quality remains high.

Low Temperature Laundry Detergents

While the MnTAP study and initial desk review showed ozone laundry had favorable paybacks of 1.5 to 3 years, there was no interest from hotels. Barriers may be the capital cost, lack of understanding of the technology, or chemical hazards. During the initial pilot, two of the five hotels were using the Ecolab Aquanomic™ low temperature laundry system. Since Ecolab has its company headquarters in St. Paul, there was a great opportunity to learn more about the product. The product was awarded the 2011 Minnesota Cleantech Tekne award for its ability to reduce costs, energy consumption and waste.

The Aquanomic program requires that the washers be programmable, which seems to be the industry standard.[5] The process does two things to save energy and water. First, the chemicals reduce the hot water temperature to 100°F from the original setting of 130-140°F. Second, the chemicals allow the washers to be reprogrammed so there are fewer fill and drain rinse cycles in the process. Ecolab provided a third party study showing water and energy savings for a variety of machines. One of the machines tested was a 60 pound capacity machine similar to the ones typically seen in hotels.

Six of the 38 hotels in the study were using the Ecolab Aquanomic program. One hotel was using what appeared to be a similar product from Procter & Gamble (P&G). Since some hotels are loyal to the P&G brand, it appears there may be an option for them as well. While the P&G product web page claims similar savings to the Ecolab product, there was no study available to validate the claims.

Energy and Water Savings

Table 8: Savings Potential for Low Temperature Laundry

Energy Savings, Therms	1,300
Water Savings, Gallons	222,000
Energy Savings, $	$1,300
Water Savings, $	$1,000
Total Savings, $	$2,300
Incremental Cost of Chemicals, $	$1,000
Simple Payback on Energy Savings, months	16
Simple Payback on Water and Energy Savings, months	5

[5] Only 15% of the washers in this study were identified as not programmable and these were in older hotels.

Table 8 provides the savings potential for the average hotel with 80 rooms and 65% occupancy. While this seems like an attractive measure with an overall payback of only 5 months, there was some resistance from hotels thinking that their laundry quality would be compromised or that the savings would not materialize. One hotel manager was concerned that the new chemicals could not address his hotel's poor water quality issues.

Incentives

Low temperature laundry programs have low market penetration. Even with the investment Ecolab put into verifying the system savings, there is still resistance from hotels to reduce their wash temperature. The overall payback of the product is less than one year when water and energy savings are considered, a necessity for a consumable product that needs to be continually purchased. Hotels frequently don't assign water and energy costs to a laundry budget, so laundry managers may struggle to justify the added cost in their budget when the savings appear in an operations budget. Utilities could offer a rebate for this product, which would serve to provide additional credibility for the energy and water savings, and may motivate management to pursue this measure. Utilities in Minnesota typically do not rebate consumables or measures with less than a one year payback. However, as shown in Table 8 the payback, exclusive of water savings, is greater than one year which might meet the regulatory requirement.

Union Gas, a gas utility serving Ontario, Canada, sets precedence for other utilities by providing a prescriptive rebate for the Aquanomic program. Their rebate is a one-time rebate for new Aquanomic users only. The rebated amount is calculated based an estimate of one year of use. The utility assumes that the system will be in place for 7 years.

Other Measures Considered

Guest Room Energy Management Systems

A guest room energy management system (GREMS) provides occupancy-based control of the room HVAC unit and even lighting to save energy. The best practice for a GREMS system includes installing a door switch to detect when the guest enters the room and an occupancy sensor (ultrasonic and/or passive infrared) to detect motion in the room. The occupancy sensor can be a wireless remote or built into the thermostat. The guest has control of the thermostat while in the room. Typical setbacks for a system are 4 to 7 degrees when the room is unoccupied. The addition of the door switch and proper placement of the occupancy sensors greatly reduces the chance for the system to malfunction while the guest is in the room.

A more simplistic version of GREMS consists of a key card slot, which, when a room key is inserted allows the lights and HVAC unit to operate. Affordability is the key advantage of this system. These systems are common in Europe. A few hotels in Rochester, MN, who declined to participate in the study, have key card systems. The industry trend in the US leans toward the occupancy sensor configurations, perhaps because of an impression that guests are inconvenienced with the key card kind of system.

There is no debate that GREMS provide energy savings. A 2012 DOE study (Pacific Northwest National Laboratory, 2012) on GREMS documented an average installed cost of $375 per room, annual savings per room of 167 to 589 kWh, and a simple payback between 5 and 18 years. The costs for these projects included installation of a wall thermostat. Wall thermostats are frequently required as part of a brand standard, so removing that baseline cost could provide a more favorable incremental cost for to help justify a retrofit installation. In Minnesota, some municipal utilities provide a prescriptive rebate of $75/room; custom rebates are available from other utilities.

Based on the field experience and conversations with hotel managers, GREMS were not an attractive retrofit project. Only one hotel had a full system installed. Four others had conducted pilots, but were not planning further implementation. Some managers expressed concerns about GREMS due to previous experience at other hotels or advice from other hotel managers. A primary concern was guest complaints that room heating or cooling would shutoff while occupied. In the future, codes may require this type of control system which will improve market penetration. Deeper adoption of this technology waits on a shift of experience and mentality that the technology is cost effective, necessary, and well-functioning.

Behavioral Measures

Energy savings from behavioral actions, while difficult to quantify, contributes to the overall efficiency of a hotel. Best practices for housekeeping staff include adjusting the thermostat setpoint, closing blinds and turning off lights when leaving a room after cleaning. Maintenance practices can save energy and include activities such as: regular preventative maintenance, fixing water leaks, replacing air filters, cleaning evaporator and condenser coils, properly maintaining pool equipment, and sealing air leaks around PTAC units.

General Managers (GM) offer a mixed reaction at the idea of engaging their staff in energy efficiency. Some complain that their staff turnover is too high to be worth the investment of time or that their staff is not receptive to additions to their responsibilities. Others have not had problems engaging their staff in energy management. Leadership from both the GM and the department managers helps to create a positive environment to incorporate behavioral measures. The on-boarding process of a new staff member is a good time to introduce additional expectations. Finally, hotels should recognize that an employee may derive satisfaction from participating in environmentally friendly actions at work. Promoting a measure as cost saving might be less motivating than promoting it as green or as good customer service.

LED Lighting and Maintenance Savings

Every hotel audited was a candidate for at least one lighting efficiency measure. The primary driver for energy savings is lamp runtime, and common area lighting in hotels is on 24 hours per day. Even though most hotels audited had already converted to CFL lamps in hallway and lobby fixtures, long runtime combined with minimal fixture modification (retrofit instead of replacement) resulted in low paybacks – an average of 0.9 years for common area lighting measures.

Non-energy benefits also motivated general managers to consider LED lighting upgrades. The lifetime for LED lamps is significantly longer than that of traditional compact fluorescent, linear fluorescent, and high intensity discharge lamps such as metal halide or high pressure sodium. Longer LED lifetimes become a major benefit when considering hard-to-reach fixtures such as exterior pole lights. Additionally, many LEDs have internal drivers which remove the need for a separate driver or ballast. Hotel managers and facility staff noted that the reduced maintenance and fewer replacement lamps over time are incentives to convert to LED, not to mention the energy savings.

From a financial and mind share standpoint, it appears LED lighting has arrived in the hospitality sector, but there are still some concerns with the technology. A few hotel managers were concerned about implementing LED lighting in common spaces, citing poor experience with light color and levels. Managers were also concerned that guests might steal LED lamps installed in guestrooms, though due to the limited hours of use in guest room, LED replacements were not recommended for guestrooms at this time.

PTHP vs. PTAC

Nearly all hotels in the pilot study used packaged terminal equipment for guestroom heating and cooling. A minority utilized packaged terminal air conditioners (PTACs), which rely on electric resistance heating in the winter and direct expansion cooling in the summer. The majority of hotels used packaged terminal heat pumps (PTHPs), which use the existing refrigeration system in reverse for heating when the ambient outside temperature is above 25°F (below this threshold, the unit switches to resistance heating). Heat pump heating produces three times as much heat per input energy than electric resistance heating[6]. During spring, fall, and cool summer nights, heat pump mode can replace electric heating, thereby saving energy.

Heat pump technology is known within the hotel sector, though it is occasionally confused with the standard PTAC. Several hotels with PTACs were already in the process of converting to heat pumps. Utilities offer a rebate to incentivize the upgrade to PTHP technology; however, many managers were unaware of the rebates. Replacing standard PTACs with heat pump units was proposed as an incremental cost. As existing equipment reaches end of life, heat pumps could be installed instead of a replacement PTAC. The incremental cost of upgrading to PTHPs was found to be between $60 and $100, and utility rebates often covered most if not all of this cost.

Measures worth Further Investigation

Water Heating Measures

As described in the hotel end use section, domestic hot water systems consume 20-40% of the gas used by a facility and represent the single largest gas user. The key measures for domestic hot water are low flow fixtures and high efficiency water heating systems. The average flow

[6] Electric heat system efficiency is measured with a coefficient of performance (COP), defined as the ratio of heating provided to the electrical energy consumed. Package terminal heat pump COP values are typically about 3.0, compared to electric resistance heating with a COP of 1.0.

rating for showerheads and faucet aerators was 2.2 gpm. If hotels can find high performing low flow fixtures that meet the brand standard requirements, significant savings can be achieved. Most hotels heated domestic water with conventional 80% efficient storage tank heaters and pool water was heated with 80% efficient heaters. More efficient systems were observed in the newer hotels and pool rooms. This included 95% efficient tankless heaters (for pool heating only).

There was an opportunity at one hotel to explore additional options for pool heating. This hotel received a budget quote of approximately $17,000 to install a solar thermal water heating system and another budget quote of $44,000 for 95% tankless heaters for domestic water. There was also some interest in a combined heat and power system to reduce peak electrical demand while recovering waste heat for water heating. Since over 80% of natural gas is used for water heating, these emerging technologies may have merit for the hotel sector, but further evaluation is needed to determine which technology is the best fit for the hotel owner.

Building Envelope

Building envelope testing was conducted in the first five hotels audited. Results from testing indicate that by and large rooms are equivalently sealed with respect to the outside. The most egregious infiltration occurred around the PTAC, so a manual inspection of the seal and caulking around the wall sleeve is recommended even without specific quantification of the energy impact. Blower door testing, as was conducted during this pilot, is time consuming and not practical without further testing and justification for the expected savings.

Hotels were typically maintained at a negative pressure, a result of having exhaust fans running 24/7 with no dedicated make-up air. Supply air is designed to enter through windows, doors and some of the general area HVAC systems for the pool, laundry or lobby. One consequence of the building being negatively pressurized is that the pool room needs to be maintained at even more of a negative pressure to keep odors and moisture from penetrating into the rest of the hotel. This results in additional energy use for the pool area. Some hotels were able to reduce the exhaust fan run time by installing timers so the fans only about 10 hours per day.

Analysis

Measure Impact

In a business environment, energy saving measures need to be justified with energy savings or other cost savings such as reductions in water use or maintenance. The project team only presented measures to hotel participants that had a simple payback of less than 10 years. Each measure recommended to a hotel was tracked and aggregated to describe the average impact of each measure and how deep the market penetration reached.

Table 9: Energy Savings Opportunities for Hotels (>40% hotels identified)

Energy Saving Measure	% of Hotels in need of Measure	Average Measure Cost ($)	Average Electrical Savings (kWh)	Average Monthly Demand Savings (kW)	Average Gas Savings (therms)	Average Annual Energy Savings ($)	Average Non-Energy Savings ($)	Average Utility Rebate ($)	Average Payback (Years)
Replace Exterior Lighting with LED	92%	$14,000	27,000	-	-	$1,700	$740	$2,200	4.8
Retrofit T8 and T12 Fixtures with LED Tubular Lamps	92%	$6,600	12,000	2.3	-	$1,100	$330	$1,500	3.9
Replace Pool Area Lighting with LED	74%	$3,500	11,000	1.7	-	$940	$340	$470	2.3
Replace Common Area Lighting with LED	76%	$3,900	17,000	2.5	-	$1,500	$1,500	$1,400	0.9
Install Occupancy Sensors in Public Spaces	74%	$730	3,400	0.1	-	$260	$-	$130	3.0
Replace PTACs with Heat Pump Units	42%	$6,000*	54,000	3.5	-	$4,200	$-	$4,800	0.3
Install Liquid Pool Cover	79%	$920	2,100	0.1	690	$740	$30	$-	1.6
Install Efficient Showerheads in Guestrooms	84%	$5,700	-	-	710	$640	$690	$380	4.6
Install Efficient Faucet Aerators in Guestrooms	92%	$600	-	-	140	$120	$190	$70	2.4
Replace Standard Water Heaters with High Efficiency Units	66%	$5,800*	-	-	840	$690	$-	$1,000	7.0
Implement Low Temperature Laundry System	82%	$1,000*	-	-	1,100	$1,000	$1,100	$-	0.5
Install Occupancy Controller for Vending Machines	66%	$590	2,600	-	-	$170	$-	$120	2.9
TOTALS		**$49,340**	**129,100**	**10.2**	**3480**	**$13,060**	**4920**	**$12,070**	**2.1**

*Incremental cost

Table 9 lists the opportunities that were identified for 40% or more of the hotels audited. Note that the payback was calculated after the utility rebate and included annual energy, water, and maintenance savings. Finally, note that for several measures, non-energy savings constituted more than 50% of the savings. Inclusion of these ancillary benefits can greatly improve a measure's outlook.

Program Potential

A goal of this research was to identify the potential energy savings in the hotel sector in the state of Minnesota. The documentation of the potential savings from each measure, shown in the previous section, provides the foundation for this estimation. To account for varying rates of measure implementation, each measure savings is multiplied by the percentage of hotels in which the measure was identified as an opportunity – creating a weighted impact. Subsequently, that number can be multiplied by the number of hotels a program intends to reach to determine the program impact. This adjusted savings potential is shown in the row titled "weighted single-property savings" in Table 10.

After the savings are weighted individually and then summed, the measures above represent an 11% savings in electric use and 8% savings in gas use for the average hotel. Combined, this is a 9% savings in total energy use. This corresponds to the pre-study assumption of 12% combined savings for gas and electric.

Determining the statewide impact requires an estimate of how many hotels could be reached with an efficiency program. The project team originally estimated 1,800 hotels categorized under SIC code 701101 based on available database information. After removing a population of unverified businesses, the project team settled on a more conservative estimate of 1,250 hotel properties (ReferenceUSA). This SIC category encompasses all hotel and motel properties that this study included. In Table 10 below, the rows "MN Savings Potential" divide that state population of hotels by proposed penetration rates of 10%, 25%, and 50% to account for varying levels of interest and participation among the state's hotels. The program impact is then calculated based on the single property weighted savings and the total number of expected participants.

Table 10: Savings Potential for Minnesota Hotels

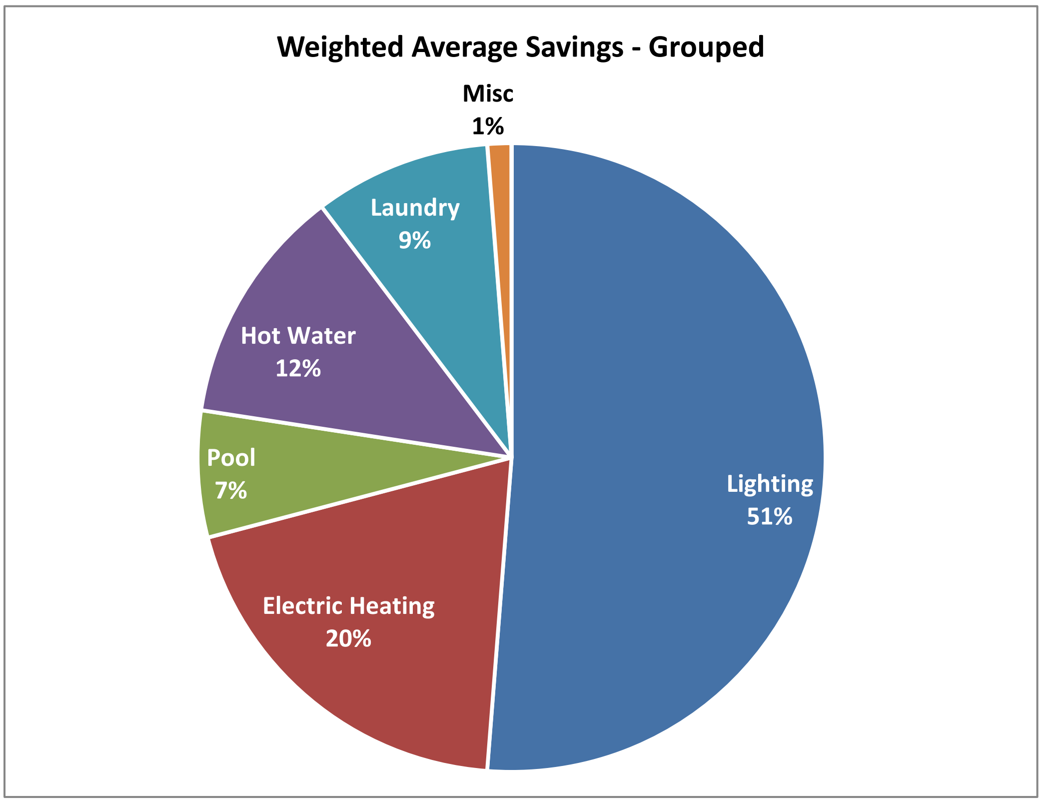
Savings Potential		Electrical Savings (kWh)	Monthly Demand Savings (kW)	Gas Savings (therms)	Annual Energy Savings ($)	Non-Energy Savings ($)
Weighted Single-Property Savings		85,600	6.9	2,700	$9,000	$4,100
MN Savings Potential	10% Impact 125 Hotels	10,700,000	860	340,000	$1,100,000	$510,000
	25% Impact 310 Hotels	26,800,000	2,200	840,000	$2,800,000	$1,300,000
	50% Impact 625 Hotels	53,500,000	4,300	1,700,000	$5,600,000	$2,600,000

A conservative estimate would be that 25% of the hotels in Minnesota would participate in a rebate program. At the 25% participation level, hotels in Minnesota would save nearly 27 million kWh and 840,000 therms per year. About $2,800,000 annually of energy savings would be realized in the Minnesota hotel sector. This compares to the team's original assumption of $5,100,000 energy savings at the 25% level (assuming 12% savings). In addition, $1,300,000 of non-energy savings would be achieved, which was not accounted for in the initial estimates.

Priority Measures

Some of the measures recommended in this study have a greater impact than others. Knowing which measures are high impact helps shape priorities for rebates, technical assistance, and marketing. To identify the impact of specific measures for the average hotel, the project team weighted each measure as described in the previous section. The results, shown in Figure 20, show the impact in percent of total energy savings identified for each measure, adjusted for the frequency the measure was identified in the field. This gives a view into which measures are particularly high impact, sector-wide.

Figure 20: Weighted Average Energy Savings



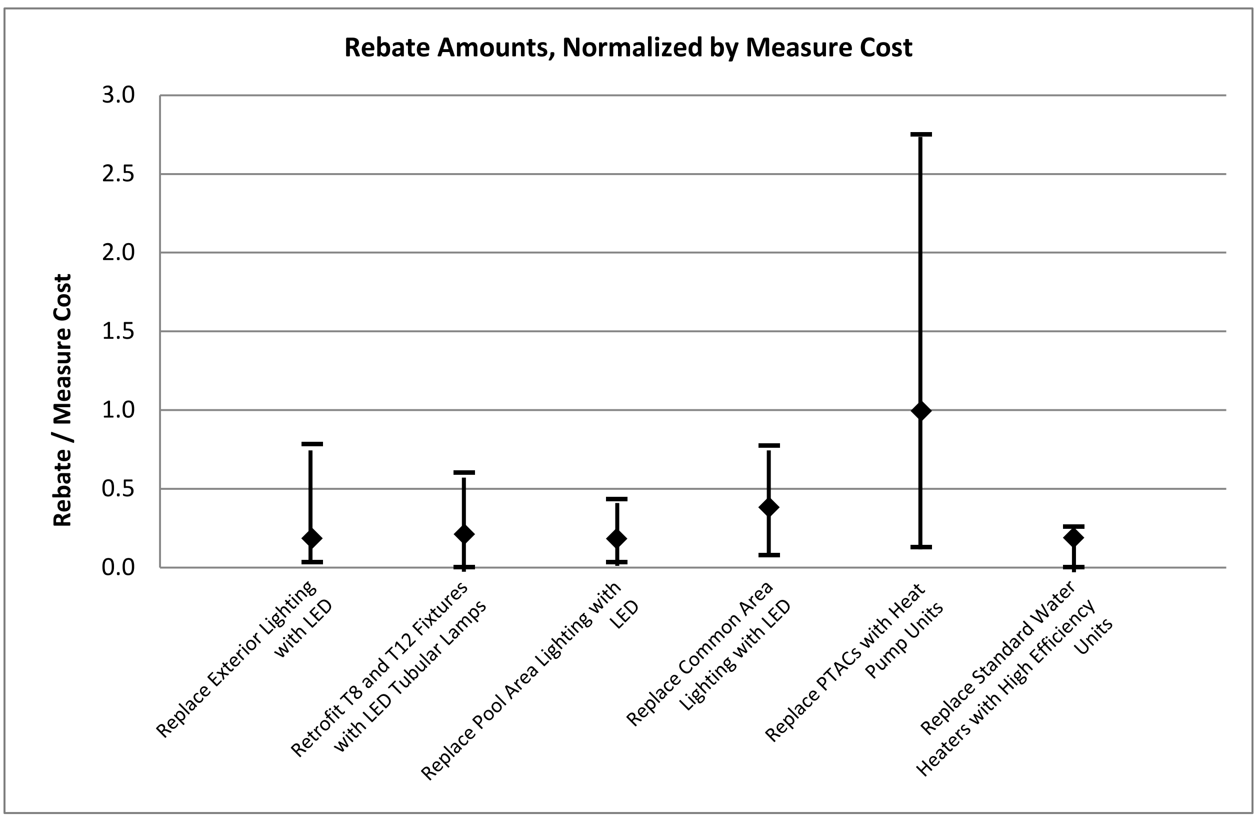
Lighting measures comprise about 50% of the savings identified in this sector. The technology gain in LED lighting coupled with the long hours of operating in the hotel sector result in large savings opportunities for lighting. Upgrading PTAC units to heat pumps only accounts for 20% of savings when weighted for the opportunity in the sector. If a given hotel needs to upgrade their PTAC units, that individual hotel is likely to capture closer to 40% of their savings from that measure; however, PTHPs are becoming the industry standard and so fewer hotels have need for this measure. It is appropriate to mention that in Minnesota space heating drives energy usage; in other climates, the impact of PTHP upgrades would be decreased.

Finally, despite much-to-do about low occupancy rates inflating ENERGY STAR scores, the savings for many of the recommended measures is not tied to occupancy, but rather square footage (or loosely to the number of rooms). In particular, pool measures and lighting measures are not occupancy dependent. Guest room heating and cooling does have an occupancy component, but it's not clear that hotels above a certain baseline occupancy adjust their room setpoints with much rigor. Perhaps occupancy only affects hotels when it dips below a point and they start closing down floors and trying to deeply reduce costs.

Utility Incentives and Rebates

Utility rebates are under-utilized by this sector. Many hotels stated that they were unaware that rebates existed and some had recently installed eligible equipment. Rebates were particularly supportive of lighting upgrades and PTHP upgrades, but not quite as favorable for measures such as hot water heater replacement. An analysis of rebate amounts per dollar spent on select technologies is shown in Figure 21. The top and bottom of the line indicate the high and low rebate amounts offered by utilities with customers participating in this study, and diamond mid-point indicates the average rebate amount.

Figure 21: Variation in Utility Rebates by Technology



Rebate amounts varied across the state. In most utility territories, the rebate covered the incremental cost of the upgrade to a heat pump from a PTAC unit, and in the most generous cases, covered almost three times the incremental cost. Based on conversations with these utilities, there is a strong desire to promote efficient technology for guestroom heating and cooling, no doubt because it constitutes a large share of total energy use for hotels. This is contrasted against the rebate for high efficiency water heaters where the average rebate only covers 20% of the incremental cost. LED lighting rebates are particularly lucrative as utilities work to drive customer awareness and familiarity with the technology. Lighting measures are generally standardized in terms of average rebate to cost ratio, regardless of the technology. For instance, upgrading exterior lights to LED technology is the most expensive of the lighting measures due to having the most full-fixture replacements recommended, and the associated rebates are similarly high.

Additionally, an energy audit is an important service that some utilities offer to this market sector. Energy audits are sometimes maligned as doing nothing but produce a shelf-sitting, dust-gathering report. However, in the experience of this pilot program, the hotel management greatly valued the information the audit revealed, in particular the cost and payback information which helps with project prioritization. The vast majority of hotel managers had not received recommendations on energy management in the past. In addition, each hotel is unique enough to merit an individual analysis. Some measures might be easily assessed by contractors, like lighting for instance. But many of the end uses, in particular the pool eco-system, can be quite complicated. Pool system contractors should be incorporated into utility trade ally programs since they are capable of addressing these systems.

Screening High Potential Hotels

Screening hotels before conducting a site visit is a wise strategy for keeping a program cost effective and creating a positive experience for the customers, ensuring the sufficient energy savings will be identifiable once the audit process is complete. However, having an accurate benchmark for comparison is critical to successful screening. Qualities of a good benchmark typically include the ability to isolate extraneous variables and conditions and normalization for size and weather.

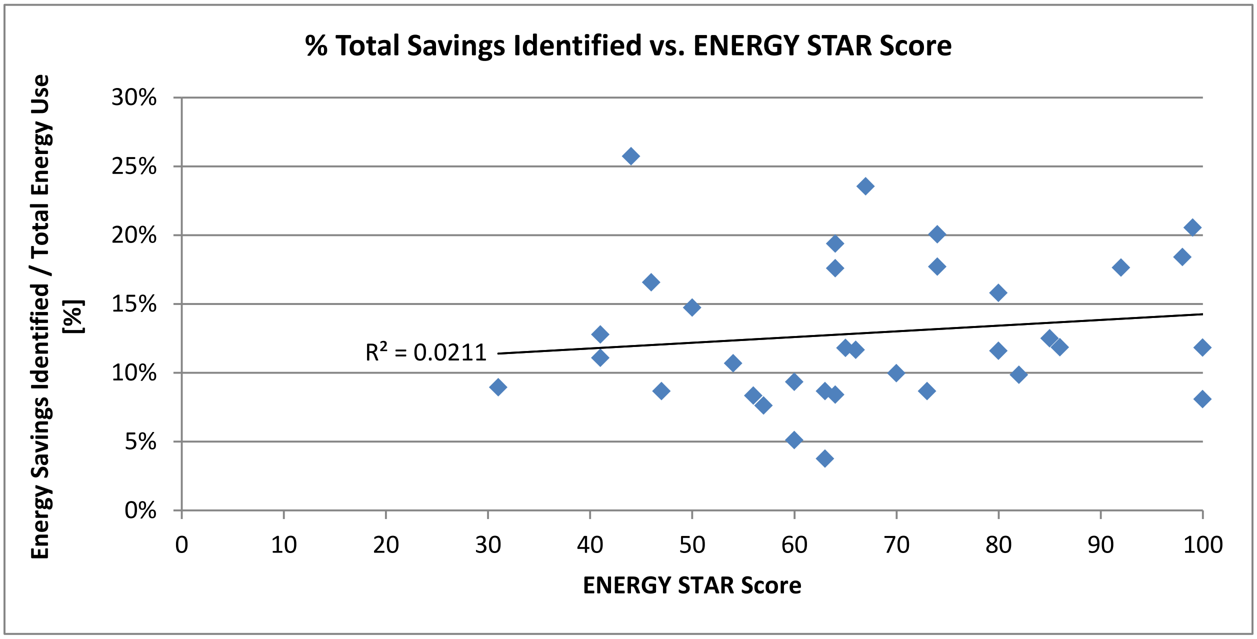
The project team chose ENERGY STAR as a no-cost tool with national recognition to conduct benchmarking and pre-screening of hotels in this pilot. ENERGY STAR, while a little cumbersome initially, is relatively user friendly. The input data required is limited, and it's used frequently in the industry. In addition, high scoring facilities can be rewarded with certification, which creates a positive incentive for businesses as well.

The expectation of a benchmarking tool is that a poor score, relative to the benchmark, would indicate significant opportunity for energy efficiency. Likewise, a high score would mean the facility had mostly completed its upgrades and recommendations would be minimal. This was not the experience of the project team in the field, and frequently project team members left sites somewhat bewildered as to why a facility received a high or low score. Upon analysis of the overall performance of ENERGY STAR compared to the opportunities identified, this confusion was born out.

In Figure 22, the ENERGY STAR score is analyzed as the independent variable in this pilot, with the savings opportunities as a percent of total usage shown as the dependent variable. A linear relationship with the line sloping downward to the bottom left would indicate that an ENERGY

STAR score could predict potential savings opportunity. Unfortunately, the actual linear regression suggests that hotels with a higher ENERGY STAR score have more savings potential – a result contrary to the team's original assumption. Additionally, the low R^2 value of 0.02 indicates that there is virtually no correlation between the score and the percent savings identified.

Figure 22: ENERGY STAR Score versus Percent Energy Savings Identified



There is an import caveat to this analysis. The audits performed in this study were designed to target the most likely savings opportunities for the hotel sector, not to exhaustively dissect every savings opportunity possible for a given property. As a result, some extremely out of the ordinary properties (very large, unusual controls or equipment, poor building envelope, or significant amount of non-hotel space usage) were not audited in a way to capture all the savings potential. But all that said, it still seems unlikely that ENERGY STAR, given the lack of occupancy sensitive analysis, can be the preferred tool for benchmarking this sector.

The project team analyzed the data collected in search of an alternative benchmark. Energy use intensity on a square foot basis is a common choice, but did not yield strong correlation in this study's data. Additionally, adding in normalization for occupancy did not produce a predictive benchmark.

The independent variable in this data set to predict a given hotel's gross savings potential, were overall dollar spent on energy and number of rooms. Those analyses are shown in Figure 23 and Figure 24. Such benchmarks are, unfortunately, rather simplistic. At best they serve to reinforce that larger facilities will be able to justify the cost of technical support through energy savings. Additionally, since many measures (lighting and HVAC) are related to overall square footage or number of rooms rather than occupancy, the savings will be more dependent on the size of the building.

Figure 23: Number of Rooms versus Savings Potential ($)

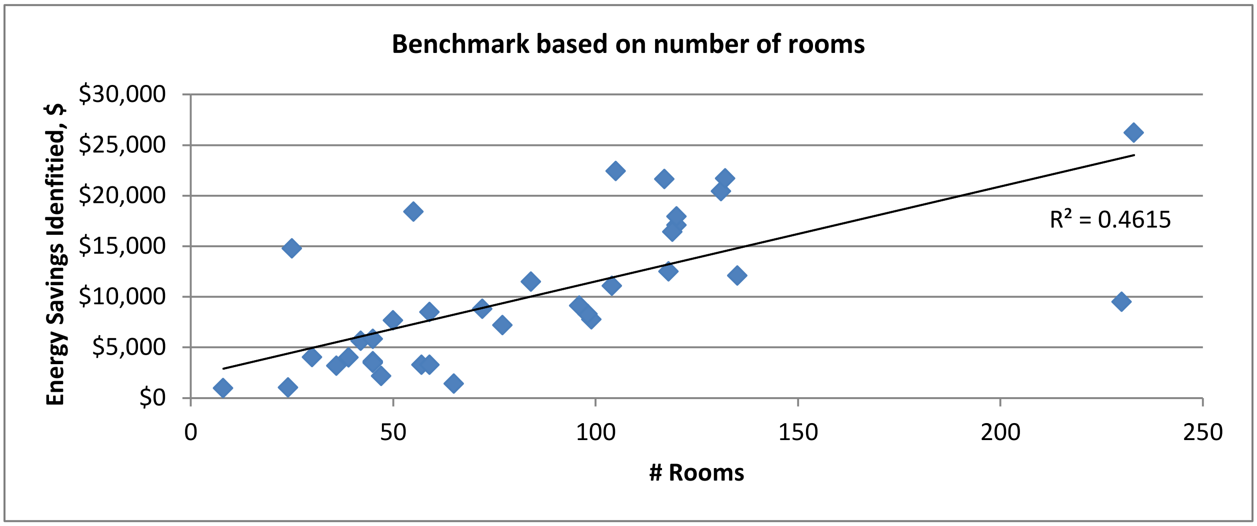
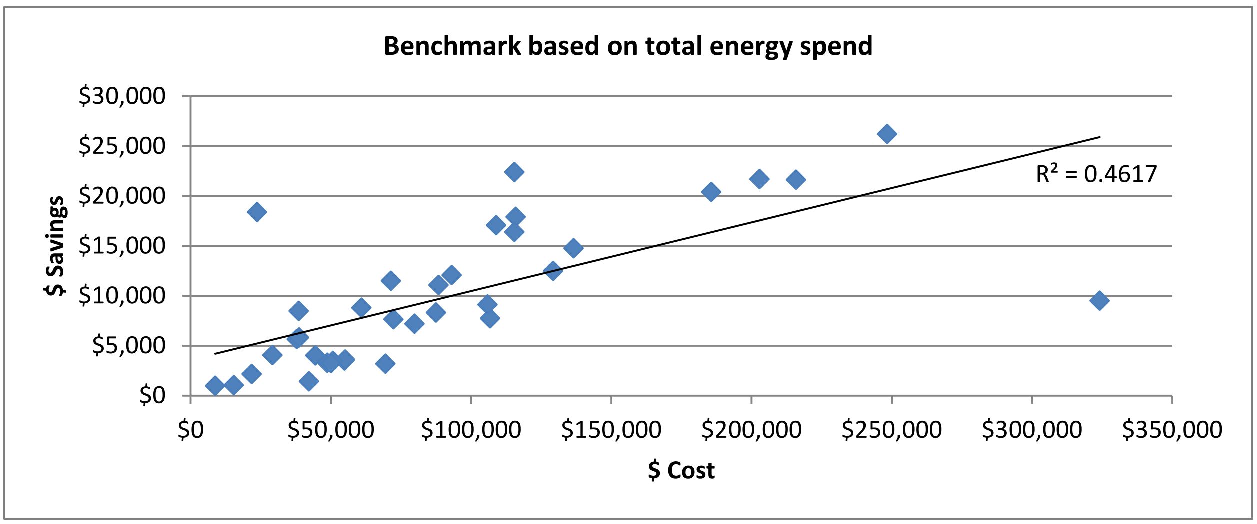


Figure 24: Total Dollars Spent on the Energy versus Savings Potential ($)



Hotel Sector Specific Considerations

Guest Comfort

At their core, all hotels are in the business of providing a comfortable place for guests to spend the night. Energy decisions with perceived or real impacts on guest comfort will first be judged in terms of the impact on the guest. Financial or environmental considerations will be secondary.

The parallel research performed by the University of Minnesota demonstrates that the effects of energy efficiency are not noticed by guests (positively or negatively). This means that hotel management can be less concerned about guest comfort as they proceed with upgrades. It also means that if a hotel wishes to get "credit" for greening their operation, they need to communicate it explicitly because guests will not pick up on the improvements independently.

Hotel Business Model and Decision Making

Three parties share influence in leadership and decision making in hotels. An ownership entity provides the financial backing for the hotel and takes profits or losses from the success of the business. A management entity, hired by the ownership entity, manages the day-to-day operation of the facility. In some cases the ownership entity also manages the hotel. Finally, the ownership/management team contracts with a third party brand entity to license the use of their brand. Each brand has a "brand standard," a set of requirements that the hotel must meet in order to be part of the brand family. For instance, a brand standard might specify that a hotel must be one story, have a pool, offer 4 pillows per bed, and serve a cookie at check-in among other specifications.

The brand standard's influence ranges depending on the brand's business model, from very prescriptive to quite permissive. In terms of influence over energy efficiency, the brand standard can be an important tool. Some hotels in this study shared that they were required to use a specific 2.5 gpm showerhead as part of their brand standard. Complying with brand standards can be costly, so some requirements are only enforced upon sale of the business; examples might be LED upgrades to hotel signage or adding wall thermostat control to existing PTAC units.

At its most effective, the brand standard compels positive action among an entire population of hotels. Various hotels brands have internal green awareness programs, but the brand standard can serve to elevate the significance and participation of those programs. For example, in 2015 IHG implemented a new standard, requiring all of its affiliates to complete the first level of their Green Engage™ program. This online tool helps IHG hotels measure and manage their energy, water and waste, and promotes recommendations for cost effective reduction. Compliance at the first level consists of 10 easy to implement solutions and results in an expected energy use reduction of 10% (U.S. Department of Energy, 2015).

For items not specified by the brand standard, either management or ownership may have primary influence. Ownership most likely engages around authorizing the annual capital expenditure budget. Management develops that proposal, typically has a small amount of money that can be spent without capital approval, and oversees day-to-day operations and maintenance. Management companies, responsible for multiple hotels, gain an added advantage of being able to do comparisons and resource sharing among the hotels in their group.

On the whole, these multiple players add complexity to an energy efficiency project at a hotel. However, navigating these relationships and structures is the job of a General Manager and should not present undo restrictions on implementation. Furthermore, the opportunity for hotels brands or management groups to leverage change in multiple (or hundreds) of hotels at once is a benefit of this multi-party business structure.

Program Recommendations

Program Design

Utilities should feel encouraged to develop a hotel-specific energy efficiency program. Not all utilities will have the hotel customer population to merit an on-going program, but developing a focus for a triennial plan could be a smart approach. The anticipated measures would include lighting, PTAC/PTHP, pool systems, hot water use (including laundry), and guest room energy management systems. An energy audit is a good way to initiate the program. Hotels are just complicated enough in their usage and equipment that the investment of an audit is justified. In addition, larger hotels, with more complicated centralized systems and higher energy use, are likely to be the target of utility programs, further justifying an energy audit.

Beyond the energy audit, the ideal program for the sector would facilitate easy connections to qualified contractors. Having a contractor on-site, during or shortly after the audit, to provide a budget quote eases one hassle related to implementation. Either contractors or auditors need to support hotels in identifying rebates for which they may be eligible. General Managers are frequently unaware of rebate programs.

The average hotel in this study spends $105,000 per year on energy. Savings in the range of 5-20% are reasonable, based on this study. Unusually, their energy use is split evenly between gas and electric, which creates opportunities for conservation of both fuels. Screening hotels before conducting targeted outreach can improve the likelihood that the process will be mutually beneficial for the utility and the hotel. Screening on total dollars spent or number of rooms in a facility is simple and sufficient.

Non-energy benefits, specifically water savings and reduced maintenance, substantially impacted the overall payback of the measures considered. In some cases, over 50% of the savings attributed to a measure were from non-energy savings. Include estimates of these benefits when documenting the opportunity in a written report, when calculating simple payback, and when describing the measure to a decision maker. For many hotel decision makers, it is likely the clinching factor to move forward with a project may not be the energy bill cost savings, but other benefits such as increased guest comfort, reduced maintenance, improved safety, reduced breakdowns, and brand image.

Rebate Design

Utility rebates serve a function beyond making a project more affordable. By offering a rebate, a utility is making the statement that the energy savings of a particular product are real and that investment makes sense. Utilities should consider rebating some of the newer technologies explored in this study, like low-temperature laundry and liquid pool covers, to help make such a statement.

Liquid pool covers are about 65% as effective as a solid pool cover and for a typical hotel could save $700-$1,200 per year. Since the equipment required is only a standard pool pump and the chemicals are readily available for purchase, any pool supply/maintenance company could install the liquid pool cover. Even with the expense of a pool pump, this technology may have less than a one year payback, which could present a challenge to some utility cost-benefit calculations. This technology is especially appropriate for the hotel sector since they have long "open swim" hours, but infrequent guest use on weekdays. A solid pool cover would be removed most of the day, but a liquid pool cover can form whenever the pool surface is still.

Low-temperature laundry systems provide significant water and gas savings. Ozone systems have shifted out of popularity among hotel management, but low temperature systems are quickly gaining market share. The energy savings and water savings is sufficient to produce the less than one year payback needed to justify the annual chemical expense, but utilities could rebate the product based only on first year gas savings. Further work is needed by Minnesota utilities and the State of Minnesota Department of Commerce to determine how liquid pool covers and/or low temp laundry may be rebated.

Guest room energy management systems have yet to be adopted by the Minnesota hospitality sector (and, one might argue, their guests). Utilities should continue to provide rebates and consider using the incremental cost of adding the occupancy components to a thermostat installation in the savings calculation, since wall mounted thermostats are becoming more the industry norm and some brands are requiring their installation.

Operation and maintenance measures can contribute to energy reduction. In particular, pool room maintenance is not well understood. Pool room setpoints can frequently be poorly set-up, which results in wasted energy. Any effort to track and attribute behavioral savings could be well applied to the hotel sector.

Work Cited

Barber, N. (2014). Profiling the potential "green" hotel guest": Who are they and what do they want? *Journal of Hospitality and Tourism Research, 38*, 361-387.

Barsky, J. (1992). Customer satisfaction in the hotel industry: Meaning and measurement. *Journal of Hospitality & Tourism Research, 16*, 51-73.

Cadotte, E. &. (1988). Key factors in guest satisfaction. *Cornell Hotel and Restaurant Administration Quarterly, 28*, 44-51.

ENERGY STAR. (2007, December). *Chapter 12) Facility Type: Hotels and Motels*. Retrieved March 20, 2015, from ENERGY STAR Building Manual: http://www.energystar.gov/ia/business/EPA_BUM_CH12_HotelsMotels.pdf

ENERGY STAR. (2014, November). *Technical Reference: ENERGY STAR Score for Hotels in the United States*. Retrieved March 1, 2015, from www.energystar.gov: https://www.energystar.gov/sites/default/files/tools/Hotel.pdf

Explore Minnesota Tourism. (2008). *Minnesota Travel Green Task Force: Report and Recommendations.* Saint Paul, MN: State of Minnesota.

MnTAP, University of Minnesota. (2011). *Pollution Prevention and Energy Efficiency for Minnesota's Lodging Sector.* Sponsered by US EPA, EPA X0-00E95201-0.

Pacific Northwest National Laboratory. (2012, September).

ReferenceUSA. (n.d.). *Minnesota SIC 701101 "Hotels and Motels"*. Retrieved March 23, 2015, from U.S. Businesses Database, ReferenceUSA: http://0-www.referenceusa.com.alpha.stpaul.lib.mn.us/Home/Home

Susskind, A. &. (2011). Hotel guests' reactions to guest room sustainability initiatives. *Cornell Hospitality Report, 11*, 4-13.

Tierney, P. H. (2011). Do travelers support green practices and sustainable development? *Journal of Tourism Insights, 2*, 2, Article 5.

U.S. Department of Energy. (2015, March 3). *Dealerships to Donuts: Best Practices for Energy Efficiency in the Franchise Model*. Retrieved April 6, 2015, from Better Buildings Webinar Series: https://www4.eere.energy.gov/challenge/sites/default/files/uploaded-files/Dealerships_to_Donuts_March3_508.pdf

Zhang, J. J. (2012). Pushing the frontier of sustainable service operations management: Evidence from US hospitality industry. *Journal of Service Management, 23*, 377-399.

Appendix A: Guest Survey Results, March 2015

UNIVERSITY OF MINNESOTA | EXTENSION

TOURISM CENTER

Mainstreaming Motel Optimization: Guest Survey Results

March 6, 2015

Authored by Xinyi Qian, Ph.D., Katrina Nygaard, University of Minnesota Tourism Center, and Carl W. Samuelson, C.E.M., Michaels Energy

Editor:
Elyse Paxton

Report Reviewers:
Nancy Kelly Alexis Troschinetz

Partners/Sponsors:

This project was supported in whole by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development (CARD) program, which is funded by Minnesota ratepayers.

Michaels Energy contracted the University of Minnesota Tourism Center to conduct the research documented in this report. The research is part of a larger CARD grant to document energy efficiency opportunities in the hotel sector. The results of the full project, including those shared in this report, will be available in the future by the Department of Commerce.

The University of Minnesota Tourism Center is a collaboration of University of Minnesota Extension and the College of Food, Agricultural and Natural Resource Sciences.

© 2015 Regents of the University of Minnesota. All rights reserved. University of Minnesota Extension is an equal opportunity educator and employer. In accordance with the Americans with Disabilities Act, this material is available in alternative formats upon request. Direct requests to (612) 624-7165.

Table of Contents

List of Figures

List of Tables

LITERATURE REVIEW

The existing literature on hotel guest experience is abundant. Studies range from determining items of primary concern to guests, to the importance of sustainability and "going green" in the lodging sector, to survey design methods. These studies have facilitated the understanding of sustainable lodging and guest comfort, as well as guided survey design for the Motel Optimization Project. The literature review begins with an outline of relevant definitions and an overview of the theoretical framework. Next, it outlines important findings from the existing literature, as well as provides two case studies as guiding examples for our research. An annotated bibliography is included in Appendix A of this report.

CONCEPTS AND DEFINITIONS

The study of guest behavior within the lodging sector can be broken into three main categories based on the time the guest is surveyed. These categories include pre-stay expectations, during-stay comfort, and post-stay satisfaction.

Pre-stay expectations

Guest expectations regarding service quality and anticipated experience are derived from a variety of sources: room price, past experiences, and knowledge gained from others and the media (Barsky, 1992). These perceptions can be measured before or after a stay by conducting surveys about guest expectations and whether or not they were met.

During-stay comfort

For hoteliers, comfort during the stay is a very important part of the guest experience (Barsky, 1992; Min, Min, & Chung, 2002). Comfort, which can also be viewed as meeting expectations, is the most important factor in determining overall satisfaction (Barsky, 1992). However, unlike pre-stay expectations or post-stay satisfaction, guest comfort is very difficult to measure because feelings of comfort or discomfort change throughout the stay, a time in which survey administration is unlikely, if not impossible. To compensate for this problem, during-stay comfort is typically measured through the proxy of post-stay satisfaction surveys (Gunderson, Heide, & Olsson, 1996; Min, et al., 2002; Saleh & Ryan, 1992; Segarra-Ona, Peiro-Signes, Verma, Mondejar-Jimenez, & Vargas-Vargas, 2014).

Post-stay satisfaction

The most common measurement of guest perceptions of their hotel stay is post-stay satisfaction. In surveys conducted after a stay, guests may reveal their willingness to pay for a specific amenity, factors of importance to them or complaints about the quality of service (Atkinson, 1988; Cadotte, 1988; Dalton, Lockington, Baldock, 2008). By understanding guest satisfaction, hoteliers can better work to improve their product and grow their customer base (Atkinson, 1988).

The purpose of the survey in the Motel Optimization Project is to assess how a guest's comfort is affected by a hotel's energy efficiency. As outlined above, guest comfort, while the paramount concern of the hotel industry (Atkinson, 1988), is difficult to assess. Following other studies included in the literature review, our survey will be conducted immediately following the stay, while guests are still in the vicinity of the hotel (Min et al., 2002, Susskind & Verma, 2011).

THEORIES OF CUSTOMER SATISFACTION

Since the 1970s, academic interest in theories of customer satisfaction has grown immensely (Barsky, 1992). Two existing theories regarding how customers make choices are the rational choice theory and the disconfirmation theory. These theories operate in sequence under the economic principle that customers make decisions to optimize utility. Consumers make rational choices they feel will best suit their needs, based on previous knowledge and judgments. Once a decision has been made, customers establish expectations, and the confirmation or disconfirmation of these expectations lead to a sense of satisfaction or dissatisfaction (Barsky, 1992). Barsky posits that hotel guest satisfaction can be measured using these two theories.

GUEST COMFORT AND SUSTAINABLE PRACTICES

Interest in guest satisfaction and environmental sustainability practices has grown during the past three decades. The intersection of these two research areas has also been gaining popularity, particularly in the last ten years. The following three sections outline key findings from the existing literature in these research areas as they relate to the current project.

Determinants of guest comfort

Researchers have attempted to determine which physical features and staff-related elements of the hotel are most important to guest comfort and post-stay satisfaction. While the results of each study varied, the factors frequently identified as important to guest comfort are quietness of the room, safety, cleanliness, and employee attitude (Atkinson, 1988; Cadotte, 1988; Gunderson, et al., 1996; Lewis, 1984). Physical attributes of the room, such as bed comfort or lighting, while not as important, still had significant effects on overall satisfaction (Barsky, 1992; Gunderson, et al., 1996). In short, both physical and staff-related elements are important to post-stay satisfaction, despite variance in guest preferences across demographics and hotel types (Saleh & Ryan, 1992).

Guest preference of sustainable practices

Dalton, et al. (2007) examined the role of renewable energy sources (RES) in Australian hotels. They selected four hotels which were operating under RES or other energy efficiency measures and examined guest support for these systems. Through surveys and interviews of guests and staff, the researchers found that guests tended to be very supportive of energy efficiency measures in the lodging sector. Over 70 percent of survey respondents expressed willingness to reduce energy use by reducing use of heaters and air conditioners. Sixty percent of the respondents would be sympathetic to a power outage or black out if they knew it was due to malfunctioning of the RES system. In addition, nearly half of the respondents would be willing to pay more for hotels implementing energy efficiency measures, with acceptable cost increase between 5percent and10percent.These results were unprecedented, both in terms earlier researching findings and perceptions of hotel operators. The researchers argued that the findings suggest that researchers and hoteliers had "underestimate[d] both tourist confidence in RES and their willingness to accommodate any inconveniences arising from RES" (Dalton, et al., 2007, p.2183). In other words, the researchers attributed their findings to changing attitudes towards energy efficiency and sustainability in hotel design and operation.

Millar and Baloglu (2011) surveyed 571 travelers about their preferences for sustainable attributes in U.S. hotels. They asked guests to identify the most important of seven attributes, including a recycling policy, refillable shampoo dispensers, controlled lighting, energy efficient bulbs, towel and linen reuse programs, and green certification. These attributes were selected based on a literature review of green certification programs, guest preferences, and the researchers' own pilot study. The researchers found that green certification and energy efficient bulbs were the most important factors for guests. Moreover, cues such as certification are exceptionally helpful in determining at which hotel to stay. One problem with certification (e.g., the US Green Building Council's LEED Certification) is the prohibitive cost, which has resulted in a very small number of hotels that have sought certification. Unlike Dalton et al. (2007), Millar and Baloglu found that most customers were not willing to pay higher prices for green attributes and attributed the finding to the price sensitive characteristics of leisure travelers. The researchers concluded with the argument that additional research is needed to examine the effects of green attributes on guest comfort in different types of hotels.

Effects of sustainable practices on guest comfort and hotel operations

In recent years, "going green" has become increasingly important for hoteliers and guests (Barber, 2014; Bohdanowicz, 2005; Millar & Baloglu, 2011). Multiple studies have measured tangible changes to business practices while providing managers with tools to better run their operations (Becken, Frampton, & Simmons, 2001; Chan & Lam, 2003; DeFran, 1996). These best management practices include recommendations for changes in energy efficiency, waste management, and water conservation, both in guest rooms and common spaces (DeFran, 1996). Research on sustainability in the lodging sector has also assessed employee training programs and guest attitudes. The combination of physical changes, as well as changes in hotel management and staff training can help increase the importance and success of sustainability in hotel operations (Bohdanowicz, 2005; Bohdanowicz, Zientara, & Novotna, 2011; Kasim, 2004). Guests' demands for environmentally friendly accommodations have also played an increasing role in facilitating sustainable practices in the lodging sector (Barber, 2014; Han, Hsu, Li & Sheu, 2011; Millar & Baloglu, 2011).

The effects of sustainable practices can be measured through guest perceptions and satisfaction, as well as changes in hotel operation costs. Susskind and Verma (2011) monitored the impact of lighting and television improvements on guest satisfaction at the Statler Hotel at Cornell University. Neither overall satisfaction with television quality nor satisfaction with television picture quality differed by energy setting. Additionally, bathroom lighting conditions did not make a significant difference in satisfaction with bathroom lighting. Other studies that have measured the integration of sustainable features into hotel operations have focused on energy costs and the hotel's bottom line. Tested features include timers, occupancy sensors, low energy-consuming materials, renewable energy sources, and heat pumps for pools (Chan & Lam, 2003; Erdogan & Tosun, 2009; Meade, 2014). While these studies measured the monetary and energy use effects of various upgrades, they did not examine the effect of energy efficiency on guest comfort, which is "the primary consideration in any hotel building project" (Energy Star, 2008, p. 2).

SURVEY METHOD

Since the 1970s, interest in methods, strategies and best practices for tracking hotel guests' expectations, comfort, and satisfaction has grown. Researchers have been able to better understand guest preferences and to use that data to inform best practices for hotel managers, through detailed surveys and interviews (Lewis & Pizam, 1981). Therefore, survey methods have evolved to enable researchers to obtain higher quality data. Some of the evolutions include providing space for comments, the use of a Likert scale, inclusion of "neutral" or "not applicable" as answer options, and clear, direct questions (Lewis & Pizam, 1981; Schall, 2003).

SUMMARY

Clearly, there has been extensive research on hotel guests' expectation and satisfaction. There has also been growing attention on the sustainable practices of hotels and guest attitudes toward these practices. Much less research has been conducted to assess how hotels' sustainable practices influence guests' perceived comfort or satisfaction. Therefore, the purpose of the current guest survey is to assess whether and how hotels' energy efficiency performance, which is an aspect of sustainability, affects guests' perceived comfort.

METHODOLOGY

Questionnaire

The guest comfort questionnaire was developed based on previous research findings (see Appendix B for a copy of the actual questionnaire). The questionnaire included items directly related to energy efficiency and corresponded with technical data collection, including temperature control and consistency, noise level of the heating and cooling unit, ambient noise, water temperature and pressure, lighting, and air quality. Respondents also answered questions about bed comfort and room cleanliness—two factors, according to previous research, that are highly relevant to overall room experience. Both the lighting and air quality items were measured using a 1-7 scale, where the mid-point was "about right" while both higher and lower scores reflected less satisfactory quality. Specifically, for the lighting item, 1=too dim, 4=nicely lit, and 7=too bright. For the air quality item, 1=too dry, 4=about right, and 7=too humid. All other items were measured on a 7-point Likert scale, with higher scores reflecting greater satisfaction or desirability. For all items, a "not applicable" option was available.

Survey Sites

The guest comfort survey was administered in four hotels in the Minneapolis-Saint Paul Metropolitan Area and one hotel in Rochester, Minnesota. All five hotels were built between 1994 and 2000. In each of the five hotels, the survey took place in the breakfast room, given its central location and the high volume of guests using the space each morning. All but one hotel offered a complimentary breakfast to its guests. As an incentive, each respondent who completed the questionnaire received a five-dollar gift card to a coffee shop.

Survey Process

For one hotel in Minneapolis, the survey was administered in two mornings—on a Saturday and then a Wednesday. The survey was administered in one morning for each of the other four hotels, with three on Wednesdays and one on a Thursday. A trained research assistant from the University of Minnesota approached guests in the breakfast room of each hotel and asked if the guest would be interested in completing a questionnaire. Most respondents completed the questionnaire themselves. However, a few questionnaires were administered verbally, with the research assistant reading aloud the questions and answer options.

Technical Data Collection

A team of engineers audited each of the five hotels to analyze energy efficiency opportunities. Data collected at each hotel is shown in Table 1.

Since comfort is a subjective perception that involves multiple aspects during guests' stay, relating the technical data to specific survey questions of comfort was an imperfect effort. Some relationships are more intuitive (e.g., dimness to perceived lighting); others, such as temperature control and consistency, were more challenging.

The categorization of technical data faces two challenges. First, there was not always variability among the five hotels. For instance, they had similar performance in terms of shower head flow and room tightness. Second, a value code was assigned to each of the five hotels for every technical measurement. However, it is not clear whether performance moderately below or above the recommended code is desirable. For instance, ventilating at greater than 50 CFM may not be better than ventilating at 50 or even 45 CFM. For the analyses reported in this document, the hotels were grouped according to similarity in value code for each technical measurement to the best of our ability.

Table 1: Data collected during Engineering Assessment

Building Description and Bill Data	Equipment Specifications	Field Measurements
Square footage Number of rooms Occupancy rate Gas usage history Electric usage history Water usage history	HVAC equipment efficiency Water heater efficiency Showerhead flow Faucet aerator flow Lighting types/wattage Control set-points	Exhaust fan flow Noise levels Light levels Room tightness (in relation to outside) Pool temperature Air temp and humidity

Data Entry and Analysis

Survey data was entered into Microsoft Excel (version 2010). The data file was checked and cleaned. Analysis provided percentages, means, medians, and standard deviations for all items on the questionnaire for each of the five hotels, as well as descriptive statistics of survey participants. To provide descriptive statistics for the lighting and air quality items, the data was recoded as follows:

Original Value	New Value
1 or 7	1
2 or 6	2
3 or 5	3
4	4

To understand the relationship between different aspects of guests' perceived comfort, Pearson correlation was used to examine bivariate correlations between the following four pairs of factors: (1) ease of temperature control and temperature consistency, (2) ambient quietness and quietness of the heating and cooling unit, (3) satisfaction with water temperature and with water pressure, and (4) sheet softness and towel softness. A *t*-test was used to assess whether or not perceived temperature consistency differed between those who adjusted the thermostat and those who did not. Additionally, regression was used to examine which factors had significant effect on guests' overall room experience.

To explore the correspondence between objective measures of hotel energy efficiency and guests' perceived comfort, technical data obtained through engineering audits was paired with guest survey data and merged into a single dataset. The technical data includes shower head flow, faucet aerator flow, water temperature, lighting output (for the headboard, desk, and vanity), the Energy Efficiency Ratio (EER) of heating/cooling equipment, average guest room tightness in cubic feet per minute (CFM), average CFM of exhaust fan, electricity usage, gas usage, and water usage. The merged dataset was then imported into SPSS (version 22.0) for further analysis. One-way Analysis of Variance (ANOVA), one-way Analysis of Covariance (ANCOVA), two-way ANCOVA, and *t*-test were conducted to assess whether guests' perceived comfort differed by hotels' energy efficiency performance. To conduct the analyses, the five hotels were divided into different categories according to their energy efficiency performance. Altogether, nine one-way ANOVA tests, three *t*-tests, two one-way ANCOVA tests, and one two-way ANCOVA were conducted. See Table 2 for the categorization and ANOVA tests performed.

Table 2: Categorization of technical data and list of statistical tests performed

	Description	Categorization[1]				Statistical test	Outcome variable	Control variable(s)
		1	2	3	4			
Water Temperature	120 is the best practice. Settings lower than 120 require special laundry facilities	Hotel 1	Hotels 1, 4, and 5	Hotel 3	--	ANOVA	Satisfaction with water temperature	--
						ANOVA	Sheet softness	--
						ANOVA	Towel softness	--
Shower Head Flow	1.5 is recommended	Hotels 1 and 5	Hotels 2 and 4	Hotel 3	--	ANOVA	Satisfaction with water pressure	--
EER	The higher the better	Hotels 3 and 5	Hotels 1, 2 and 4	--	--	*t*-test	Temperature consistency	--
						t-test	Satisfaction with temperature control	--
						t-test	Quietness of the heating and cooling unit	--
Room Tightness	The lower the better[2]	Hotel 2	Hotels 1 and 3	Hotel 4	Hotel 5	ANOVA	Ambient quietness	--
Vanity Lighting	19 is the best practice. Below 19 is too dim; way above 19 is too bright	Hotel 2	Hotel 4	Hotel 5	Hotels 1 and 3	ANOVA	Lighting	--
Headboard Lighting		Hotel 4	Hotels 1 and 5	Hotel 2	Hotel 3	ANOVA	Lighting	--
Desk Lighting		Hotel 2	Hotel 5	Hotels 1 and 3	Hotel 4	ANOVA	Lighting	--
Exhaust Fan Rate	50 is the best practice. Below 50 may be humid; above 70 may be dry	Hotel 4	Hotels 3 and 5	Hotel 1	Hotel 2	ANOVA	Air quality	--
Energy Star Rating	The higher, the better	Hotel 5	Hotels 1 and 2	Hotels 3 and 4	--	ANCOVA	Overall room experience	Bed comfort, room cleanliness
Gas Usage	The less used, the better	Hotels 1 and2	Hotels 3 and 5	Hotel 4	--	ANCOVA	Overall room experience	Bed comfort, room cleanliness
Electricity Usage		Hotel 3	Hotels 1 and 2	Hotels 4 and 5	--			

	Description	Categorization[1]				Statistical test	Outcome variable	Control variable(s)
		1	2	3	4			
Water Usage		Hotels 2 and 5	Hotel 1	Hotels 3 and 4	--	ANCOVA	Overall room experience	Bed comfort, room cleanliness

[1]The higher the category number, the higher the score on a technical variable.
[2]While the 5 hotels have been categorized, there was very little difference between air flow rates.

RESULTS

Descriptive statistics

Guest room amenities

Overall, the level of satisfaction with various aspects of the guest room was high (Table 3, Figure 1). Respondents were highly satisfied with water temperature, and there was little variation in the level of agreement (as indicated by a small standard deviation). Guests were also fairly satisfied with water pressure and room temperature control, with average ratings close to 6 out of 7. The ratings for bed comfort, sheet and towel softness, as well as temperature consistency were high as well, with an average between 5.6 and 5.8. The two aspects with the lowest average ratings were ambient quietness and quietness of the heating and cooling unit—the former had an average just above five, and the latter had an average below five.

Table 3: Summary statistics of perceived room amenities

	Mean[1]	Median[1]	SD
Satisfaction with Water Temperature (n=124)	6.20	7	1.20
Satisfaction with Water Pressure (n=124)	5.98	7	1.38
Satisfaction with Temperature Control (n=116)	5.87	6.5	1.38
Bed Comfort (n=125)	5.80	6	1.44
Sheet Softness (n=122)	5.70	6	1.16
Temperature Consistency (n=122)	5.66	6	1.40
Towel Softness (n=125)	5.64	6	1.23
Ambient Quietness (n=124)	5.10	5	1.47
Quietness of the Heating and Cooling Unit (n=122)	4.74	5	1.65

[1]Rated on a scale where 1=Least satisfactory, 4=Neutral, 7=Most satisfactory

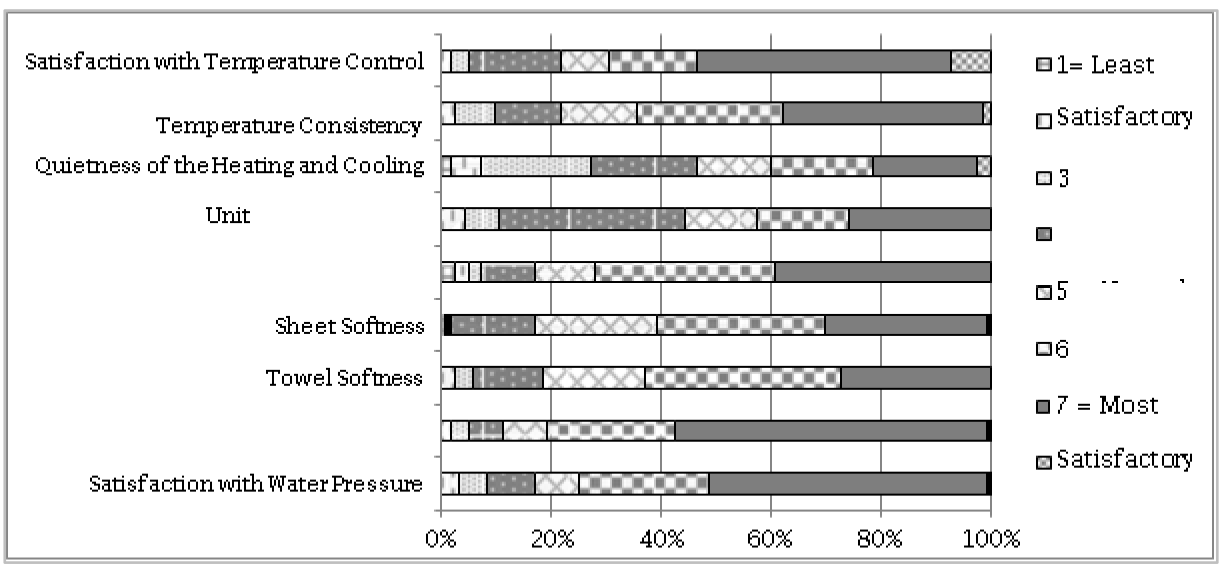


Figure 1: Guest ratings of perceived room amenities (n=125)

Setting room temperature

About 72 percent of the respondents (n=89) adjusted the thermostat in their guest rooms during their stay (Figure 2). Among the 89 respondents, 26 percent set the temperature at 68 degrees Fahrenheit and 20 percent at 70 degrees (Figure 3). The average temperature the respondents set was 70 degrees Fahrenheit, and the variation in temperature setting was small (Table 4).

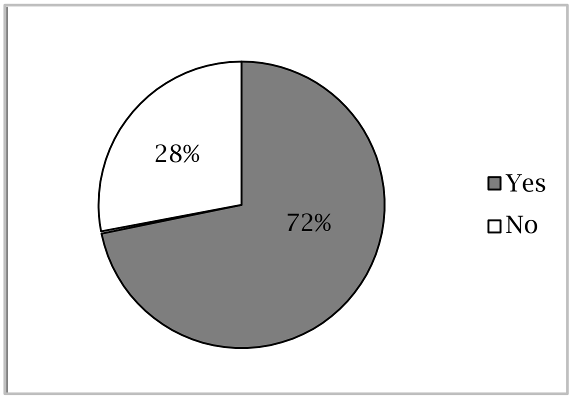


Figure 2: Percentage of respondents who did and did not adjust thermostat in room (n=124)

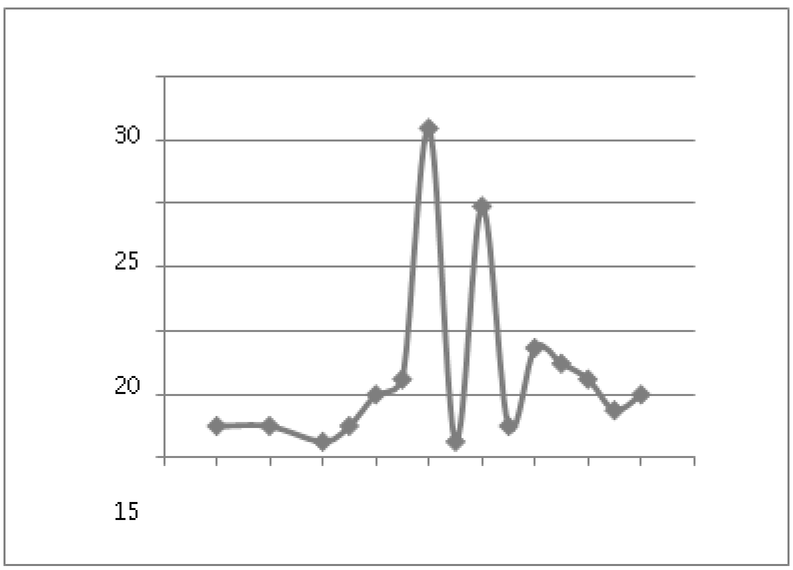


Figure 3: Percentage of respondents setting different temperatures in room (n=81)

Table 4: Summary statistics of respondents' in-room temperature setting (n=89)

Mean[1]	Median[1]	SD
70	70	3.50

[1]In Degrees Fahrenheit

Light and air

Both air quality and lighting received high ratings from the respondents (Table 5, Figure 4). About 75 percent of the respondents rated the air in the room "about right"—neither too dry nor too damp. A little over 70 percent rated the room as nicely lit, neither too dim nor too bright.

Table 5: Summary statistics of perceived lighting and air quality (n=125)

	Mean[1]	Median[1]	SD
Air Quality	3.68	4	0.60
Lighting	3.65	4	0.61

[1]Rated on a scale where 1 = Least satisfactory, 4 = Neutral, 7 = Most satisfactory

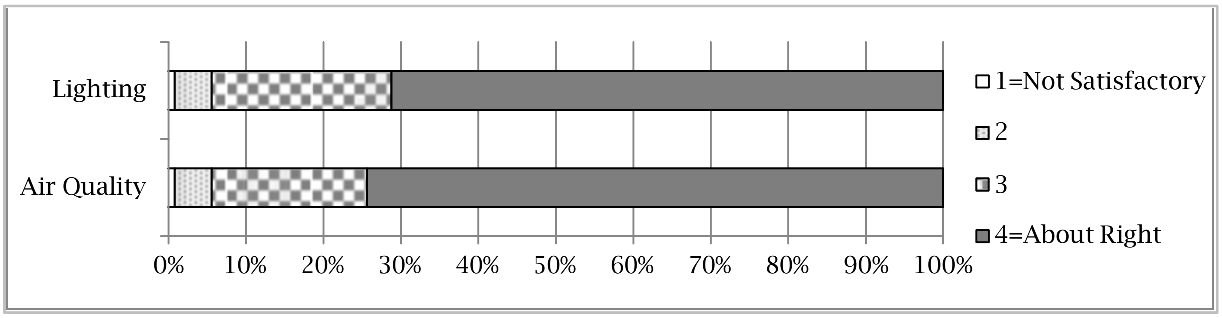


Figure 4: Respondents' ratings of lighting and air quality (n=125)

Overall room experience

The ratings for room cleanliness and overall room experience were high, both with an average above 6 (Table 6). Only about 10 percent of respondents rated the room cleanliness and overall room experience as neutral or worse (Figure 5).

Table 6: Summary statistics of respondents' overall room experiences (n=122)

	Mean[1]	Median[1]	SD
Room Cleanliness	6.19	7	1.13
Room Experience	6.11	6	1.09

[1]Rated on a scale where 1=Least satisfactory, 4=Neutral, 7=Most satisfactory

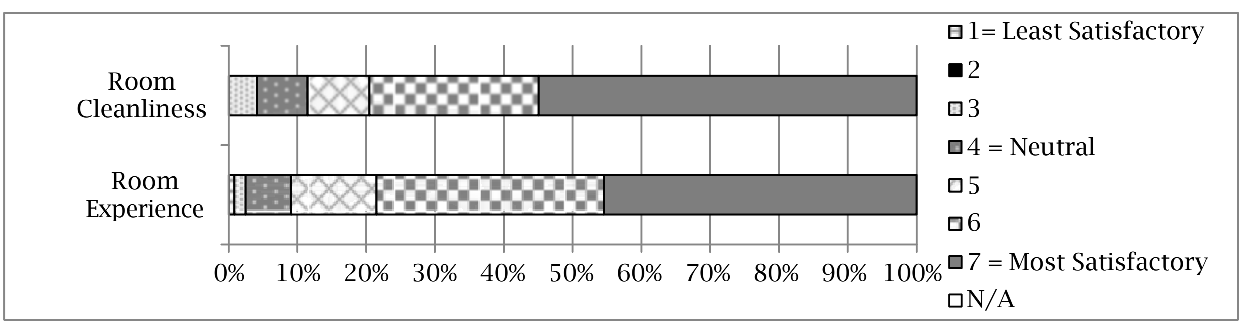


Figure 5: Respondents' ratings of overall room experiences (n=122)

Hotel qualities, room amenities, and energy efficiency certification

Location was the most important quality that respondents considered when choosing a hotel, as identified by close to 80 percent of the respondents (Figure 6). Room comfort and cost were the next two most important hotel qualities, identified by more than 60 percent of the respondents. Close to 50 percent of respondents identified hotel amenities and previous experience as important qualities to consider when choosing a hotel. The remaining three qualities—hotel brand, guest reviews, and availability of special packages—were important to no more than 35 percent of respondents.

Figure 6: Important qualities to consider when choosing a hotel. Multiple responses allowed. (n=122)

More than 90 percent of the respondents identified cleanliness, and close to 80 percent identified bed comfort as important hotel amenities that make their stay comfortable (Figure 7). There were also more than 50 percent of respondents identifying quietness and friendly staff as important to a comfortable stay. Room temperature is important to a little more than 40 percent of the respondents. No more than 25 percent of the respondents identified bathroom amenities, hotel common areas, or room lighting as amenities important to a comfortable stay.

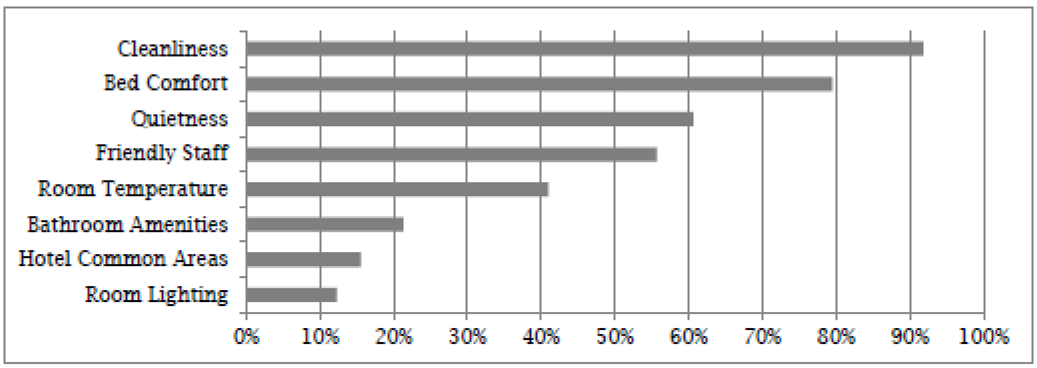


Figure 7: Hotel amenities important to a comfortable stay. Multiple responses allowed. (n=122)

If other criteria (e.g., cost, location) were comparable, 60 percent of respondents would choose a hotel that was certified as energy efficient (Figure 8), 36 percent of the respondents would not, and 4 percent preferred not to answer the question.

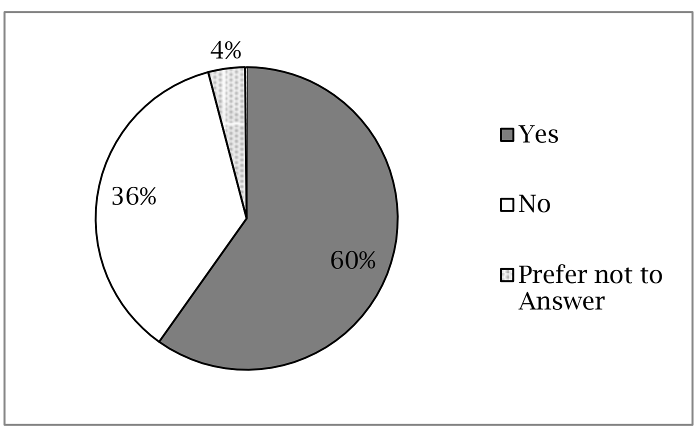


Figure 8: Percentage of respondents who would and would not choose an energy efficient hotel (n=122)

Trip purpose and previous hotel experiences

Close to 60 percent of respondents had not stayed at the property before (Table 7). Of the 43 percent who had stayed at the property before, half had stayed one to three times. Sixty percent of respondents traveled for business purposes, 23 percent for leisure, 7 percent for a combination of business and leisure, and 10 percent for purposes other than business or leisure. Finally, 51 percent of respondents had previously complained to a hotel because a room was uncomfortable, and 48 percent had not. Guests also provided additional, qualitative comments about their stay at the end of the questionnaire (see Appendix C for actual comments).

Table 7: Trip purpose and previous hotel experiences of respondents

	Frequency	Percentage (percent)
Have you stayed at this hotel before? (n=122)		
No	70	57percent
Yes	52	43percent
1 – 3	26	50percent
4 – 6	9	17percent
7 – 10	9	17percent
More than 10 times	8	16percent
Please indicate the purpose of your trip (n=121):		
Business	73	60percent
Leisure	28	23percent
Business and Leisure	8	7percent
Other	12	10percent
Have you ever complained to a hotel because a room was uncomfortable? (n=120)		
Yes	61	51percent
No	58	48percent
Prefer not to answer	1	1percent

Relationships among different aspects of guest room experience

Bivariate correlations between all four pairs of variables were significantly positive at the 0.01 level (Table 8).The correlation for three of the four pairs was greater than 0.40, with the fourth pair (sheet softness and towel softness) lower than 0.30.

Table 8: Summary of Pearson Correlation results (n=125)

Variables	Pearson Correlation
Satisfaction with temperature Control, Temperature Consistency	.426*
Quietness of the Heating and Cooling Unit, Ambient Quietness	.524*
Satisfaction with Water Pressure, Satisfaction with Water Temperature	.588*
Sheet softness, Towel softness	.265*

*Significant at .01 level

Perception of temperature consistency differed significantly (*t*=2.47, *p*=0.016) between respondents who adjusted the in-room thermostat and those who did not (Table 9). Guests who did not adjust the in-room thermostat perceived room temperature to be significantly more consistent than those who adjusted the thermostat.

Table 9: *t*-test results comparing temperature consistency perception between guests who adjusted thermostat and those who did not

Thermostat adjustment	n	Mean	SD	*t*-value	df
Yes	88	5.49	1.48	2.47*	79
No	33	6.09	1.07		

*$p<0.05$

Room cleanliness (β=0.37, $p<0.0005$) and bed comfort (β=0.26, $p=0.001$) had significant effects on a guest's overall room experience. Guests who perceived the room as clean, or perceived the bed as comfortable, were more likely to rate the overall room experience highly. None of the other 10 factors had a significant effect on overall room experience (Table 10)

Table 10: Summary of multiple regression analysis for respondents' overall room experience (n=125)

Variable	B	SE (B)	β
Lighting	0.15	0.14	0.08
Air Quality	0.18	0.13	0.10
Satisfaction with Temperature Control	0.05	0.07	0.06
Temperature Consistency	0.08	0.07	0.11
Quietness of the Heating and Cooling Unit	0.08	0.06	0.12
Ambient Quietness	0.01	0.06	0.01
Bed Comfort	0.20	0.06	0.26*
Sheet softness	0.09	0.08	0.101
Satisfaction with Water Pressure	-0.00	0.08	-0.00
Satisfaction with Water Temperature	-0.01	0.10	-0.01
Towel softness	-0.02	0.08	-0.02
Room Cleanliness	0.37	0.09	0.37*

*$p<0.01$

Linking technical data to guest perception

To understand the effect of a hotel's energy efficiency on a guest's perceived comfort, we assessed whether hotels' energy efficiency performances made significant differences in corresponding perceived comfort measures. For example, we assessed whether a hotel's room tightness made a difference in a guest's perception of ambient noise. Altogether, there were three statistically significant findings: (1) exhaust fan rating made significant differences in perceived in-room air quality; (2) EER rating made significant differences in perceived temperature consistency; and (3) hotels' gas usage made significant differences in guests' overall room experience.

The first significant finding is that guests from hotels with different exhaust fan ratings perceived in-room air quality differently (*F*=5.31, *p*=0.002; Table 11). Specifically, guests staying in Hotel 2 perceived in-room air to be significantly drier than those staying in Hotel 1. Indeed, Hotel 2 had an exhaust fan rating of 85, which is higher than Hotel 2's, which was 69. Meanwhile, guests staying in Hotel 3 and 5 also perceived in-room air to be significantly drier than those staying in Hotel 1.
However, Hotel 3 and 5 had an exhaust fan rating around 35, which indicates *humid* air! Therefore, the significant finding is the opposite of what would be expected.

It is important to note that, while satisfaction with water pressure did not differ significantly by shower head flow rate, the flow rates of the five hotels were similar to each other (differing by only .50 gpm), which may be the reason for the insignificant finding. Table 11 summarizes the findings of these tests.

Table 11: Summary of one-way Analysis of Variance and one-way Analysis of Covariance tests results

Dependent variable	Independent variable	n	Mean	SD	*F*
	Water temperature				
Satisfaction with water temperature	Hotel 2	22	6.41	0.85	0.78
	Hotels 1, 4, and 5	79	6.10	1.26	
	Hotel 3	23	6.35	1.27	
	Water temperature				
Sheet softness	Hotel 2	22	5.33	1.09	1.67
	Hotels 1, 4 and 5	78	5.82	1.23	
	Hotel 3	22	5.64	0.90	
	Water temperature				
Towel softness	Hotel 2	22	5.68	1.36	1.36
	Hotels 1, 4 and 5	80	5.74	1.11	
	Hotel 3	23	5.26	1.48	
	Shower head flow				
Satisfaction with water pressure	Hotels 1 and 5	37	5.84	1.44	0.33
	Hotels 2 and 4	64	6.00	1.36	
	Hotel 3	23	6.13	1.39	
	Vanity lighting				
Perceived lighting[3]	Hotel 2	22	3.95	0.49	0.73
	Hotel 4	43	3.95	0.72	
	Hotel 5	15	3.67	0.62	
	Hotels 1 and 3	45	3.96	0.80	
	Head board lighting				
Perceived lighting[3]	Hotel 4	43	3.95	0.72	0.44
	Hotels 1 and 5	37	3.81	0.70	
	Hotel 2	22	3.95	0.49	
	Hotel 3	23	4.00	0.85	
	Desk lighting				
Perceived lighting[3]	Hotel 2	22	3.95	0.49	0.73
	Hotel 5	15	3.67	0.62	
	Hotels 1 and 3	45	3.96	0.80	
	Hotel 4	43	3.95	0.72	
	Exhaust fan rating				
Air quality[3]	Hotel 4	43	4.07	0.51	5.31*
	Hotels 3 and 5	38	3.82	0.83	
	Hotel 1	22	4.45	0.60	
	Hotel 2	22	3.82	0.59	
	Room Tightness[2]				
Ambient quietness	Hotel 2	22	5.18	1.62	0.30
	Hotels 1 and 3	44	4.95	1.56	
	Hotel 4	43	5.23	1.41	
	Hotel 5	15	5.00	1.25	
	Energy Star Rating				
Overall room experience[1]	Hotel 5	22	6.35	0.67	1.75
	Hotels 1 and 2	37	5.81	1.43	
	Hotels 3 and 4	66	6.20	0.95	
	Water Usage				
Overall room experience[1]	Hotels 2 and 5	35	5.99	1.45	0.60
	Hotel 1	21	6.14	0.72	
	Hotels 3 and 4	65	6.16	1.09	

*$p<0.005$. [1]Effects of bed comfort and room cleanliness controlled for. There is little difference between room tightness across all five hotels. [3]Adjusted to a 1- 4 scale.

The EER rating of the heating/cooling unit in each room was used as an indicator of the age and quality of the heating and cooling unit. A higher EER was also assumed to indicate a quieter unit that would maintain a set point more accurately and be easier to control. Respondents from hotels with different EER ratings perceived in-room temperature consistency differently (t=-3.08, p=0.003; Table 12). Specifically, guests staying in hotels with higher EER perceived the temperature to be more consistent than those staying in hotels with lower EER.

Table 12: *t*-test results comparing perceived temperature consistency, ease of temperature control, and quietness of heating and cooling unit between hotels with lower EER and those with higher EER

	EER	n	Mean	SD	*t*-value	df
Temperature Consistency	Hotels 3 and 5 Hotels 1, 2, and 4	36 86	5.00 5.94	1.67 1.17	-3.08*	50
Ease of Temperature Control	Hotels 3 and 5 Hotels 1, 2, and 4	34 82	5.76 5.91	1.58 1.30	-0.49	52
Quietness of Heating and Cooling Unit	Hotels 3 and 5 Hotels 1, 2, and 4	37 85	4.38 4.89	1.83 1.55	-1.50	59

*p<0.05

Guests' overall room experience differed significantly by gas usage (F=10.37, p=0.002) but not electricity usage, after controlling for the effects of bed comfort and room cleanliness (Table 13). Specifically, guests staying in Hotel 1 and Hotel 2 rated their overall room experience as more comfortable than those staying in Hotel 3 or Hotel 5. The former two hotels used less gas than the latter two. Meanwhile, guests staying in Hotel 4, which used the most gas, also rated their overall room experience as more comfortable than those staying in Hotel 3 or 5. The gas usage in Hotel 4 was higher due to a full service restaurant on the premise.

Table 13: Summary of two-way Analysis of Covariance tests

		Overall room experience			*F*
		n	Mean	SD	
Gas usage[1]	Hotels 1 and 2	41	6.32	0.69	10.37*
	Hotels 3 and 5	37	5.51	1.45	
	Hotel 4	43	6.42	0.85	
Electricity usage[1]	Hotels 1 and 2	22	5.77	1.02	2.25
	Hotels 3 and 5	41	6.32	0.69	
	Hotel 4	58	6.09	1.31	

*p<0.005

[1]Effects of bed comfort and room cleanliness controlled for

DISCUSSION

Little research has examined the relationship between hotels' energy efficiency performance and guests' perceived comfort (see Susskind & Verma, 2011, as an exception). Therefore, the current study is among the first to fill this void and to provide initial insight into this increasingly important aspect of hotel operations. Overall, hotels' energy efficiency does not have much effect on guests' experience of comfort.

Cleanliness and bed comfort were the two most important aspects to a satisfactory hotel room experience, as documented in the literature (Barsky, 1992; Cadotte, 1988; Gunderson, 1996; Saleh & Ryan, 1992). One can assume that room comfort is primarily interpreted as these two amenities. In addition, only 60 percent of guests would choose an energy efficient hotel when presented two comparable options. Therefore, while it is not likely that energy efficiency will drive people to or away from a hotel, it is also not likely that energy efficiency improvement will be noticed by guests, as its impact on comfort seems minor.

The four pairs of significant correlations suggest that, when filling out the questionnaire, guests reflected on aspects of their in-room experience in a more general rather than specific way, making it difficult to associate any specific energy efficiency measure with guest perception. For example, a guest may have assessed overall room quietness, rather than differentiating between the quietness of the heating/cooling unit and ambient quietness. Similarly, guests may have assessed the shower experience as a whole, instead of as an experience that consists of both water temperature and water pressure.

The significant effect of EER rating of heating and cooling units on perceived comfort indicates that a more efficient unit makes a positive contribution to guests' perceived comfort. Hotel owners can confidently invest in more efficient units, knowing the investment will reduce their energy bills and improve (or at least maintain) guest comfort.

The significant effect of exhaust fan flow on air quality and that of gas usage on overall room experience are puzzling and need more information for appropriate interpretation. For the effect of exhaust fan on air quality, the most likely explanation is that the measurement of bath fan exhaust flow in CFM is not sufficient enough to explain perceived air quality. Other variables, such as fan location, window operation, room tightness, and common space ventilation, also affect air quality but were not available for the current analysis.

The effect of gas usage on guests' overall room experience was also intriguing, as guests staying in hotels with low gas use and those with high gas use rated their experience as more satisfactory than those staying in hotels with moderate gas use. All five hotels were built between 1994 and 2000. From an engineering perspective, the five hotels do not differ much in equipment efficiency. Therefore, it is unlikely that the significant effect of gas use is a spurious effect of recent renovation or variations in equipment. The survey was administered between May 31 and June 4 with higher than historical average temperatures of above 80 degrees Fahrenheit. Therefore, it is unlikely that guests were concerned with heating when they responded to the survey. One possible explanation is hotel management practice. Regular maintenance helps reduce gas use and may contribute to guest comfort.

Aside from the significant findings, the insignificant results also provided valuable insights. Hotels do not have to use a lot of water to create satisfactory room experience for guests, as water usage had no effect on guests' overall room experience. It is also encouraging that a hotel's water temperature setting did not matter to guest satisfaction with either water temperature, perceived sheet softness, or perceived towel softness. Hotels with high water temperature settings can be encouraged to lower the setting to save energy without hampering guest experience. Furthermore, hotels can reduce lighting levels (desk, vanity, and headboard), as none of these lighting factors had significant effect on guest satisfaction, and room lighting is the least important hotel amenity, according to the survey finding. In terms of shower head flow, a 0.5 gallon per minute (gpm) difference (2.5 versus 2.0) is sizable, although no hotel had a "low-flow" showerhead rated at 1.5 or less gpm. The lack of difference in satisfaction with water pressure or temperature between guests staying in hotels with 2.5 gpm and those with 2.0 gpm offers hope that further reduction in water pressure to reach "low-flow" status may go unnoticed and create no adverse effect on guest comfort.

Lastly, several aspects of the survey process are worth discussion. First, the question that asks respondents whether they would choose an energy efficient hotel, assuming other criteria were comparable, spans two lines. It is possible that some respondents answered the question without reading the entire question, especially the second line of the question that reads "assuming other criteria (e.g., cost, location) were comparable." Therefore, answers to this question may not reflect hotel guests' actual preference for energy efficiency hotels when other criteria are comparable.
Second, the survey mostly took place on weekdays rather than weekends, which may explain the finding that more respondents were business rather than leisure travelers. The prevalence of business travelers, in turn, may explain the unimportance of hotel brand and special package availability as hotel amenities. Many businesses and organizations have pre-arranged contracts with certain hotel brands, leaving little to no choice to the individual business travelers in terms of hotel brand and special package availability. The third aspect of the survey process worth noting is access to potential respondents. All but one hotel offered free breakfasts to guests. This situation may have affected the sample at the hotel with a paid breakfast, as some guests did not have breakfast in the hotel, thus not being approached for the survey. Additionally, a complimentary airport shuttle (where available) may provide an additional opportunity to approach guests for the survey but was not exploited in the current study.

APPENDIX A: ANNOTATED BIBLIOGRAPHY

The following publications were consulted in order to better understand the role of energy efficiency in the lodging sector. The subject of the currently published literature falls into seven major categories: American studies in sustainable lodging, international studies in sustainable lodging, tools for hotels, guest satisfaction, determinants of guest comfort, guest attitudes towards green practices, and research methodology.

American studies in sustainable lodging

Minnesota Technical Assistance Program (2011). *Pollution Prevention and Energy Efficiency for Minnesota's Lodging Sector.* Minneapolis, MN: University of Minnesota.

This report examined energy efficiency measures in 27 Minnesota hotels. MnTAP used surveys and onsite checks to monitor and determine the available efficiency measures and associated costs, savings, and payback time. The report found that 81percent of hotels already practice some energy efficiency measures, with the most common being efficient lighting. While not included in the report, data collection was scheduled to last an additional two years to further understand long term effects.

Nicholls, S., & Kang, S. (2012a). Going green: the adoption of environmental initiatives in Michigan's lodging sector. *Journal of Sustainable Tourism, 20* (7), 953-974.

Nicholls and Kang surveyed 217 Michigan hotels, most of which were small, independent properties in rural areas of the state. Their survey attempted to determine which green practices were most common in these properties. They found the most common was linen and towel reuse (84percent of properties). In terms of energy efficiency, using efficient light bulbs and Energy-Star appliances were most common (64-77 percent), whereas key card activated electricity was rarely employed (11 percent).

Nicholls, S., & Kang, S. (2012b). Green initiatives in the lodging sector: Are properties putting their principles into practice? *International Journal of Hospitality Management, 31*, 609-611.

This article was a continuation of Nicholls and Kang's previous study of employing green tools in Michigan hotels. Working with the same set of hotels, they were able to determine the gap between what hotel operators felt they should be doing and if those practices were actually being adopted. They found the margin of difference was small for some measures, such as a linen and towel reuse program (86 percent believe it should happen compared to 84 percent employing it). However, the margin was quite large in the case of environmental certification (54 percent compared to 12 percent). They attributed these differences to structural barriers to implementation.

Smerecnik, K., & Andersen, P. (2011). The diffusion of environmental sustainability innovations in North American hotels and ski resorts. *Journal of Sustainable Tourism, 19* (2), 171-196.

Smerecnik and Andersen surveyed 49 hotels and ski resorts to determine which environmentally friendly practices were being implemented and why. Ski resorts were selected because they rely on the natural environment for profit and typically support environmentally conscious guests. One of their survey categories was energy efficiency, and 90 percent of the hotels employed one or more energy efficiency practices. The authors concluded the simplicity of environmental practices was the largest predictor in whether or not it would be employed.

Zhang, J., Jogelkar, N., & Verma, R. (2012). Pushing the frontier of sustainable service operations management: Evidence from us hospitality industry. *Journal of Service Management, 23 (3),* 377-399.

This study examined the relationship between sustainability practices and operating performance in hotels across the United States. The authors found hoteliers were often unaware of the economic benefits of sustainability measures, which was a major barrier to implementation. Their research found that customer behavior drove demand for hotel sustainability, so it is recommended hotel owners and operators consult guests more.

Zhang, J., Jogelkar, N., Verma, R., & Heineke, J. (2014). Exploring the relationship between eco-certifications and resource efficiency in us hotels. *Cornell Hospitality Report, 14 (7),* 4-16.

This study examined the connections between eco-certification and the use of resources by both hotels and consumers. The researchers assessed the consumption of water, energy, and waste in more than 2,000 hotels. They found that hotels constrained by an environmental certification and audit process consumed fewer resources. Guests at these eco-certified properties were also more likely to consume less as well.

International studies in sustainable lodging

Becken, S., Frampton, C., & Simmons, D. (2001). Energy consumption patterns in the accommodation sector: The New Zealand case. *Ecological Economics, 39*, 371-386.

This study of the New Zealand accommodations industry attempted to determine the difference between lodging types and energy usage. Energy use was monitored year-round at a variety of lodging types, and costs spent on energy and fuel type were recorded. Resulted indicated that hotels consumed the most energy and used primarily electricity to operate. However, much variation in the data existed due to differences in business size and the amount of visitor-nights per year.

Bohdanowicz, P. (2005). European hoteliers' environmental attitudes: Greening the business. *Cornell Hotel and Restaurant Administration Quarterly, 46*(2), 188-204.

This study focused on the differences between chain and independent hotels in Europe and their perceptions of "greening" the lodging industry. The researcher found that hoteliers, especially independent ones, had relatively low levels of interest in environmental protection and were often meeting minimum compliance levels. However, an increase of awareness and customer-driven demand for green practices would likely change hotel operations.

Bohdanowicz, P. (2006). Environmental Awareness and Initiatives in Swedish and Polish Hotel Industries: Survey Results. *Hospitality Management, 25*, 662-682.

Bodanowicz's study focused on environmental practices in Swedish and Polish hotels. These two countries were chosen because Sweden is considered to be much more environmentally progressive than Poland and has policies in place for promoting green tourism. Bodanowicz found that, while hoteliers in both countries worked to reduce energy costs, environmental awareness and the presence of nation-wide standards were much more prevalent in Sweden.

Bohdanowicz, P., Zientara, P., & Novotna, E. (2011). International hotel chains and environmental protection: An analysis of Hilton's *We Care!* programme (Europe, 2006-2008). *Journal of Sustainable Tourism*, *19*, 797-816.

Bohdanowicz, Zientara, and Novotna analyzed the success of the European Hilton's *We Care!* Programme. The program was employed as a way to promote environmental awareness and stewardship, both in the hotel and in the daily lives of workers. The Hilton was able to achieve their goal of increased sustainability and gain popularity through online intranet training courses, and by operating as a "grassroots" campaign.

Chan, W., & Lam, J. (2003). Energy-saving supporting tourism sustainability: A case study of hotel swimming pool heat pump. *Journal of Sustainable Tourism, 11* (1)*,* 74-83.

Chan and Lam focused on the viability of using heat pumps as a means to heat swimming pools in Hong Kong. The success of the pump was monitored throughout the winter months, and costs and emissions were analyzed. The authors found that, despite high capital costs, the heat pump is an economical investment in the long term for both Hong Kong and other regions with similar climates.

Erdogan, N. & Tosun, C. (2009). Environmental performance of tourism accommodations in the protected areas: Case of Goreme Historical National Park. *International Journal of Hospitality Management, 28*, 406-414.

Erdogan and Tosun examined the tourism industry in Anatolia, Greece and to what extent the 140 hotels in the area employed sustainable practices. Energy saving light bulbs, low energy consuming materials, and solar energy were the most commonly used energy conserving tools among the seven energy efficiency practices assessed. The authors concluded that, overall, hotels in the region showed low levels of energy efficiency.

Erdogan, N., & Baris, E. (2007). Environmental protection programs and conservation practices of hotels in Ankara, Turkey. *Tourism Management, 28*, 604-614.

Erdogan and Baris interviewed and administered questionnaires to 54 hotel managers in Ankara, Turkey to determine which elements of environmental protection were being integrated into day to day operations. They focused on many attributes of environmental protection, including energy efficiency. The authors found that, while managers were interested in the cost savings associated with energy efficiency, many barriers to implement environmental measures existed, including a lack of legal framework and support and a lack of interest in sustainability.

Tools for Hotels

Bohdanowicz, P., Zientara, P., & Novotna, E. (2011). International hotel chains and environmental protection: An analysis of Hilton's *We Care!* programme (Europe, 2006-2008). *Journal of Sustainable Tourism*, *19*, 797-816.

At the end of the report of Hilton's *We Care!* programme, the authors outlined key strategies to replicate or adapt the program to different hotels. They noted that setting goals, working closely with employees to provide support, and adopting a holistic attitude towards environmentalism were all pillars to a strong hotel sustainability program.

DeFran, A. (1996). Go green: An environmental checklist for the lodging industry. *Cornell Hotel and Restaurant Administration Quarterly, 37,* 84-85.

DeFran provided a short, accessible checklist for hotel managers and operators to determine if they are being environmentally conscious. The checklist was divided into three areas: energy, solid waste, and water. Within the energy category, hotels could improve efficiency in a variety of areas: guestrooms, common areas, housekeeping, and maintenance.

Energy Star (2007). Facility type: Hotels and motels. In *Energy Star Building Upgrade Manual* (pp. 1- 18). Washington, DC: Environmental Protection Agency.

This chapter of the Energy Star Building Manual was focused on energy efficiency measures in hotels, providing general background and specific examples of improvements. It also noted the importance of guest comfort and how to best balance comfort with energy efficiency. It served as a tool and provided resources for hotel operators to start improving efficiency.

United Nations World Tourism Organization. (2014). *Hotel Energy Solutions (HES) e-Toolkit*. Retrieved on February 17, 2014.

The HES Energy Toolkit by United Nations World Tourism Organization is a free online calculator that helps businesses track their energy usage and performance. Based on survey information, the calculator will provide assessments and recommendations for further energy savings. Currently, the calculators are only available to small and medium-sized European hotels, but general resources are also available on the site, including best practices, as well as sample reports and suggestions for hotels.

Meade, B. (2014). Top 5 environmental management strategies affecting your hotel's bottom line. *Hotel Business Review*. Retrieved from https://hotelexecutive.com/business_review/483/top-5-environmental-management-strategies-affecting-your-hotelpercentE2percent80percent99s- bottom-line on February 17, 2014.

Meade suggested a framework and series of related tools to improve energy efficiency in hotels, including timers, occupancy sensors, and thermostatic controls as cost effective energy savings technologies. Meade also suggested that hotels take advantage of local and federal tax incentives and develop an environmental management plan to monitor progress.

Stipanuk, D. (2001). Energy management in 2001 and beyond: Operational options that reduce use and cost. *Cornell Hotel and Restaurant Administration Quarterly, 42,* 57-70.

Stipanuk began with a summary of the state of energy use in the lodging sector and then provided a set of steps to assist hotel managers with creating their own energy efficiency program. He argued that short and long-term goals were important and that monitoring energy use through inspections was the best way to determine which areas of the hotel can be improved. Stipanuk recommended that hotel operators work with staff, customers, and their utility providers to promote awareness of the project.

Withiam, G. (2010). Make sustainability a part of day-to-day hotel operations. *Hotel and Motel Management*. Retrieved on March 26, 2014.

Withiam reported on a roundtable event held by the Cornell Center for Hospitality Research that examined sustainability in the hotel industry. Using information gathered at the event, he provided a brief summary of tips for hotel managers, including ways to avoid "greenwashing", the benefits of some form of certification, and the importance of showing guests tangible results of green practices.

Guest satisfaction

Barsky, J. (1992). Customer satisfaction in the hotel industry: Meaning and measurement. *Journal of Hospitality & Tourism Research, 16*, 51-73.

Barsky gave an in-depth history and theory of customer choice and satisfaction in this paper. He used these theories to develop a model to test which factors of a hotel visit are most important to guests. After reviewing 450 guest comment cards, he concluded that employee attitude, hotel location, and room cleanliness were the most important factors for guests.

Cadotte, E., & Turgeon, N. (1988). Key factors in guest satisfaction. *Cornell Hotel and Restaurant Administration Quarterly, 28*, 44-51.

This study examined comment cards from both lodging establishments and restaurants. By determining which factors were most often complained about or complimented on, the researchers were able to determine which factors are most important to customers. Their analysis found that employee attitude, cleanliness, quality of service, and quietness of surroundings were most important, often recorded as both compliments and complaints by guests.

Determinants of guest comfort

Lewis, R. (1984). Isolating differences in hotel attributes. *Cornell Hotel and Restaurant Administration Quarterly, 25*, 64-77.

Lewis studied 17 factors that could influence guest perceptions, comfort, and post-stay satisfaction. He found that the most important factors across these categories were quality of services, security, and the "overall feeling." His analysis also examined the different needs of different types of guests, e.g., business and leisure travelers, different age and income groups, as well as male and female guests.

Min, Ho., Min, Hy., & Chung, K. (2002). Dynamic benchmarking of hotel service quality. *Journal of Services Marketing, 16*(4), 302-321.

This study of hotels in Korea identified three major concerns to guests: cleanliness, quiet, and comfort. These factors were ranked using weights determined by guest surveys. The weights were then compiled to create benchmarks for monitoring guest comfort. The authors also discussed their methods and the difficulty of getting participants without small incentives.

Saleh, F., & Ryan, C. (1992). Client perceptions of hotels: A multi-attribute approach. *Tourism Management, June,* 163-168.

Saleh and Ryan tested 30 factors to determine which factors were important to guest comfort and whether or not they would return to the hotel. They found that a clean room, comfortable beds, and a quiet stay were the most important factors. However, there was significant variation in preference for different types of guests.

Guest attitudes towards green practices

Barber, N. (2014). profiling the potential "green" hotel guest: Who are they and what do they want? *Journal of Hospitality and Tourism Research, 38*, 361-387.

Barber conducted an email survey of 563 American hotel guests in an attempt to understand what drives consumer preference, particularly in green lodging. Guests were categorized into "shades of green" or clusters of participants with similar responses. Barber found that guests who were considered to be the most green were most concerned with price savings and improved environmental quality as benefits of going green.

Dalton, G.J., Lockington, D.A. & Baldock, T.E. (2008). A survey of tourist attitudes to renewable energy supply in Australian hotel accommodation. *Renewable Energy, 33*, 2174-2185.

This study focused on guests' and hotel operators' attitudes toward renewable energy sources (RES) in hotels. Through interviews and surveys, the authors determined if there was support for RES, guests' willingness to pay for RES, and if guests would be willing to change their own behavior to be more sustainable. Contrary to other studies, the researchers found that guest tolerance was much higher than managers originally thought and there was an overall desire for RES in hotels.

Explore Minnesota Tourism (2008). *Minnesota Travel Green Task Force: Report and Recommendations.* Saint Paul, MN: State of Minnesota.

Explore Minnesota's report featured the findings of a series of surveys about hotel energy efficiency. The study focused on customer interest in green travel and explored the potential of a "green hotels" certification program. The study found that, while customers were interested in a certification program, it would not be viable, given high time and financial costs associated with the certification process. Instead, awareness of hotels using green practices would be more beneficial.

Gunderson, M., Heide, M., & Olsson, U. (1996). Hotel guest satisfaction among business travelers: What are the important factors? *Cornell Hotel and Restaurant Administration Quarterly, 37* (2), 72-81.

The authors surveyed business travelers in three areas (reception, food and beverage, and housekeeping) to determine which factors are most important to a positive stay. By evaluating 22 different items and testing correlations, they were able to determine that interactions with the front desk and the availability of their room at check-in were the most important. Tangible factors such as room amenities and a broad survey category "general comfort" were less important to guests.

Han, H., Hsu, L., Li, J., & Sheu, C. (2011). Are lodging customers ready to go green? An examination of attitudes, demographics, and eco-friendly intentions. *International Journal of Hospitality Management, 30*, 345-355.

The researchers attempted to determine what caused consumers to choose green hotels and what types of customers were more likely to stay at these hotels. Through an online survey, the researchers found that the importance of being environmentally friendly and corporate responsibility were the most important factors in influencing hotel choice. Gender was the only statistically significant demographic factor in shifting the likeliness of choosing a green hotel, with women being more likely than men.

Kasim, A. (2004). socio environmentally responsible hotel business: Do tourists to Penang island, Malaysia care? *Journal of Hospitality and Leisure Marketing, 11* (4), 5-28.

Based on the growing interest in green hotel operations, Kasim studied the preferences of guests for green hotel attributes in Malaysia. The survey revealed that, while guests were aware of environmentally friendly attributes, few were willing to pay more or to switch hotels for these attributes. In other words, green attributes did not aid guests’ decision making process.

Millar, M., & Baloglu, S. (2011). Hotel guests' preferences for green guest room attributes. *Cornell Hospitality Quarterly, 52* (3), 302-311.

Millar and Baloglu surveyed 571 travelers in an attempt to determine which sustainable features are the most attractive to hotel guests. The authors used conjoint analysis to determine the effects of these factors individually and in pairs. They tested seven attributes and found that green certification, towel or linen reuse programs, and energy efficient light bulbs were the most important to guests.

Ogbeide, G. (2012). Perception of green hotels in the 21st century. *Journal of Tourism Insights, 3* (1), Article 1.

Ogbeide examined what a 21st century tourist expects from a green hotel. Relying on 241 surveys collected in Arkansas and Texas, the author determined the importance of "green" as a concept for travelers, as well as what types of practices guests were "more prone to endure" (p. 3). Among water and energy conservation, waste reduction and "general" green practices, energy conservation was most important to guests, with 89.6 percent responding that it was "somewhat important to very important" (p. 4).

Segarra-Ona, M., Peiro-Signes, A., Verma, R., Mondejar-Jimenez, J., & Vargas-Vargas, M. (2014). Environmental management certification (ISO 14001): Effects on hotel guest reviews. *Cornell Hospitality Report, 14* (8), 4-19.

Using data from hotel websites and bookings.com, the authors examined the effects of green certification (ISO 14001) on guest comfort in Spanish hotels. They found guests tended to give higher scores on satisfaction surveys, a proxy for during-stay comfort, if the hotel was ISO 14001 certified. Of the six items tested, certified hotels scored significantly higher on housekeeping, comfort, location, and services than those not certified.

Susskind, A., & Verma, R. (2011) Hotel guests' reactions to guest room sustainability initiatives. *Cornell Hospitality Report, 11* (6), 4-13.

This study assessed whether or not guests preferred energy saving measures in hotel rooms in the Statler Hotel at Cornell University. Neither overall satisfaction with television quality nor satisfaction with television picture quality differed by energy setting. Additionally, bathroom lighting conditions did not make any significant difference in satisfaction with bathroom lighting.

Tierney, P., Hunt, M., & Latkova, P. (2011). Do travelers support green practices and sustainable development? *Journal of Tourism Insights, 2* (2), Article 5.

The authors used an online survey to monitor hotel managers' attitudes towards green practices in the U.S. and the Caribbean. With responses to a series of 18 agree/disagree statements, the researchers found that both guests and hotel operators regarded going green as increasingly important. In fact, 93 percent of respondents felt that becoming greener was imperative for the resort industry.

Research Methodology

Atkinson, A. (1988). Answering the eternal question: What does the customer want? *Cornell Hotel and Restaurant Administration Quarterly, 29* (2), 12-14.

Atkinson’s article discussed survey design for hotels, particularly a survey that was conducted for the Days Inn chain. The researcher identified items of major concern to guests and created a ranking system for the importance of these factors. The researchers also discussed engaging respondents and emphasized the importance of incentives for participation.

Lewis, R., & Pizam, A. (1981). Guest surveys: A missed opportunity. *Cornell Hotel and Restaurant Administration Quarterly, 22*, 37-44.

This paper addressed common problems with guest satisfaction surveys. The researchers argued that creating a space for comments, using a wide scale, and weighting factors are the most important to obtain meaningful data. By weighting factors, hotel operators would see not only factors that need to be improved but also how important those improvements are to guests.

Schall, M. (2003). Best practices in the assessment of hotel guest attitudes. *Cornell Hotel and Restaurant Administration Quarterly, 44* (2), 51-65.

Schall provided an in-depth review of different survey methods and styles for the hospitality industry. He also identified the most effective way to gather good data from guests, including how to appropriately write questions and answer options. Furthermore, the researcher discussed the importance of having response options of "neutral" and "not applicable" in order to obtain more accurate responses.

APPENDIX B: HOTEL GUEST COMFORT QUESTIONNAIRE

Hotel Guest Comfort Questionnaire

Michaels Energy & the University of Minnesota Tourism Center

Please take a few moments to answer the following questions about how comfortable your room was. Your feedback will be helpful in improving your future stay. Thank you!

The lighting in the room was...

Too dim			Nicely lit			Too bright	
1	2	3	4	5	6	7	N/A

The air in the room was...

Too dry			About right			Too damp	
1	2	3	4	5	6	7	N/A

Did you adjust the thermostat in your room?

☐ No
☐ Yes, to what temperature:____________˚F

Control of temperature in the room was...

Very difficult			Neutral			Very easy	
1	2	3	4	5	6	7	N/A

The temperature in the room was...

Not consistent at al l						Very consistent	
1	2	3	4	5	6	7	N/A

The noise level of the heating and cooling unit in the room was...

Very loud			Neutral			Very quiet	
1	2	3	4	5	6	7	N/A

The ambient noise level in the room was...

Very loud			Neutral			Very quiet	
1	2	3	4	5	6	7	N/A

The bed was...

Very comfortable			Neutral			Very quiet	
1	2	3	4	5	6	7	N/A

The sheet was...

Very stiff			Neutral			Very soft	
1	2	3	4	5	6	7	N/A

The water pressure was...

Very unsatisfactory			Neutral			Very satisfactory	
1	2	3	4	5	6	7	N/A

The water temperature was...

Very unsatisfactory			Neutral			Very satisfactory	
1	2	3	4	5	6	7	N/A

The towels in the bathroom were...

Very stiff			Neutral			Very soft	
1	2	3	4	5	6	7	N/A

In general, the room was...

Very dirty			Neutral			Very clean	
1	2	3	4	5	6	7	N/A

The overall experience in the room was...

Very comfortable			Neutral			Very comfortable	
1	2	3	4	5	6	7	N/A

Would you stay at this hotel again?

☐ Yes ☐ No ☐ Prefer not to answer

What are the most important qualities that you consider when choosing a hotel? (Please select all that apply)

☐ Cost ☐ Location ☐ Room comfort ☐ Guest reviews
☐ Hotel amenities ☐ Hotel brand ☐ Availability of special packages ☐ Previous experiences

What hotel amenities are most important to making your stay comfortable? (Please select all that apply)

☐ Cleanliness ☐ Quietness ☐ Room temperature ☐ Friendly staff
☐ Room lighting ☐ Bed comfort ☐ Bathroom amenities ☐ Hotel common areas

Other Comments?

Finally, a few questions about you.

Have you stayed at this hotel before?
☐ No
☐ Yes, please indicate the number of times:
☐ 1-3 ☐ 4-6 ☐ 7-10 ☐ More than 10 times

Please indicate the purpose of your trip:

☐ Business ☐ Leisure ☐ Business and leisure ☐ Other

Room Number:_________________

Have you ever complained to a hotel because a room was uncomfortable?

☐ Yes ☐ No ☐ Prefer not to answer

If you knew that a hotel was certified as energy efficient, would you be more likely to choose this hotel, assuming other criteria (e.g., cost, location) were comparable?

☐ Yes ☐ No ☐ Prefer not to answer

For administrative purposes only: WEEKDAY WEEKEND (Friday 1pm-Sun)
Date:________________/________________________ Time:________am/pm
Location:________________________________

APPENDIX C: QUALITATIVE COMMENTS FROM HOTEL GUEST QUESTIONNAIRE

Guests were invited to write any additional comments about their stay at the end of the questionnaire. Of the 125 survey participants, 43 wrote additional comments. The following comments are quoted directly from the guest surveys.

Comments

- Have been pleased with this hotel- everything has been great. Free good breakfasts!
- Wifi is an important amenity
- This hotel needs a lamp on the table for working. Some hotels do not have lights near reading chairs. We brought our own pillows. The thermostat should be digital-- easier to control. Like hotels where breakfast is included.
- Workout/Pool is important. Set Thermostat lower.
- New carpet smell
- Turned air on low
- My door was broken- wouldn't latch shut. Dirty common areas and elevator.
- Staff is great, room is clean, and I found the breakfast to be good and well maintained.
- Wifi is an important amenity
- Not much one can do about 3am + 4am freight train horns… sigh
- Upgraded cooling and heating units should include a humidifier. Use of commercial laundry services tends to produce sheets and pillowcases with a nasty odor.
- Wish there were grab bars in bathroom by the tub and toilet
- Turned thermostat down. Water handles were too stiff to operate reasonably. The room layout was nice. Loved the stairs and the general layout and décor of the common area. Connection to restaurant neat.
- Breakfast was great
- I like a good gym too
- Piece of debris under bathroom counter when we came in. Energy efficiency is important- I hate the wasteful a/c units in rooms but….
- Turned thermostat down. Ice bucket lid was sticky, complained at this hotel because the original room was too close to the elevator.
- Pet friendly
- Free breakfast and wifi are important
- One of the lamps didn't work. The shower head was quiet but they should change to new air conditioning units.
- Enjoyed stay! Would stay again
- The hotel is nice and clean
- Nice place to stay
- I travel 40percent of my time for work, plus my daughter spends a lot of time traveling for softball. I really like this hotel. Very nicely upgraded.
- Great experience here. Great service and very clean room.
- The control of the temperature was easy once we found the unit and the noise level was good.
- Turned off a/c unit. Hilton Garden Inn is my favorite- Embassy Suites 2nd place.
- Use of hotel shuttle very very good (from this visit and last visit)
- Good gym.
- I wish there were a few different types of pillows on the bed so guests have a selection and can choose one similar to one they use at home instead of only having large fluffy pillows (as you can tell, I prefer a flatter pillow)

- Shuttle, pool and exercise room
- Fitness room equipment
- Hot tub/pool
- very good stay
- Sink and tub in room (128) drained very slow
- The temperature was set at 70. Control of the thermostat was easy in one room of the two room suite.
- The cleanliness of the carpet impacts my overall impression of the room. I turned the air conditioner off.
- exercise room
- Non-smoking facility important. Many chains use carpet chemicals that can trigger asthma attacks. Holiday Inn Express is one chain that consistently does not use these- so it it is "safe" for asthmatics. Others are "hit and miss"- Hampton, Best Western etc. Mold control also an issue for asthmatics.
- Free breakfast rather than over-priced (and overly big) high-end hotels. Really like hotels that have window air that creates strong "white noise" that helps sleep and privacy.
- Turned off the AC because it was loud. The carpet wasn't so clean. People were stomping in the room above.
- Noise level was worse the second night since the hotel was busier.
- Easy early check-in

Appendix B: Marketing Brochure

…and CUT ENERGY COSTS at the same time.

Program Benefits

- FREE energy audit on your facility
- ENERGY STAR benchmark shows how you stack up
- Learn your best options to cut energy use in the guest rooms, laundry, pool and common spaces
- Get utility rebate dollars to support your efficiency upgrades

What's Next?

- To enroll you must:
  - Sign a release so we can work with your utility to get one year of gas/electric/water data
  - Fill out a demographic questionnaire for ENERGY STAR benchmarking
- Schedule a site visit with our engineer
- We'll report our findings and you implement the measures YOU choose

Who's Eligible?

- Open to Minnesota hotels
  - Mid-Scale/Limited Service (loosely defined)
  - Pools but not water parks
  - Approximately 20-200 guest rooms
- If you think you fit, give us a call – you probably do!

Funding

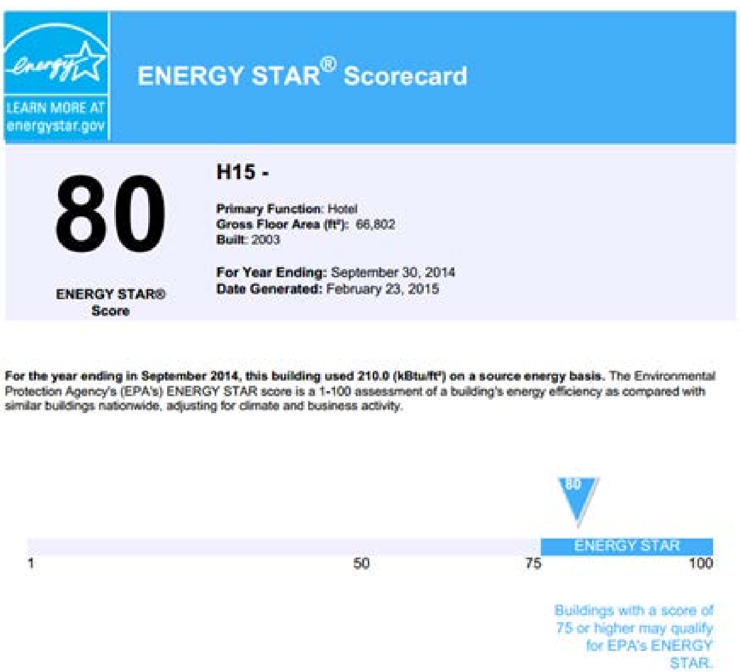
This project was supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources.

Contact Us to Get Started!

Carl Samuelson, Michaels Energy
612-418-5496 cwsamuelson@michaelsenergy.com

Appendix C: Sample of Audit Report

[HOTEL NAME]
Energy Audit



MichaelsEnergy

March 2015
Prepared By: Aaron Conger

This project was supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Development (CARD) Program.

Contents

Executive Summary

The [HOTEL NAME] in City, MN is interested in reducing energy costs and increasing profits through energy efficiency improvements in its operations and facility. As such, [HOTEL NAME] has partnered with Michaels Energy to assist in this effort. This report documents the findings of the Energy Audit that was performed at the facility. The Minnesota Department of Commerce-Division of Energy Resources is funding the cost of this audit through a research grant, with the goal being to assist utilities in providing better rebate programs to the mid-scale hotel sector.

The purpose of this Energy Audit is to identify high-level energy efficiency measures along with estimated project costs and savings estimates. The next step is to implement the measures included in this report. Michaels Energy can assist with information transfer to utilities, contractors or financial consultants to assist with project implementation.

Based on the annual utility bills, the energy intensity is 15 kWh/square foot and 0.5 therms/square foot. The water use intensity is 45 gallons/square foot or 99 gallons/occupied-room-day.

The hotel had an ENERGY STAR score of 80 for the year ending September 2014. To obtain the ENERGY STAR building certification, a hotel requires a minimum score of 75 and a Professional Engineer to review building operation for proper ventilation, lighting levels and comfort conditions. The engineer's review would need to state that the building operation does not compromise comfort to attain lower energy or water usage.

The following table summarizes energy saving measures that were analyzed and includes the estimated costs, savings, utility rebate and the simple payback period. Non-energy savings include water and maintenance savings. The cost estimates include materials and labor. These costs may be subject to increase or decrease due to unforeseen conditions. Generally, recommended measures include projects with less than a 10-year simple payback period.

The goal is to provide a package of measures that meet an overall simple payback of five years and to achieve project implementation with savings of up to 20%. Some projects may not make economic sense to implement until the existing equipment has reached or is near the end of useful life (indicated below with "incremental cost"). Other measures are included at the end of this report. These may have been investigated, but they are either outside the scope of this project or additional testing would be needed to quantify the savings.

Energy Saving Measure	Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
Replace Exterior Lights with LED Fixtures	$22,000	46,000	-	-	$3,100	$1,200	$2,175	4.5
Retrofit T8 Fixtures with LED Tubular Lamps	$8,700	14,000	2.1	-	$1,200	$800	$0	4.4
Retrofit Pool Area Fixtures with LED Lamps	$1,300	6,400	1.5	-	$600	$300	$105	1.4
Retrofit Common Area Fixtures with LED Lamps	$7,000	23,000	2.8	-	$1,900	$2,000	$670	1.6
Retrofit Walk-In Cooler Fixtures with LED Lamps	$40	200	0.0	-	$10	$10	$19	0.7
Install Occupancy Sensors in Public Spaces	$500	5,500	-	-	$400	$0	$70	1.0
Replace Standard PTACs with Heat Pump Units**	$10,000	68,000	5.0	-	$5,300	$0	$8,068	0.5
Install Liquid Pool Cover	$800	2,500	-	200	$400	$10	Unknown*	2.1
Replace Constant Speed Pool Pump with VS Pump	$1,600	9,300	1.1	-	$800	$0	$90	2.0
Replace Constant Speed Spa Pump with VS Pump	$1,600	11,000	1.2	-	$900	$0	$90	1.7
Install Efficient Showerheads in Guestrooms	$8,400	-	-	1,600	$1,300	$900	$658	3.4
Install Efficient Faucet Aerators in Guestrooms	$900	-	-	200	$200	$100	$74	2.7
Implement Low Temperature Laundry System***	$2,000	-	-	2,200	$1,800	$1,400	Unknown*	0.6
Totals	**$64,840**	**185,900**	**13.7**	**4,200**	**$17,910**	**$6,720**	**$12,020**	**2.2**

* Measure must be reviewed with and approved by utility for rebate

** Incremental cost used for replacing end of life equipment

*** Measure already implemented

1. Building Description

1.1 Building Details

Name	[HOTEL NAME]
Number of rooms	120
Year built	2003
Occupancy rate	70%
Building size	66,802 ft^2
Building construction	Gabled roof, three stories
Parking lot size	45,000 ft^2
Commercial kitchen?	Yes

1.2 Lighting Systems

Guestrooms	13-/30-watt CFL
Hallways/lobby	23-/26-watt CFL
Pool	70-watt metal halide
Office/mechanical	T8 fluorescent
Exterior	70-/250-watt metal halide

1.3 HVAC Systems

Guestrooms	*Rooms:* GE PTAC, 8,500 BTU/hr (10.6 EER) *Suites:* GE VTHP, 17,500 BTU/hr (10.0 EER)
Common areas	(3) Bryant furnace/AC units (ENERGY STAR)
Pool	Dectron AHU (water heat recovery)

1.4 Guestrooms

Bath exhaust	Manual
Bath exhaust flow >50 cfm?	Yes
Operable windows, >4% of room area?	Yes (est.)
Guest Room Energy Management System (GREMS)	No
Programmable thermostats in rooms?	No
Guestroom refrigerator	Avanti, 4.5 cu. ft. (not ENERGY STAR)

1.5 Pool Systems

Heating	(2) Raypak pool/spa boilers, 80% efficient
Pool temperature	84°F
Pool size	25,000 gallons, 600 ft^2
Pool pump	2 hp
Pool flow rate	90 gpm
Spa temperature	104°F
Spa size	1,500 gallons
Spa pump	2 hp
Spa flow rate	115 gpm
Pool room air temperature	84°F (setpoint), 78°F (measured)
Pool room humidity (relative)	50% (setpoint), 34% (measured)

1.6 Domestic Hot Water and Laundry Systems

DHW heaters	(2) AO Smith water boilers, 80% efficient
DHW discharge temperature	125°F
DHW pump	(1) Grundfos, 1/20 hp (est.)
Guestroom sink aerator flow rate	1.5 gpm
Guestroom showerhead flow rate	2.5 gpm
Laundry HW heater	(2) AO Smith water boilers, 80% efficient
Laundry HW temperature	120°F
Laundry processed (annually)	400,000 lbs (est.)
Washers	(2) UniMac washer-extractors, 60 lb capacities
Dryers	(3) UniMac dryers, 75 lb capacities

1.7 Miscellaneous Systems

Fireplace	Yes (lobby)
Icemakers	1
Vending	None
Kitchen dishwasher	Hobart commercial dishwasher
Kitchen refrigerator	(1) Walk-in cooler/freezer (3) Solid-door reach-in coolers
Kitchen freezer	(1) Walk-in cooler/freezer

2. Electricity and Fuel Usage

Electric consumption is provided in Table 1. Natural gas consumption is provided in Table 2. The average cost for electricity was estimated at $0.09/kWh and natural gas average cost is $0.81/therm, based on utility bills and/or current utility rates.

TABLE 1: ELECTRICITY CONSUMPTION

Month	Energy (kWh)	Demand (kW)	Total Bill ($)
Jan	97,000	238	$8,730
Feb	107,600	255	$9,684
Mar	92,400	225	$8,316
Apr	84,600	220	$7,614
May	66,400	173	$5,976
Jun	69,000	152	$6,210
Jul	78,200	173	$7,038
Aug	89,600	175	$8,064
Sep	89,200	173	$8,028
Oct	72,800	160	$6,552
Nov	66,800	136	$6,012
Dec	78,400	188	$7,056
Total	**992,000**		**$89,280**

FIGURE 1: ANNUAL ELECTRIC USE PROFILE

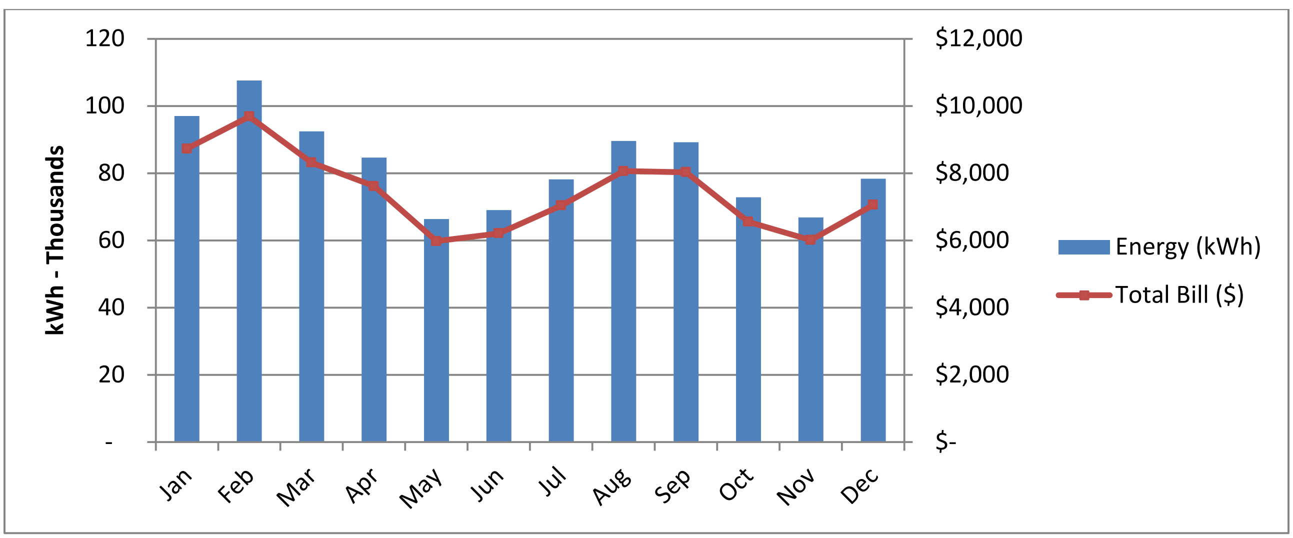
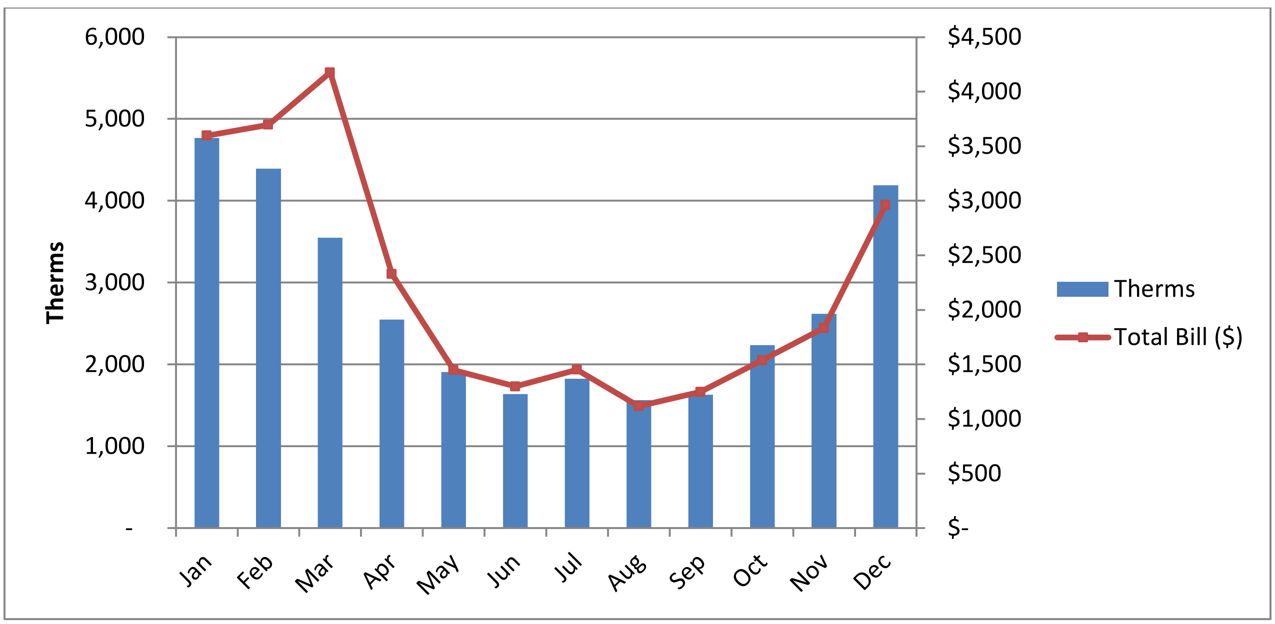


TABLE 2: NATURAL GAS CONSUMPTION

Month	Energy (therms)	Total Bill ($)
Jan	4,766	$3,597
Feb	4,394	$3,697
Mar	3,547	$4,176
Apr	2,548	$2,328
May	1,908	$1,449
Jun	1,638	$1,299
Jul	1,824	$1,453
Aug	1,564	$1,118
Sep	1,632	$1,248
Oct	2,234	$1,538
Nov	2,618	$1,835
Dec	4,189	$2,963
Total	**32,862**	**$26,700**

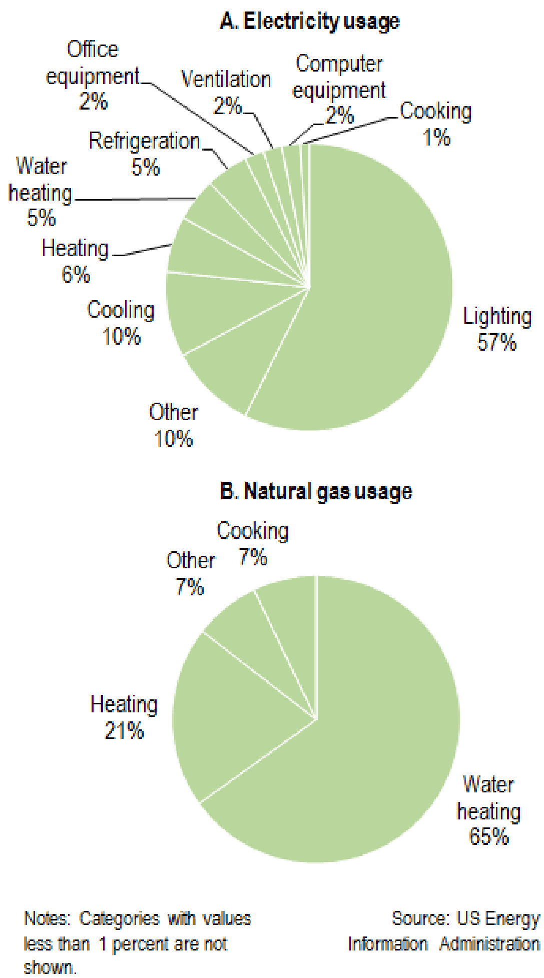
FIGURE 2: ANNUAL NATURAL GAS PROFILE



3. End Use of Energy

Average energy use data for hotels is provided in Figure 3 and reflects energy use of hotels across the country averaged over an entire year. This information is used in determining the areas of primary emphasis for energy conservation activities, and in estimating the savings from the implementation of building and system modifications.

FIGURE 3: AVERAGE ENERGY USE DATA



Source:

Managing Energy Costs in Hotels and Motels. (n.d.). Retrieved November 10, 2014, from Business Energy Advisor: http://bizenergyadvisor.com/hotels-and-motels

4. Building ENERGY STAR Evaluation

The hotel has an ENERGY STAR score of 80 for the year ending September 2014. To obtain the ENERGY STAR certification, this hotel would need to have a score of 75 and have a Professional Engineer review building operation.

ENERGY STAR certification for a hotel validates the balance between energy efficiency and guest comfort. Energy efficiency must be demonstrated without sacrificing guest comfort. Specifically, the main areas of interest for guest comfort include[7]:

- Thermal comfort (example: sufficient room heating capacity)
- Guest safety and security (example: adequate exterior and hallway lighting)
- Adequate task lighting (example: desk or vanity lighting)
- Indoor air quality (example: areas are free of mold)
- Indoor sound levels (example: rooftop HVAC equipment is properly insulated from guest rooms)

Thermal comfort is evaluated by measuring room and common-area temperatures, and compared to ASHRAE Standard 55. Lighting levels are analyzed with light meters, primarily at the desk and bathroom in guest rooms. Carbon dioxide and humidity levels are measured to determine indoor air quality, along with exhaust system capacity (high humidity levels can lead to mold problems). Visual observations ensure there is no apparent mold. Sound readings are taken in guest rooms and compared to the applicable ASHRAE standard.

Lighting levels measured in three guest rooms along with the IESNA Lighting Guideline values are shown below in Table 3**Table**. The lighting levels exceed the minimum IESNA guidelines for the room sampled.

TABLE 3: ILLUMINANCE LEVELS OF KEY GUEST ROOM AREAS, SHOWN IN FOOT CANDLES

Area	IESNA Guideline[8]	Standard Room
Desk	19	36.5
Vanity	19	62.0

The exhaust flow was measured at 50 cubic feet per minute (cfm) during the initial walkthrough, which meets code requirements for ventilation.

ENERGY STAR certification is recommended for this hotel. The building has already achieved an ENERGY STAR score of 80. Additional certification by a professional engineer would be required to complete the ENERGY STAR Data Verification Checklist. As a part of this DER grant, Michaels Energy can provide professional engineering support to complete the certification process.

---

[7] ENERGY STAR. (Revised 2007). *ENERGY STAR Building Manual, Chapter 12 - Facility Type: Hotels and Motels.*

[8] Per IES Design Guide for Hotel Lighting IES DG-25-12; horizontal foot candles for Visual Ages 25 to 65 years old.

5. Energy Efficiency Measures

The savings calculated for these measures are estimated based on knowledge of the systems and the condition and operation of the equipment during the site visit. Due to the limited time available during the site visit, it is possible that some conditions may exist that will be revealed during implementation that will impact both the savings and implementation cost of any particular measure. Michaels Energy staff has taken steps to minimize this potential but cannot eliminate this entirely.

Additionally, the savings calculated for these measures are “order of magnitude” type savings that are meant to give an idea of what the savings could be, not an actual prediction of the energy savings. Also, these measures should not be considered mutually exclusive because there are interactions among them, depending on the package of measures that are eventually implemented. Therefore, the savings cannot be totaled by simply adding the savings values in all cases. Because of the interconnectivity of some of the measures, the total savings would likely be somewhat less than the sum of the separate measures.

5.1 Lighting Systems

5.1.1 Replace Exterior Lights with LED Fixtures

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$22,000	46,000	-	-	$3,100	$1,200	$2,175	4.5

The parking lot is served by 21 250-watt metal halide pole fixtures. The building exterior is illuminated by 16 250-watt metal halide wall packs, 17 70-watt metal halide bollards, and eight 70-watt metal halide ceiling fixtures in the entrance canopy. All exterior lights are controlled by photo sensors.

All of these fixtures can be replaced with LED fixtures. Consider replacing the wall packs with 57-watt LED wall packs, and the pole fixtures with either 52-watt or 78-watt LED area lights depending on the height. The bollards can be retrofit with 18-watt LED omni-cob lamps, and the canopy fixtures with 19-watt LED flood lamps. Maintenance savings for this measure is calculated from the reduction in replacement product and labor costs with the conversion to longer life LEDs.

While these costs are based on current market rates, it is expected that LED fixtures will become less costly in this rapidly changing market. Replacement product and labor costs were provided by Premier Lighting. This lighting measure is supported by prescriptive rebates from their electric utility.

FIGURE 4: ENTRANCE CANOPY LIGHTING

FIGURE 5: PARKING LOT POLE FIXTURE

5.1.2 Retrofit T8 Fixtures with LED Tubular Lamps

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$8,700	14,000	2.1	-	$1,200	$800	$0	4.4

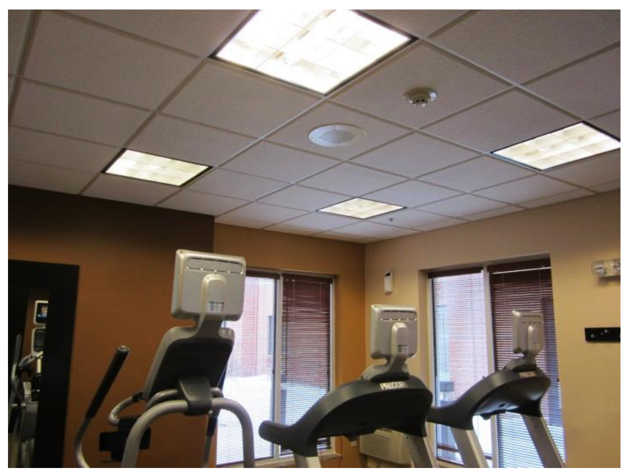
The fitness, business center, laundry, mechanical, storage, kitchen, conference, and stairwell areas are illuminated by T8 fluorescent light fixtures, many of which are on 24 hours per day.

Consider retrofitting these fixtures with 18-watt LED tubular lamps. The energy savings and costs for this measure are based on a direct retrofit of each T8 lamp with a LED tubular lamp. In addition to saving energy, new LED lamps have a longer life, lower overall maintenance costs, and have less light degradation over time.

Replacement product and labor costs were provided by Premier Lighting.

FIGURE 6: CONFERENCE ROOM LIGHTING

FIGURE 7: FITNESS ROOM LIGHTING



5.1.3 Retrofit Pool Area Fixtures with LED Lamps

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$1,300	6,400	1.5	-	$600	$300	$105	1.4

The pool area is illuminated by 21 70-watt metal halide ceiling fixtures, which are on 12 hours per day. Consider retrofitting these fixtures with 23-watt LED A-shape lamps. Maintenance savings for this measure is calculated from the reduction in replacement product and labor costs with the conversion to longer life LEDs.

Replacement product and labor costs were provided by Premier Lighting. This measure is supported by prescriptive rebates from their electric utility.

FIGURE 8: POOL AREA LIGHTING

5.1.4 Retrofit Common Area Fixtures with LED Lamps

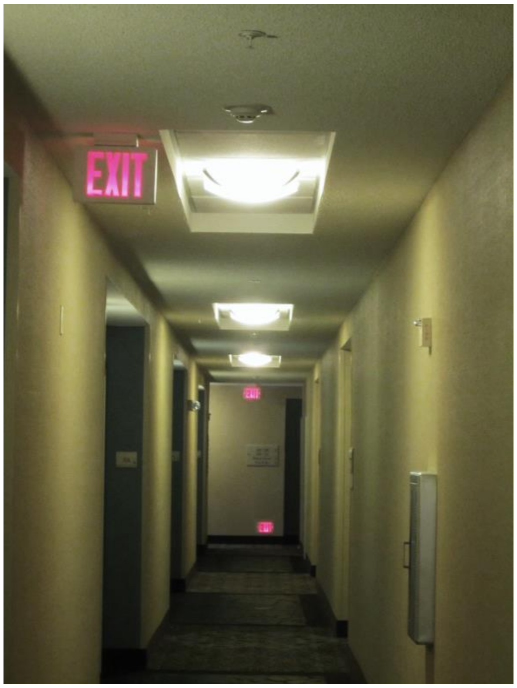
Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$7,000	23,000	2.8	-	$1,900	$2,000	$670	1.6

Common areas are mostly illuminated by CFL lighting. This includes sconces and ceiling fixtures in the lobby and hallways, breakfast area, and conference rooms. Most of these lights are on 24 hours per day. Some fixtures in the lobby have already been retrofit with LED lamps.

Consider retrofitting the wall sconce fixtures with 12-watt LED lamps, and the ceiling fixtures with 13-watt LED plug-in lamps. Maintenance savings for this measure is calculated from the reduction in replacement product and labor costs with the conversion to longer life LEDs.

Replacement product and labor costs were provided by Premier Lighting. This measure is supported by prescriptive rebates from their electric utility.

FIGURE 9: HALLWAY FIXTURES



5.1.5 Retrofit Walk-In Cooler Fixtures with LED Lamps

Fixtures with LED Lamps

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$40	200	0.0	-	$10	$10	$19	0.7

One walk-in combination cooler and freezer is illuminated by three 23-watt CFL lamps each. These lights were estimated to be on 12 hours per day, when the kitchen is staffed. These lamps can be replaced with 14-watt LED lamps.

This lighting measure is covered by prescriptive rebates through their electric utility.

FIGURE 10: WALK-IN COOLER LIGHTING

5.1.6 Install Occupancy Sensors in Public Spaces

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$500	5,500	-	-	$400	$0	$70	1.0

Lighting in the common restrooms, business center, fitness, guest laundry, and conference rooms are controlled by wall switches and occupied intermittently. Consider installing occupancy sensors in these rooms. This measure is considered a best practice for hotels trying to achieve maximum energy efficiency. Large areas such as the conference rooms should use ceiling-mounted "dual technology" sensors, while wall mounted sensors can be installed in smaller areas like the fitness and guest laundry rooms. Occupancy sensors are already installed in housekeeping, mechanical, storage and kitchen areas.

Energy savings for this measure were calculated using an estimated savings of between 25% and 40% depending on the space type. These estimates are based on data compiled from usage of similar spaces. Occupancy sensors will be most effective in spaces that are typically occupied intermittently, and where a large number of fixtures can be controlled by a single sensor. In areas where occupancy sensors are used, programmed start ballasts should be used in T8 fixtures to maximize lamp life.

This lighting measure is covered by prescriptive rebates from their electric utility.

FIGURE 11: EXISTING OCCUPANCY SENSOR

5.2 HVAC Systems

5.2.1 Replace Standard PTACs with Heat Pump Units

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$10,000 (inc.)	68,000	5.0	-	$5,300	$0	$8,068	0.5

Standard guestrooms are heated and cooled with packaged terminal air conditioning (PTAC) units using electric resistance heating. Consider changing out existing PTACs with packaged terminal heat pump (PTHP) units when an existing unit requires replacement. PTHPs use electric resistance heating only when ambient temperatures drop below 25°F. Above this temperature, heat pumps will produce about three times as much heat for the same input energy as electric resistance heating. Suites are already equipped with heat pump units.

The incremental cost of buying a PTHP is roughly $100 per unit. Their electric utility offers a rebate that covers the majority of the incremental cost of upgrading to a PTHP.

FIGURE 12: GUESTROOM PTAC

5.3 Pool Systems

5.3.1 Install Liquid Pool Cover

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$800	2,500	-	200	$400	$10	Unknown*	2.1

It is widely accepted that pool covers save energy by providing an insulating layer over the warm pool water and reducing evaporation and associated heat loss. The most significant of these losses is the heat loss due to evaporation. In addition, indoor pools also require energy consuming dehumidification systems to maintain the pool area at a comfortable humidity level of approximately 50%.

Traditional pool covers are not a practical measure for hotels so most hotels operate without pool covers which results in wasted energy. It is recommended to install a liquid pool cover to reduce evaporation rates and water loss. The initial savings estimates for this measure are based on a liquid pool cover being 60% as effective as a more traditional physical pool cover.

This pool was equipped with a Dectron pool room heating, cooling, and relative humidity control system with water heat recovery. Savings related to the installation of a liquid pool cover for this pool were calculated based on the equipment capacity and observed operating conditions, as well as data retrieved from initial testing sites. A small amount of water savings will be achieved due to the reduction of evaporation during unoccupied hours, and therefore less makeup water required.

This measure may be supported by a rebate from their gas utility. Utilities in other states have rebated the liquid pool cover, but the technology is relatively new to Minnesota so the rebate precedence has not been established. Further conversations with Minnesota's natural gas utilities are planned as part of this research.

5.3.2 Replace Constant Speed Pool Pump with VS Pump

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$1,600	9,300	1.1	-	$800	$0	$90	2.0

The main pool system is equipped with a 2 hp pump that circulates 90 gpm constantly. The pool has two skimmers, and the Minnesota Health Code requires a minimum flow rate of 30 gpm for each skimmer. This flow rate should be equal to 80% of total circulation flow rate, so the minimum flow rate for this pool is 75 gpm.

There is an opportunity to save energy be replacing the current constant speed pump with a variable speed pump that can reduce the circulation rate. The savings is estimated using published data for average performance of small pool pumps prepared for the California Energy Commission. A more in-depth evaluation of this opportunity with a qualified contractor is recommended to refine costs and savings potential, including energy data collection, pump sizing and specific installation estimates.

This measure is supported by a prescriptive rebate from their electric utility.

FIGURE 13: POOL MECHANICAL SYSTEM

5.3.3 Replace Constant Speed Spa Pump with VS Pump

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$1,600	11,000	1.2	-	$900	$0	$90	1.7

The spa system is equipped with a 2 hp pump that circulates at least 115 gpm constantly. The Minnesota Health Code requires a minimum flow rate of 35 gpm for the spa.

This is an additional opportunity to save energy by replacing the current constant speed pump with a variable speed pump that can reduce the circulation rate, similar to the measure described for the main pool.

This measure is supported by a prescriptive rebate from their electric utility.

5.4 Domestic Hot Water Systems

5.4.1 Install Efficient Showerheads in Guestrooms

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$8,400	-	-	1,600	$1,300	$900	$658	3.4

Guestroom showerheads are rated at 2.5 gallons per minute (gpm). In the past there has been resistance to retrofitting showerheads to low flow models because the units available were of poor quality. However, there are many high quality showerheads available in the market today which should not affect guest comfort.

It is recommended to install low flow showerheads rated at 1.5 gpm. This provides a 40% savings from a 2.5 gpm unit. The cost to retrofit showerheads is estimated at $75 each.

This measure may be supported by a custom rebate from their gas utility.

FIGURE 14: GUESTROOM SHOWERHEAD

5.4.2 Install Efficient Faucet Aerators in Guestrooms

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$900	-	-	200	$200	$100	$74	2.7

The guestroom sinks all have faucet aerators rated at 1.5 gpm. This is considered an efficient aerator, but could be retrofitted with a more efficient model rated at 0.5 gpm.

This is a low cost measure that could be implemented by hotel staff to reduce costs and could be implemented in phases to ensure guest comfort is not impacted.

This measure may be supported by a custom rebate from their gas utility.

FIGURE 15: GUESTROOM SINK

5.5 Laundry Systems

5.5.1 Implement Low Temperature Laundry System

Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
$2,000 (inc.)	-	-	2,200	$1,800	$1,400	Unknown*	0.6

Hot water usage in the laundry operation is a significant energy usage. Methods to reduce the amount of hot water consumed or reduce the temperature of the wash cycles will result in energy savings. Options to achieve these savings include ozone laundry systems, high efficiency washers and dryers and low temperature cleaning chemicals. While ozone systems and new washers and dryers require capital investment, low temperature cleaning chemicals may not require any new equipment.

This hotel has already undergone the transition to the “Aquanomic Laundry Program”. The savings is based on processing approximately 400,000 pounds of laundry per year, an average wash water temperature of 125°F, an initial consumption of 1.07 gallons of hot water per pound of laundry processed, and 47% savings on hot water usage in laundry operations.

FIGURE 16: LAUNDRY EQUIPMENT

5.6 Other Items Considered

5.6.1 Install Guest Room Energy Management System

Guest Room Energy Management Systems (GREMS) are widely used throughout the rest of the world. However, the technology is slowly being adopted in the United States and there are very few installations in mid-scale hotels in Minnesota. There are valid concerns that guest comfort may be adversely impacted so this measure requires further evaluation. However, this measure also has the potential to save a significant amount of energy so should not be dismissed.

5.6.2 Implement Scheduling Controls for Heating, Cooling, and Ventilation

There are multiple central air conditioning and furnace units that provide heating, cooling, and ventilation for common areas in the hotel.

It is recommended that programmable thermostats be installed and programmed for all common areas to allow temperatures to be automatically controlled according to the respective room's occupancy schedule. Decrease heating set points to 70°F when occupied and to 62°F when unoccupied, and increase cooling set points to 74°F when occupied and to 78°F when unoccupied. These set points are in accordance with ASHRAE Standard 55-2004 Thermal Conditions for Human Occupancy.

Implementing scheduling controls will also reduce the amount of make-up air that must be conditioned for the interior spaces, saving the majority of the energy for this measure. When the unit is scheduled off, it is not bringing in outdoor air that needs to be conditioned. Another option is to schedule the outdoor air damper to close when the spaces are unoccupied but continue to allow the unit to run and condition the space.

HVAC controls for the common areas were not reviewed during the initial walkthrough. Additional information on the existing thermostat capabilities and areas controlled would be needed to determine the measure cost, savings, and payback. Typical energy savings of 2-3% can be achieved per eight hour period that the thermostat can be setback or setup 1°F of setback or setup. This measure could also qualify for a custom rebate from their electric utility if new thermostats are required.

5.6.3 Housekeeping and Maintenance Activities

The [HOTEL NAME] currently has excellent practices in regards to housekeeping and maintenance activities that can conserve energy. While it is difficult to estimate energy savings from housekeeping and maintenance activities, it is clear that the activities in place, such as thermostat setbacks and preventative maintenance contribute to this hotel’s overall high level of efficiency.

6. Estimated Results

Potential energy savings estimates based on the Energy Audit are outlined in Table 4. Non-energy savings, incorporating water and maintenance savings, are also included. Additionally, potential rebates for all measures have been calculated using each utility's prescriptive rebate program (if available), or estimated as a custom rebate. All rebates are subject to the approval of the respective utility.

TABLE 4: ENERGY EFFICIENCY MEASURES

Energy Saving Measure	Estimated Measure Cost ($)	Estimated Electrical Savings (kWh)	Estimated Monthly Demand Savings (kW)	Estimated Gas Savings (therms)	Estimated Annual Energy Savings ($)	Estimated Non-Energy Savings ($)	Estimated Utility Rebate ($)	Approx. Payback (Years)
Replace Exterior Lights with LED Fixtures	$22,000	46,000	-	-	$3,100	$1,200	$2,175	4.5
Retrofit T8 Fixtures with LED Tubular Lamps	$8,700	14,000	2.1	-	$1,200	$800	$0	4.4
Retrofit Pool Area Fixtures with LED Lamps	$1,300	6,400	1.5	-	$600	$300	$105	1.4
Retrofit Common Area Fixtures with LED Lamps	$7,000	23,000	2.8	-	$1,900	$2,000	$670	1.6
Retrofit Walk-In Cooler Fixtures with LED Lamps	$40	200	0.0	-	$10	$10	$19	0.7
Install Occupancy Sensors in Public Spaces	$500	5,500	-	-	$400	$0	$70	1.0
Replace Standard PTACs with Heat Pump Units**	$10,000	68,000	5.0	-	$5,300	$0	$8,068	0.5
Install Liquid Pool Cover	$800	2,500	-	200	$400	$10	Unknown*	2.1
Replace Constant Speed Pool Pump with VS Pump	$1,600	9,300	1.1	-	$800	$0	$90	2.0
Replace Constant Speed Spa Pump with VS Pump	$1,600	11,000	1.2	-	$900	$0	$90	1.7
Install Efficient Showerheads in Guestrooms	$8,400	-	-	1,600	$1,300	$900	$658	3.4
Install Efficient Faucet Aerators in Guestrooms	$900	-	-	200	$200	$100	$74	2.7
Implement Low Temperature Laundry System***	$2,000	-	-	2,200	$1,800	$1,400	Unknown*	0.6
Totals	**$64,840**	**185,900**	**13.7**	**4,200**	**$17,910**	**$6,720**	**$12,020**	**2.2**

* Measure must be reviewed with and approved by utility for rebate

** Incremental cost used for replacing end of life equipment

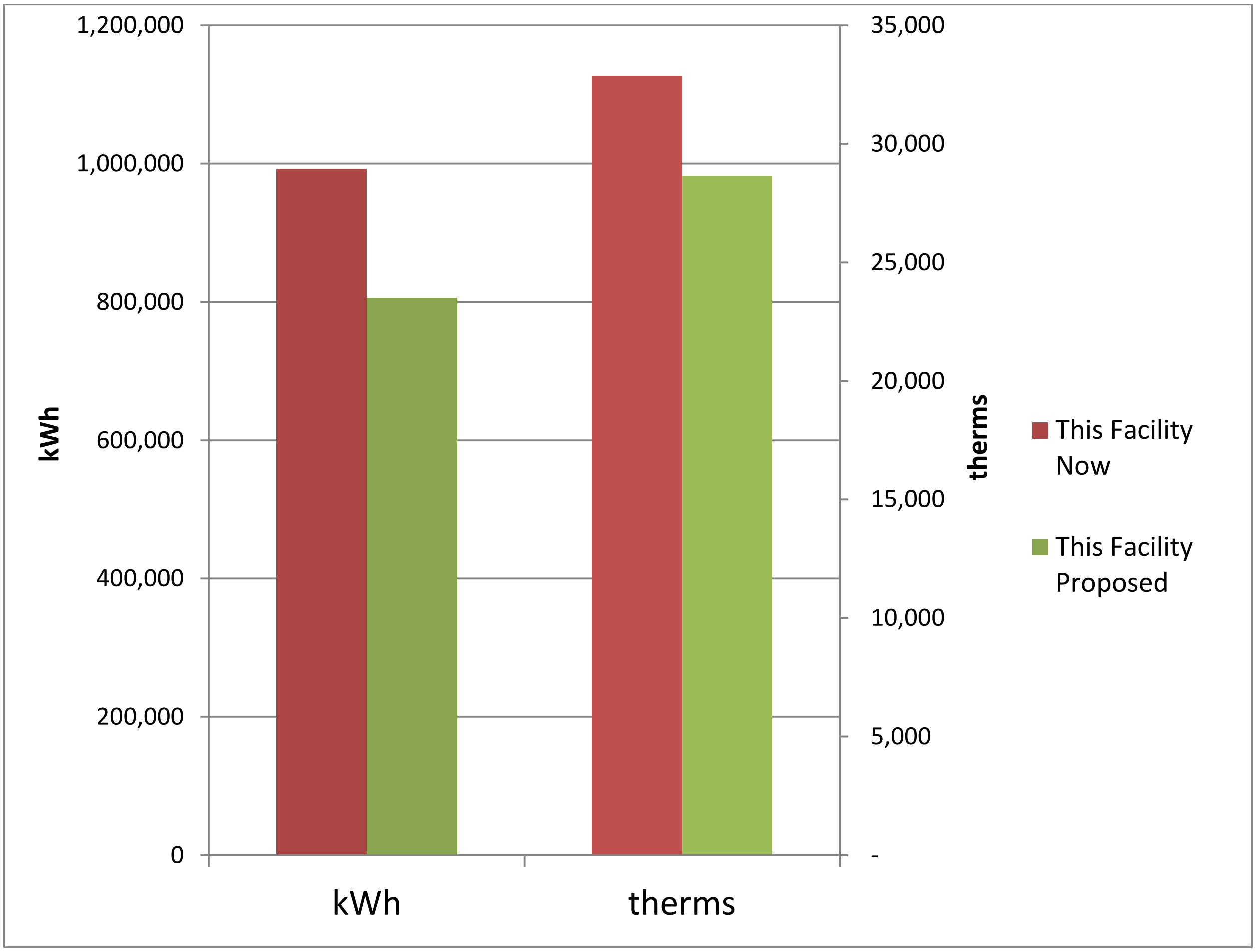
*** Measure already implemented

Disclaimer: The purpose of this audit is to identify potential energy and/or maintenance saving measures and roughly quantify their energy savings and cost effectiveness. This study does not provide investment-grade analysis of measures, as that is outside of the scope. Cost estimates should not be considered investment-grade. Cost estimates are intended to show magnitude of potential cost to assist with determining whether a project should be considered for implementation or further investigation in a detailed study. The energy savings and cost effectiveness of certain projects may be relatively well established, and these projects may not require further study before implementation. Complex projects however, will require further detailed study to ensure that these projects are feasible to implement, both physically and economically, and to calculate detailed energy savings estimates.

7. Estimated Savings Impact

FIGUREFigure 17 compares the building's current energy consumption to the estimated consumption after recommended measures have been implemented.

FIGURE 17: ENERGY CONSUMPTION COMPARISON



These savings represent 19% reduction in electricity use and 13% savings in gas use for this facility. The caveat is that these savings are expressed in absolute terms. Realizing this full reduction is unlikely since some of the measures capture savings that other measures capture as well (for instance installing a high efficiency water heater would decrease the overall savings potential for low-flow showerheads and other water heating measures).

8. Next Steps

The next step is to implement the measures from the measure list included in this report. For the majority of measures, implementation is straightforward. Michaels Energy recommends contacting your utility representative(s) to discuss possible incentives (projects that eligible for custom rebates typically require pre-approval from the Utility) and to contact a contractor to get more specific cost estimates. Michaels Energy can assist with identifying contractors for various services.

For any hotel with an ENERGY STAR score below 25, Michaels Energy will provide additional technical support, connections to contractors, help securing bids, and coordinating with Utilities. For any hotel that receives an ENERGY STAR score above 75 for the 2014 review period and meets the criteria for the professional engineers review, Michaels Energy will assist the hotel in obtaining ENERGY STAR certification. The certification will be funded by DER as a part of the grant project. However, any hotel can be certified for ENERGY STAR in the future as long as they meet the requirements listed above. In order to receive further assistance from Michaels Energy, it is important that the Hotel provide a project contact to facilitate communication and coordination.

If there is an interest in pursuing the ENERGY STAR building certification further discussions would be required to validate building operating and demographic data. The Hotel would also have to address any items that did not meet the ENERGY STAR requirements for indoor air quality, thermal comfort and illumination.

Appendix D: Hotel Site Information (n = 38)

ID Number	Energy Star Rating	City	On-site Assessment Date	Electric Utility Name	Gas Utility Name	Age of Hotel	Present Findings Date	Total Square Feet	# of Rooms	Average Occupancy Rate	Number of Workers on Main Shift	Open Parking Lot Size	Pool (Yes/No)	Pool Room Ventilation System Type [1]	Pool Surface Area, ft2	Pool Water Temp	Spa Water Temp	Pool Room Humidity SP	Pool Room Air Temp SP	Pool Circulating Water Flow Rate	PTAC/PTHP or Both [2]	Bath Exhaust Flow > 50 cfm?	Bath Exhaust - Manual or Continuous?
H01	74	Brooklyn Center	4/17/2014	Xcel Energy	CenterPoint Energy	1997	6/3/2014	47,655	84	74%	8	100,000	Yes	DX Water Heat Rec	360	82	102	52%	84	70	BOTH	Yes	Manual
H02	64	Rochester	4/10/2014	RPU	RPU	2000	6/11/2014	62,725	104	70%	13	20,000	Yes	DX Water Heat Rec	450	86	104	50%	82	60	PTAC	Yes	Manual
H03	92	Eagan	4/22/2014	Dakota Elec	MN Energy Resources	1994	6/10/2014	72,722	120	85%	17	46,830	Yes	OA DIL (with DX coil, no heat rec.)	630	88	103	50%	78	100	PTAC	No	Manual
H04	85	Eagan	5/7/2014	Dakota Elec	MN Energy Resources	1998	7/22/2014	60,000	99	70%	15	59,733	Yes	OA DIL	450	85	103	60%	85	60	PTAC	No	Manual
H05	46	Chanhassen	5/1/2014	Xcel Energy	CenterPoint Energy	1999	6/13/2014	47,460	77	80%	10	20,000	Yes	DX Air Heat Rec	493	86	104	75%	83	60	PTHP	No	Cont.
H06	98	Bloomington	1/13/2015	Xcel Energy	CenterPoint Energy	1983	3/6/2015	112,000	135	46%	36	107,900	Yes	OA DIL (with DX coil, no heat rec.)	465	83	102	50%	84	85	PTHP	Yes (est.)	Manual
H07	80	Worthington	12/15/2014	Worthington Public Utilities	MN Energy Resources	1991	3/18/2015	23,189	42	69%	7	22,000	Yes	OA DIL	544	82	102	55%	78	40	PTHP	No	Humidistat
H08	74	Perham	12/11/2014	Ottertail Power	City of Perham	2008	3/9/2015	26,547	45	54%	6	27,000	Yes	OA DIL	639	84	103	50%	79	75	PTAC	Yes	Timeclock
H09	n/a	Tyler	12/16/2014	Tyler Municipal Utility	Tyler Municipal Utility	1960	3/1/2015	4,300	8	35%	2	3,760	No	None	NA	NA	NA	NA	NA	NA	None	Yes	Manual
H10	41	North Branch	11/12/2014	North Branch Water & Light	MN Energy Resources	2000	2/13/2015	27,903	50	60%	4	22,800	Yes	OA DIL	527	87	105	30%	83	106	PTHP	Yes	Timeclock
H11	66	Blaine	1/29/2015	Connexus Electric	CenterPoint Energy	2007	3/20/2015	72,600	98	52%	8	46,050	Yes	DX Water Heat Rec	735	84	104	40%	86	80	Both	Yes	Manual
H12	64	Coon Rapids	11/5/2014	Connexus Electric	CenterPoint Energy	1997	3/18/2015	44,000	72	62%	7	23,800	Yes	OA DIL	400	87	105	30%	92	72	BOTH	Yes	Manual
H13	65	Two Harbors	1/5/2015	City of Two Harbors	City of Two Harbors	1996	2/27/2015	24,475	45	55%	5	16,200	Yes	OA DIL	527	84	104	55%	71	70	PTHP	NA	Manual
H14	70	Burnsville	11/4/2014	Dakota Electric	CenterPoint Energy	1985	12/19/2014	93,300	131	60%	25	110,000	Yes	OA DIL	480	85	103	36%	74	80	None	Yes	Cont.
H15	80	Maple Grove	1/21/2015	Wright-Hennepin	CenterPoint Energy	2003	3/17/2015	66,802	120	70%	20	44,865	Yes	DX Water Heat Rec	578	84	104	50%	84	90	Both	No	Manual
H16	56	St. Cloud	11/20/2014	Xcel Energy	Xcel Energy	1997	12/2/2014	27,066	45	65%	8	30,464	Yes	OA DIL	702	84	103	52%	76	56	PTHP	No	Manual
H17	41	Rochester	2/2/2015	RPU	MN Energy Resources	1972	3/2/2015	72,360	118	60%	17	22,140	Yes	OA DIL	824	84	101	55%	79	83	Both	No	Timeclock
H18	63	Sauk Centre	12/3/2014	Sauk Centre Public Utilities	CenterPoint Energy	1996	3/16/2015	31,479	57	64%	8	110,000	Yes	OA DIL	491	84	102	51%	75	90	PTHP	Yes	Manual
H19	57	Baudette	12/16/2014	Baudette Muni	MN Energy Resources	1997	2/23/2015	36,080	45	65%	8	24,500	Yes	OA DIL	612	87	104	55%	78	60	PTHP	Yes (est.)	Manual
H20	73	Bemidji	12/15/2014	OtterTail Power	MN Energy Resources	1989	2/18/2015	36,000	59	70%	11	30,789	Yes	OA DIL	527	85	104	55%	76	60	PTHP	Yes (est.)	Manual
H21	54	Paynesville	12/3/2014	Xcel Energy	CenterPoint Energy	1996	3/2/2015	17,652	39	55%	7	10,556	Yes	OA DIL	490	85	102	46%	81	120	PTHP	No	Manual
H22	60	New Ulm	2/11/2015	City of New Ulm	City of New Ulm	1962	4/2/2015	7,840	24	60%	2	11,200	No	None	NA	NA	NA	NA	NA	NA	None	No	Manual
H23	60	St. Cloud	1/28/2015	Xcel	Xcel Energy	1978	3/1/2015	163,631	230	59%	64	112,000	Yes	OA DIL (with DX coil, no heat rec.)	870	87	101	none	variable	60	Both	No	Manual
H24	64	Bloomington	1/22/2015	Xcel	CenterPoint Energy	1994	4/2/2015	136,512	233	82%	35	17,000	Yes (2)	DX Water Heat Rec	832	85	104	50%	84	60	Both	No	Manual
H25	44	Eagan	10/23/2014	Dakota Electric	MN Energy Resources	1997	12/12/2014	56,979	105	80%	14	40,482	Yes	DX Water Heat Rec	500	84	102	46%	78	60	Both	Yes (est.)	Manual
H26	86	Lutsen	1/6/2015	Arrowhead Cooperative	Propane	1992	3/24/2015	13,772	30	40%	3	11,700	Spa only	OA DIL	NA	NA	91	20%	72	NA	PTHP	No	Manual
H27	47	Lakeville	11/11/2014	Xcel	CenterPoint Energy	1982	2/18/2015	91,473	132	69%	15	119,160	Yes	OA DIL (with DX coil, no heat rec.)	1,003	85	103	50%	83	100	PTHP	Yes	Manual
H28	31	Austin	12/2/2014	Austin PU	Austin PU	1988	2/17/2015	67,400	117	55%	30	200,000	Yes	OA DIL (with DX coil, no heat rec.)	512	81	101	50%	80	120	PTAC	Yes (est.)	Manual
H29	67	Austin	12/2/2014	Austin PU	Austin PU	1988	2/17/2015	13,516	59	55%	15	20,930	No	None	NA	NA	NA	NA	NA	NA	PTAC	Yes (est.)	Manual
H30	61	Two Harbors	1/5/2015	Coop Light and Power	Propane	1999	2/25/2014	28,000	25	56%	20	25,000	Yes	OA DIL	440	86	103	50%	90	90	PTHP	Yes (est.)	Manual
H31	100	Marshall	12/16/2014	City of Marshall	Great Plains Natural Gas	1977	3/1/2015	18,578	47	48%	4	14,200	No	None	NA	NA	NA	NA	NA	NA	PTHP	No	Manual
H32	1	Grand Portage	1/5/2015	Arrowhead Cooperative	#2 deisel and wood chip back-up	1975	3/19/2015	67,550	95	53%		130,875	Yes	OA DIL	674	86	NA	31%	72	No	PTAC	No	Cont.
H33	63	Pipestone	12/15/2014	Xcel Energy	CenterPoint Energy	1888	3/2/2015	37,500	36	75%	9	0	No	None	None	NA	NA	NA	NA	NA	None	No	Cont.
H34	n/a	Bemidji	12/15/2014	Ottertail Power	MN Energy Resources	1981	3/2/2015	31,670	59	80%	10	22,813	Yes	OA DIL	576	84	105	50%	73	70	None	Yes (est.)	Manual
H35	82	Fergus Falls	12/10/2014	Ottertail Power	Great Plains Natural Gas	1971	3/2/2015	68,085	96	48%	15	132,000	Yes	OA DIL (with DX coil, no heat rec.)	1,445	83	102	60%	77	70	Both	No	Timeclock
H36	100	Shakopee	11/18/2014	Shakopee Public Utility?	CenterPoint Energy	1994	3/3/2015	38,000	65	50%	8	43,000	Yes	OA DIL	672	86	103	40%	78	75	PTHP	NA	Manual
H37	50	Maple Grove	1/15/2015	Wright-Hennepin	CenterPoint Energy	2000	3/25/2015	79,995	119	75%	12	47,600	Yes	OA DIL	437	88	102	30%	75	70	Both	Yes	Manual
H38	99	Austin	12/1/2014	Austin PU	Austin PU	1980	1/27/2015	26,320	55	20%	3	0	No	None	NA	NA	NA	NA	NA	NA	PTAC	Yes	Manual
Average	66					1987		51,398	82	61%	14	48,614			610	85	103	48%	80	76			
Max	100					2008		163,631	233	85%	64	200,000			1,400	88	105	75%	92	120			
Min	1					1888		4,300	8	20%	2	0			360	81	91	20%	71	40			
Count	36					38		38	38	38	37	38			31	31	31	31	31	30			
Median	64					1994		41,000	70		10	26,000			530	90	100		80	70			
Assumption																							

ID Number	GREMS (Yes/No/Test)	Energy Star TVs?	Energy Star Fridge?	Resaturant? (yes/no)	Shower gpm rating	Pounds of Laundry	Low Temp Laundry (Yes/No/NA) [3]	Water Heater Discharge Temp for Laundry	Water Heater Discharge Temp for Domestic	(2013 Base Year) kWh	Base kW (Average)	(Base Year Elec Cost)	(2013 Base Year) therms	(Base Year Gas Cost)	Total Energy Cost	(Base Year) Gallons Water	(Base Year Water Cost)	Savings Identified, kWh	Monthly kW Savings	Savings Identified, Therms	Overall Energy Savings, $	Non-Energy Savings, $	% Savings Identified, kWh	% Savings Identified, Therms	Desk Light FC >10	Bath
H01	Test	NA	No	No	2.2	216,705	No	145	120	662,400	120	$59,616	16,662	$11,820	$71,436	2,397,000	$11,290	124,000	13.8	3,640	$11,480		19%	22%	Yes	Yes
H02	No	NA	NA	No	2.0	223,600	No	140	140	804,800	159	$72,432	20,538	$15,961	$88,393	2,501,910	$13,665	167,000	6.4	3,600	$11,060		21%	18%	No	Yes
H03	No	NA	No	No	2.5	484,322	NA	125	125	904,680	176	$81,421	35,298	$27,523	$108,944	5,452,000	$25,449	147,300	14.0	6,650	$17,060		16%	19%	No	Yes
H04	No	NA	NA	Yes	2.2	285,000	Yes	118	118	833,800	189	$75,042	41,565	$31,765	$106,807	3,436,000	$13,719	110,000	8.1	5,000	$7,743		13%	12%	Yes	Yes
H05	Test	NA	NA	No	2.0	275,000	Yes	120	120	722,600	134	$65,034	21,976	$14,879	$79,913	2,145,000	$3,031	100,500	8.4	4,300	$7,193		14%	20%	Yes	Yes
H06	No	No	NA	No	2.5	293,584	No	125	125	859,800	178	$81,581	14,486	$11,534	$93,116	2,985,000	$22,021	107,400	8.0	4,400	$12,070	$6,900	12%	30%	Yes	Yes
H07	No	Yes	Yes	No	1.5	137,604	NA	137	137	316,320	68	$25,271	15,013	$12,562	$37,833	1,126,000	$6,573	39,100	14.1	1,660	$5,640	$2,100	12%	11%	Yes	Yes
H08	No	No	No	No	2.2	108,972	No	128	128	385,900	85	$29,750	12,600	$8,987	$38,737	240,613	$3,970	72,200	2.3	2,100	$5,820	$2,770	19%	17%	Yes	Yes
H09	No	No	No	No	1.5	NA	No	130	130	74,620	NA	$6,876	1,430	$1,860	$8,736	391,000	$2,398	9,500	2.1	80	$950	$60	13%	6%	Yes	Yes
H10	No	No	Yes	No	2.2	142,448	No	120	120	464,160	106	$55,150	19,541	$17,222	$72,372	1,572,000	$23,121	51,300	5.2	2,770	$7,640	$4,490	11%	14%	No	No
H11	No	Yes	No	No	2.5	243,832	No	150	150	828,480	152	$71,014	19,950	$16,527	$87,541	2,479,895	$11,528	109,000	7.0	1,900	$8,300	$4,940	13%	10%	Yes	Yes
H12	No	NA	No	No	2.2	285,000	No	120	120	486,560	107	$42,174	21,899	$18,759	$60,933	9,628,256	$7,074	75,500	5.1	4,200	$8,800	$7,050	16%	19%	Yes	Yes
H13	No	Yes	No	No	2	117,519	No	125	125	349,840	76	$41,941	17,122	$12,891	$54,832	828,000	$3,646	25,800	2.7	2,550	$3,500	$2,070	7%	15%	No	Yes
H14	Yes	NA	Yes	Yes	2.2	373,000	No	115	115	1,143,072	221	$116,847	84,789	$68,753	$185,600	3,887,000	$28,872	156,170	20.7	7,000	$20,410	$10,640	14%	8%	No	Yes
H15	No	No	No	Yes	2.5	398,853	Yes	129	125	992,000	189	$89,280	32,862	$26,700	$115,980	4,138,000	$11,458	185,900	13.7	4,200	$17,910	$6,720	19%	13%	Yes	Yes
H16	No	Yes	Yes	No	2.0	174,600	No	120	135	396,000	80	$39,696	19,396	$15,380	$55,076	2,236,520	$9,389	16,000	2.1	2,200	$3,610	$1,230	4%	11%	NA	NA
H17	Test	NA	No	No	2.0	336,000	No	140	130	1,035,200	213	$98,639	34,998	$30,679	$129,318	3,326,281	$20,681	120,100	11.8	3,700	$12,480	$6,940	12%	11%	No	Yes
H18	Test	Yes	Yes	No	2.0	172,594	No	125	130	470,000	101	$32,382	19,480	$16,324	$48,706	1,439,600	$8,559	28,900	2.2	2,090	$3,270	$3,360	6%	11%	Yes	Yes
H19	No	No	No	No	2.2	140,000	No	125.00	125.00	496,200	n/a	$33,724	22,990	$17,065	$50,789	1,698,000	$11,037	28,700	3.8	2,060	$3,450	$2,710	6%	9%	Yes	Yes
H20	No	Yes	No	No	1.5	196,103	No	120	120	394,200	83	$30,140	25,844	$19,943	$50,083	1,911,000	$15,880	14,700	1.7	2,900	$3,250	$4,130	4%	11%	Yes	Yes
H21	No	Yes	No	No	2.0	102,000	No	130	130	302,720	70	$30,926	16,536	$13,616	$44,542	1,135,000	$5,763	31,400	2.2	1,800	$4,000	$2,080	10%	11%	Yes	Yes
H22	No	Yes	No	No	2.5	68,375	No	120	120	78,650	n/a	$9,494	7,692	$5,893	$15,387	434,000	$1,567	3,500	0.2	850	$1,030	$770	4%	11%	Yes	Yes
H23	No	Yes	NA	Yes	2.0	360,000	No	120	130	2,302,400	405	$216,860	136,166	$107,285	$324,145	NA	NA	107,800	4.70	$7,300	$9,500	$10,860	5%	5%	Yes	Yes
H24	No	No	Yes	Yes	2.5	891,000	Yes	120	120	2,241,600	350	$192,925	68,255	$55,464	248,389.000	8,657,000	$55,681	315,300	31.74	$1,400	$26,200	$8,830	14%	2%	Yes	Yes
H25	No	Yes	No	No	2.5	400,000	No	143	120	960,800	182	$96,351	21,515	$19,110	$115,461	3,220,000	$14,844	185,866	6.50	7,631	$22,400	$6,720	19%	35%	NA	NA
H26	No	Yes	No	No	2	56,979	No	137	137	134,400	26	$17,193	6,870	$12,064	$29,257	NA	NA	28,400	3.18	389	$4,030	$900	21%	6%	No	Yes
H27	No	Yes	Yes	Yes	1.5	405,360	No	150	130	1,488,000	268	$139,535	78,419	$63,276	$202,811	5,310,000	$25,795	222,800	21.08	3,600	$21,700	$10,050	15%	5%	Yes	Yes
H28	No	Yes	No	Yes	2.5	305,550	No	120	112	1,491,840	280	$152,200	69,110	$63,640	$215,840	4,986,168	$7,984	218,000	22.14	3,300	$21,620	$6,270	15%	5%	Yes	Yes
H29	No	Yes	No	No	2.2	NA	No	120	120	303,400	66	$35,568	2,911	$2,947	$38,515	1,177,352	$2,175	68,100	12.13	800	$8,470	$1,160	22%	27%	Yes	No
H30	No	No	No	Yes	2	66,476	No	125	125	542,000	115	$59,218	35,105	$77,375	$136,594	1,640,134	$18,851	107,700	19.00	1,702	$14,750	$4,230	20%	5%	No	Yes
H31	No	Yes	No	No	2.5	38,250	Yes	120	120	204,300	58	$18,843	3,232	$2,907	$21,750	1,825,868	$ 14,015	16,000	0.00	660	$2,150	$1,100	8%	20%	Yes	Yes
H32	No	?	Yes	Yes	2.5	238,000	No	125	125	3,682,176	502	$293,002	188,800	$304,625	$597,627	NA	NA	133,800	1.38	280	$13,600	$7,130	4%	0%	Yes	Yes
H33	No	No	No	Yes	2.2	120,000	NA	NA	NA	371,200	91	$39,429	36,980	$30,051	$69,480	1,165,400	$3,053	28,200	0.00	900	$3,180	$1,160	8%	2%	Yes	Yes
H34	No	No	No	No	2	224,117	No	130	130	241,220	45	$20,587	NA	NA	NA	1,114,000	$10,327	32,100	2.39	3,100	$4,630	$3,330	13%	n/a	Yes	No
H35	No	Yes	Yes	Yes	2.5	227,000	No	122	122	1,076,000	299	$77,164	29,400	$28,771	$105,935	3,487,000	$10,569	117,600	10.10	2,500	$9,100	$6,030	11%	9%	Yes	Yes
H36	Yes	Yes	Yes	No	2.5	154,318	Yes	140	120	312,560	31	$ 30,594	14,056	$11,639	$42,233	1,571,000	$7,426	-	0.00	2,000	$1,400	$1,300	0%	14%	NA	NA
H37	No	Yes	No	No	2.5	423,781	No	126.00	126.00	1,012,400	185	$85,734	36,366	$29,752	$115,486	3,607,000	$11,433	171,300	10.08	4,600	$16,400	$7,220	17%	13%	No	Yes
H38	No	No	No	No	2.2	52,231	No	130.00	130.00	164,500	44	$20,307	3,388	$3,472	$23,779	425,612	$2,347	33,100	7.83	720	$18,400	$1,830	20%	21%	Yes	Yes
Average					2.2	242,727		128		777,126	156	$70,630	33,871	$33,217	$105,000	2,673,560	$12,720	92,369	8.10	2,909	$9,847	$4,457	13%	13%		
Max					2.5	891,000		150		3,682,176	502	$293,002	188,800	$304,625	$597,627	9,628,256	$55,681	315,300	31.74	7,631	$26,200	$10,860	22%	35%		
Min					1.5	38,250		115		74,620	26	$6,876	1,430	$1,860	$8,736	240,613	$1,567	0	0.00	80	$950	$60	0%	0%		
Count					27.0	36		37		38	35	38	37	37	37	35	35	38	38	38	38	33	38	37		
Median					2.2	223,859		125		519,100	120	$57,184	21,515	$17,065	$72,372	2,145,000	$11,037	88,000	6.45	2,525	$8,385	$4,130	13%	11%		
Assumption										**879,074**		**$70,596**	**29,785**	**$23,830**									**20%**	**20%**		

Appendix E: Analysis of a Liquid Pool Cover

Energy Analysis of a Liquid Pool Cover for Indoor Hotel Pools

April 23, 2015

Minnesota Department of Commerce
Division of Energy Resources
85 7th Place East, Suite 500
St. Paul, MN 55101

Michaels No.: MJ813AAN

MichaelsEnergy

ACKNOWLEDGEMENTS

This project was supported in part (or in whole) by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development (CARD) program, which is funded by Minnesota ratepayers.

p 608.785.1900 | 400 Main Street, Suite 200 | La Crosse, WI 54601

Executive Summary

The majority of mid-scale hotels in Minnesota have an indoor swimming pool. A significant amount of energy is consumed to heat the pool water and heat and dehumidify the air. This provides a comfortable space for swimmers and a humidity level that does not cause damage to the building structure. The primary method for reducing the energy consumed in these spaces is to use a pool cover. Almost no hotels use pool covers because of the time and equipment required. This study evaluated a liquid pool cover, which provides an attractive alternative to the traditional pool cover.

Ultimate energy savings from a liquid pool cover will vary based on pool size, operating conditions, ventilation system and method of humidity control. These results show the liquid pool cover reduced evaporation by 19 - 40% and performed 64 - 73% as effectively as a solid pool cover. System costs include an initial cost to install the system of $500 for the equipment and an annual cost of $0.50 per square foot of pool surface area for chemicals. For the two pools evaluated in this study, the liquid pool cover achieved energy cost savings of $800 to $1,200 per year. The entire installation should pay for itself in 7 – 14 months. The annual chemical costs should be recovered in 2-5 months of operation.

While this attractive savings may lead one to think these systems will sell themselves, there was resistance to this measure. No hotels in this study were using the liquid pool cover at the start of the grant and many had never heard of it. Pool maintenance contractors had heard of it, but were not promoting it to hotels. There were concerns about health risk to swimmers, negative effects on pool water chemistry, and whether the seal would stay in place with pool pumps running 24 hours a day. There have been studies to address potential concerns. These studies have concluded the chemical does not affect pool water quality parameters and the health risks to swimmers are negligible.[1] The liquid chemical is primarily isopropyl alcohol which is a relatively safe ingredient.

Minnesota utilities should consider including this in their list of energy saving measures for hotels. Since it is a consumable product and the energy saving payback is less than one year, it would be a unique measure to rebate. However, at a minimum, utility promotion of the liquid pool cover would provide credibility to the energy savings of a measure that has significant potential for pools in hotels and elsewhere.

[1] See Toxicology Report on company's website here.

Background

This analysis was funded by the Minnesota Department of Commerce, Conservation Applied Research & Development (CARD) grant managed by the Division of Energy Resources. The purpose of the grant was to develop and pilot a deep energy savings program for mid-scale hotels in Minnesota. A specific component of the grant was to demonstrate new technologies that hotel owners are not aware of and have little market penetration. The study included site visits to 38 hotels across the state.

Recommended Pool Room Operating Conditions:

- Room Air Temperature of 82°F
- Pool Water Temperature at 80°F
- Relative Humidity between 50% and 60%
- Room at Slightly Negative Pressure for Odor Control

The majority of mid-scale hotels in Minnesota have an indoor swimming pool. The pool room must maintain its own unique operating environment with typical settings of 82°F for air temperature, 80°F for water temperature and relative humidity levels of 50-60%. The room must also be maintained at a slightly negative pressure to control chemical odors. The majority of heat loss is from evaporation of the pool water. A smaller amount of energy loss is from the ventilation system, which conditions outdoor air and dehumidifies the indoor air to keep humidity levels below 60%.

FIGURE 1: SOLID POOL COVER AND PULLEY SYSTEM USED TO RETRACT POOL COVER

Solid pool covers, as shown in Figure 1, reduce the energy needed for water heating by 50-70%.[2] However, they are rarely used by hotel owners. At an estimated time of 15 minutes

[2] Saving estimate from U.S. Department of Energy web site on pool covers.

for each application or removal of the cover, this could have labor costs of approximately $1,700.[3]

The Heatsavr™ liquid pool cover system is an alternative to the traditional solid pool cover. It appears to be a unique product with no similar competing products other than the traditional solid pool cover. It has been on the market for 16 years[4], but has little market penetration in Minnesota and is not well understood. No hotels in this study were using the product and most had not even heard of it. Pool contractors were aware of the product, but were not actively promoting it as an energy saving measure. There were concerns about health risk to swimmers, negative effects on pool water chemistry, and whether the seal would stay in place with pool pumps running 24 hours a day. There have been studies to address potential concerns. These studies have concluded the chemical does not affect pool water quality parameters and the health risks to swimmers are negligible.[5] The liquid chemical is primarily isopropyl alcohol which is a relatively safe ingredient.

The chemical forms a transparent seal on a still pool surface as shown in Figure 2, and is therefore not effective when swimmers are using the pool. Typical hotel pools are open from 7 am to midnight or 70% of the time. During the week, hotels often have mostly business travelers and the pool is rarely used. On weekends, the pool can be occupied by families the entire open period. Between those two extremes, it is conservative to estimate that these pools are in use at most 10 hours per day on average. Using this number, the pool surface is still and the liquid pool cover can be effective about 14 hours per day, or 60% of the time. This can be compared to a traditional pool cover which is only in place approximately 30% of the time.

FIGURE 2: STILL POOL SURFACE

FIGURE 3: FEED SYSTEM FOR LIQUID POOL COVER

The liquid is delivered to the pool once a day with a feed pump similar to other pool chemical feed pumps, as shown in Figure 3. The cost to install the feed pump is about $500 and the chemical costs approximately $0.50 per square foot of pool area annually. For the average mid- scale hotel with a pool area of 600 square feet, this system would cost $800 the first year and then $300 annually thereafter. Based on information from other third party studies,

---

[3] Based on wages of $9.50/hour.

[4] See history of Heatsavr™ on company's website here.

[5] See Toxicology Report on company's website here.

the liquid pool cover has saved from 18-30% for water heating and an additional 21% for outdoor air heating.[6]

Traditional pool covers reduce pool sanitation chemical usage so it is expected that the liquid pool cover will reduce chlorine usage as well. The chemical savings for traditional pool covers is estimated at 35-60%.[7]

Indoor pool rooms in Minnesota are conditioned by one of three types of heating, ventilation and air conditioning (HVAC) systems.

Type 1: Dehumidification via outdoor air and gas heat. Larger amounts of outdoor air are brought into the space to remove humidity. The outdoor airflow is allowed to vary to meet required humidity levels. Some of these systems also include a direct expansion (DX) cooling coil to dehumidify during the summer months.

Type 2: Direct expansion cooling to provide dehumidification, with hot gas heat recovery used to heat pool water. Supplemental heat is provided for the pool and air as necessary with another source. Only minimum ventilation levels are provided for indoor air quality.

Type 3: Direct expansion cooling to provide dehumidification, with hot gas heat recovery used to reheat the supply air. Supplemental heat is provided for the pool and air as necessary with another source. Only minimum ventilation levels are provided for indoor air quality.

Table 1 shows what type of ventilation systems were observed in the 38 hotels studied. Using an estimate of 1,250 hotels in Minnesota, the market potential for this measure is significant.

TABLE 1: SUMMARY OF POOL VENTILATION SYSTEMS OBSERVED IN STUDY

Pool Ventilation Type	#	%	Market Potential
Type 1: Outdoor Air Dilution	19	50%	630
Type 1: Outdoor Air Dilution with DX Coil	6	16%	200
Type 2: DX Coil with Water Heat Recovery	6	16%	200
Type 3: DX Coil with Air Heat Recovery	1	3%	30
No Pool	6	16%	200

All of these systems use gas to heat the pool water at least as an auxiliary heater.

---

[6] See City of Thunder Bay Study on an indoor natatorium and 1999 AquaScience Study on a 1,120 ft2 indoor pool.

[7] See U.S. Department of Energy web page on swimming pool covers.

Methodology

Research Goal

This research was intended to answer two questions about this technology as it pertains to hotel pools in Minnesota.

1) What is the energy savings potential of the measure?
2) Is this a measure that would be accepted by hotel owners, operators and management in Minnesota?

Participant Recruitment

This measure has a relatively low initial cost of $800. Therefore, grant funds were used to offer this free to hotels willing to be part of the measurement and evaluation. The product supplier provided a discount and was available to answer questions that came up during the test.

Overall 4 hotels were provided the liquid pool cover system. Two hotels were evaluated for reductions in evaporation rates. The other two hotels were provided the system and asked for feedback on their qualitative experience at the end of the trial period.

Monitoring and Recordkeeping

Measurements of water consumption and indoor air conditions in baseline and proposed conditions (respectively, without and with the liquid pool cover) provide the core data for evaluation. Indoor temperature and relative humidity were collected with data loggers. Once the reduction in evaporation was determined, this data would be used in a sophisticated spreadsheet analysis of the specific HVAC system to estimate annual energy savings. Ultimately the liquid pool cover would be assigned a percent effectiveness as compared to a solid pool cover.

This evaluation was conducted over the months of August 2014 through November 2014 at two separate hotels. The test periods for baseline and proposed conditions were between 20 and 40 days long. The testing required installation of water meters as shown in Figure 4 and manual logs were used by hotel staff to record whenever water was added to the pool.

In addition to the measurement of water consumption, addition data was collected on the outdoor temperature and relative humidity and energy consumption of some HVAC components. This data was not used in the analysis but collected to gain some additional insight and verification of the test conditions and operating equipment. Finally, one more set of data was collected at one of the hotels in the winter months but this data was not included in the analysis. The effort at tracking water usage a second time was too labor intensive for hotel staff.

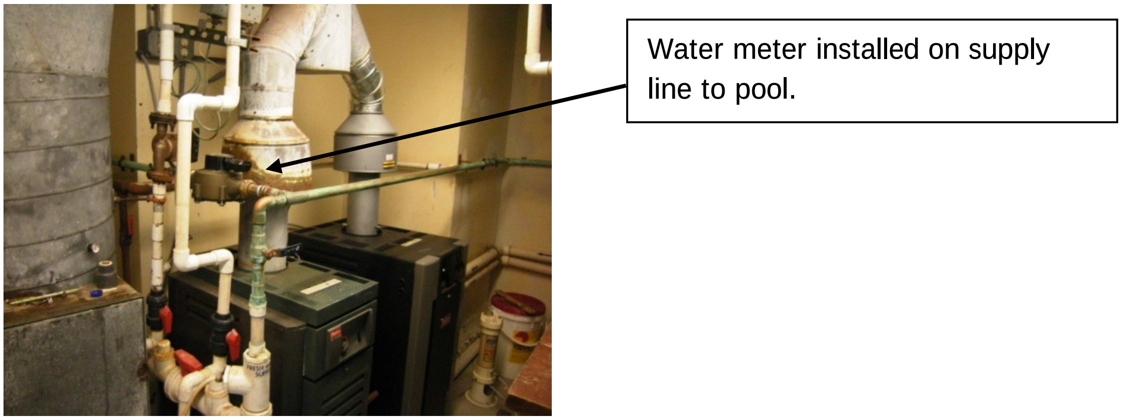


FIGURE 4: WATER METER ON POOL WATER SUPPLY

In addition to the water lost by evaporation, water is lost when the sand filters are backwashed or if there is swimmer activity. These water losses should be consistent over long periods of time but may affect the estimates of water evaporation rates over a short test period. If the data was available, the amount of water added after the filters were backwashed was accounted for. The hotels were asked to track swimmer activity by doing spot checks of the pool during the day. At the beginning of the testing it was unclear what an appropriate length of time would be. It ended up that a 30 day test period worked well for the variations that occur from day to day.

Analysis

The goal of the testing was to determine a reasonable estimate of how much the evaporation rate was reduced by using the liquid pool cover. Once that number was determined a calculation based analysis was conducted to determine an estimate of the annual energy saved. The calculation accounted for the specific HVAC system used and variations in outdoor air conditions throughout the year.

Results

Testing at Hotel 1

The following data was obtained at Hotel 1 which was located in a suburb of Minneapolis, Minnesota. The HVAC system used direct expansion cooling to provide dehumidification, with hot gas heat recovery used to heat pool water. Supplemental heat for the pool water used natural gas and supplemental room air heat used electricity. Only minimum ventilation levels were provided for indoor air quality. The surface area of the pool water was 360 ft^2. The pool water was maintained at 82°F. Table 2 provides a summary of the data logging periods. Only the first two periods were used to estimate reductions in losses due to evaporation.

TABLE 2: MONITORING PERIODS FOR HOTEL 1

Test Condition	Start	End	Duration, Days
Baseline - No Pool Cover	8/20/14	9/29/14	40
Proposed - Pool Cover	9/30/14	11/3/14	34
Proposed - Pool Cover	2/10/15	3/9/2015	27

Environmental Conditions

Figure 5 shows the baseline poolroom conditions in Hotel 1. The average room air temperature is 84°F. While the relative humidity fluctuates, the overall average is 61%. The graph shows relative humidity spiking to 83% on September 5th when the HVAC system shut down briefly.

This shows how quickly humidity can rise if the HVAC system if not running.

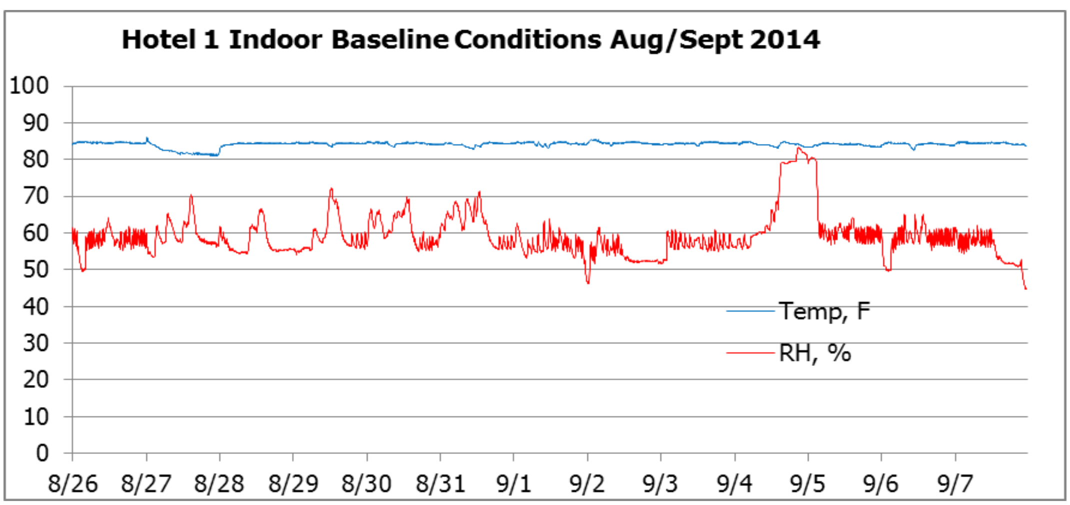


FIGURE 5: INDOOR BASELINE CONDITIONS HOTEL 1 IN AUG/SEPT 2014

There was a problem with the data loggers for the proposed poolroom conditions in October. Since the pool staff recorded the water temperature, room air temperature and relative humidity manually, backup data was available. The manually recorded baseline and proposed data are shown in Table 3 and these indicate the HVAC system was controlling to the same set points in both conditions. Since these sensors were not in the same location as the data loggers, they read different values. Appendix 1 provides a detailed summary of data recorded by hotel staff.

TABLE 3: MANUALLY RECORDED POOL ROOM CONDITIONS FOR HOTEL 1

Test Condition	Start	End	Duration, Days	Room Air Temp, °F	Water Temp, °F	Room RH, %
Baseline - No Pool Cover	8/20/14	9/29/14	40	86	82	74%
Proposed - Pool Cover	9/30/14	11/3/14	34	85	82	74%

The most in-depth testing for the liquid pool cover was conducted at Hotel 1. The staff was very detailed in their recordkeeping and allowed a second period of data logging in the winter months in the proposed condition with the liquid pool cover in service. Figure 6 shows the poolroom conditions in Hotel 1 in the proposed condition during the winter of 2015. The average room air temperature was 81°F. Relative humidity wasn't consistent until it stabilized at approximately 69%. Based on conversations with hotel staff there were operational problems with the HVAC system during the test period. The system was adjusted at the end of the test period to lower relative humidity to levels closer to 60%. This data was not used in the calculations for energy savings.

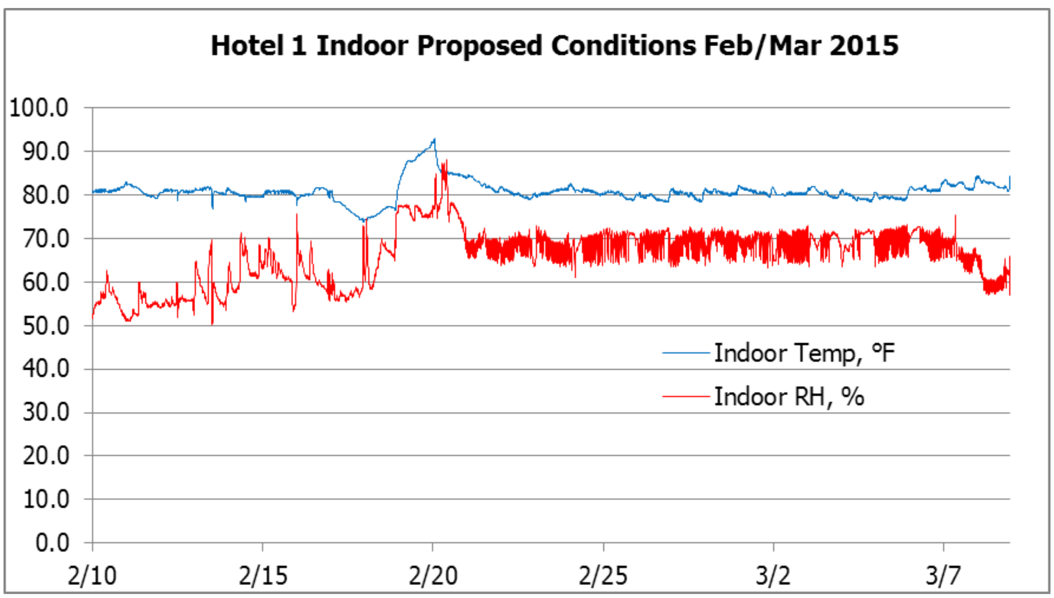


FIGURE 6: INDOOR PROPOSED CONDITIONS HOTEL 1 IN FEB/MAR 2015

Figure 7, Figure 8 and Figure 9 show the outdoor conditions for all three periods observed. The baseline period had an average temperature of 71°F and average relative humidity of 69%. The proposed period in the fall months had an average temperature of 50°F and relative humidity of 73%. The proposed period in the winter months had an average temperature of 15°F and relative humidity of 62%. These all appear to be reflective of typical outdoor conditions in Minnesota.

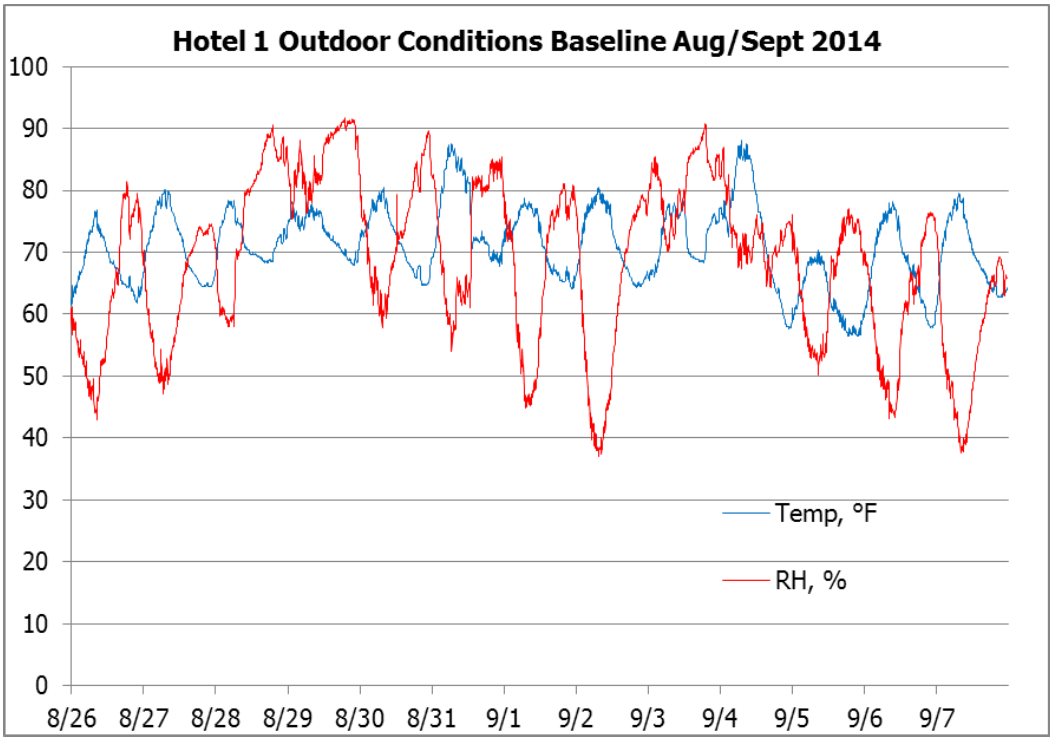


FIGURE 7: OUTDOOR CONDIIONS BASELINE AUG/SEPT

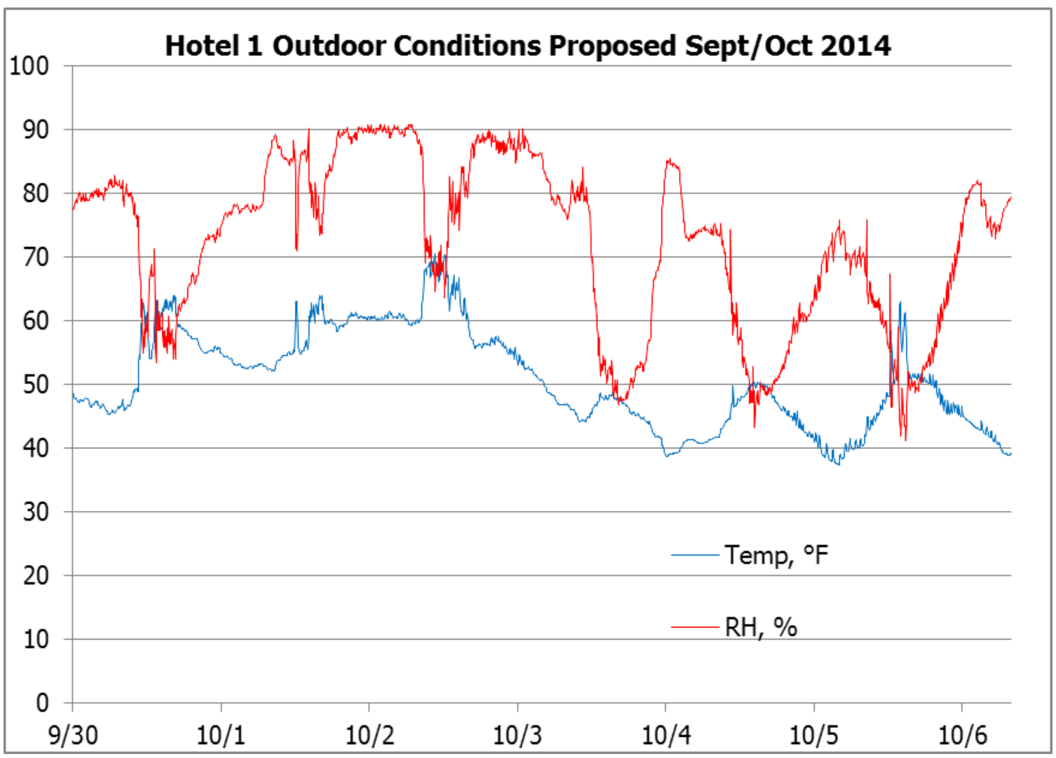


FIGURE 8: OUTDOOR CONDITIONS PROPOSED OCTOBER 2014

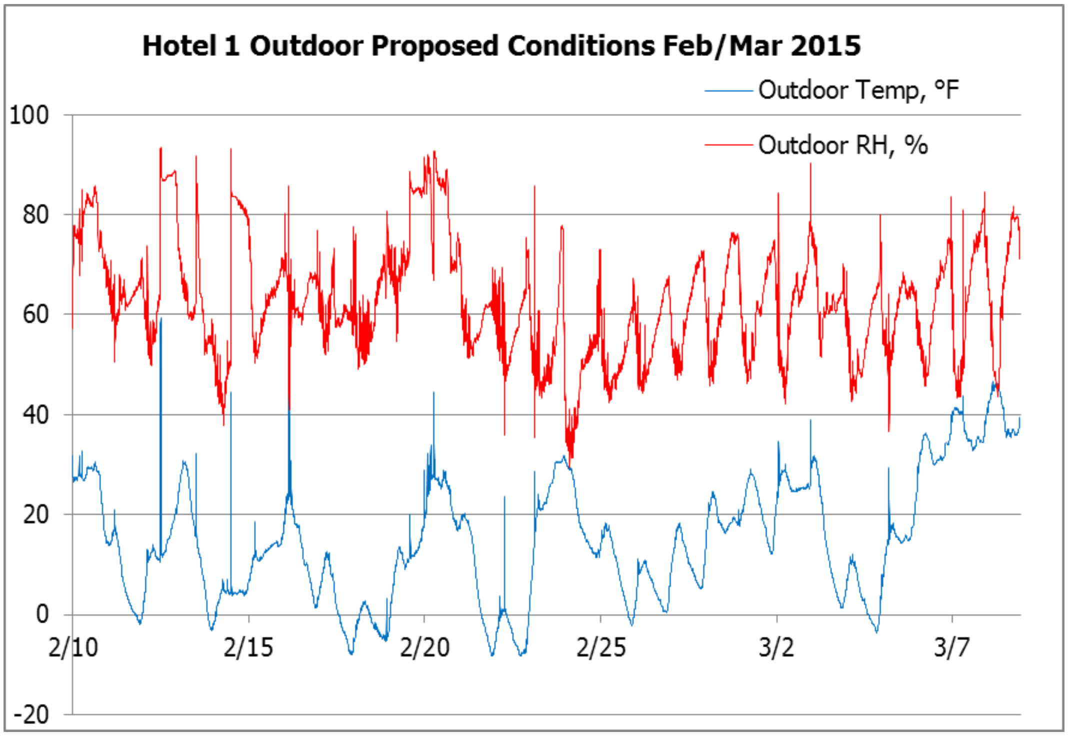


FIGURE 9: OUTDOOR CONDITIONS PROPOSED FEB/MAR 2015

Measured Energy Consumption

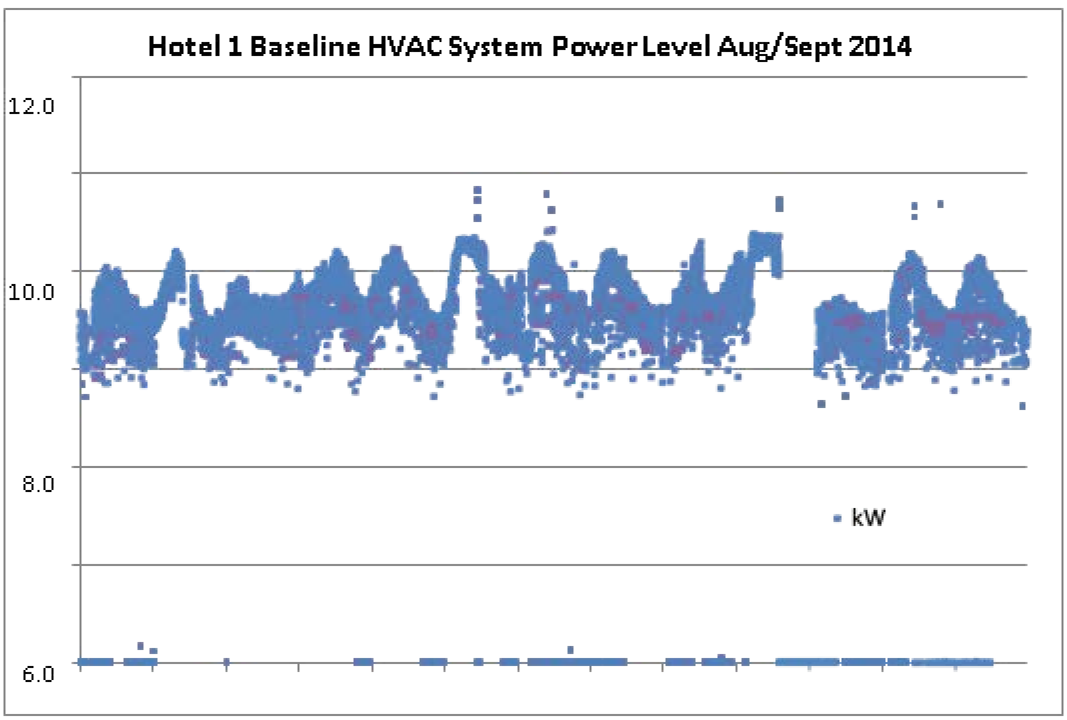


FIGURE 10: BASELINE HVAC POWER LEVEL AUG/SEPT 2014

Figure 10, Figure 11 and Figure 12 show the measured energy use on the HVAC unit for the three periods observed. The average kW load in the baseline condition was 6.5 kW. In the proposed condition in the month of September, the average kW load was 5.4 kW. In the proposed condition during February and March of 2015 the average kW load was 5.5 kW. Since outdoor air conditions were different no conclusions can be made about whether this data indicates energy was saved.

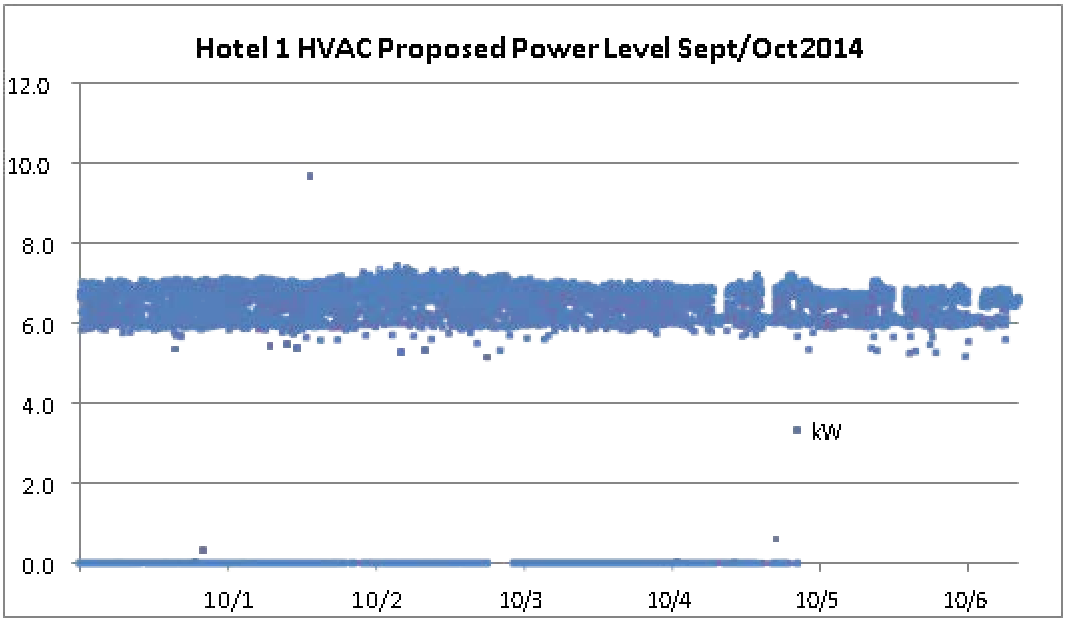


FIGURE 11: PROPOSED HVAC POWER LEVEL SEPT/OCT 2014

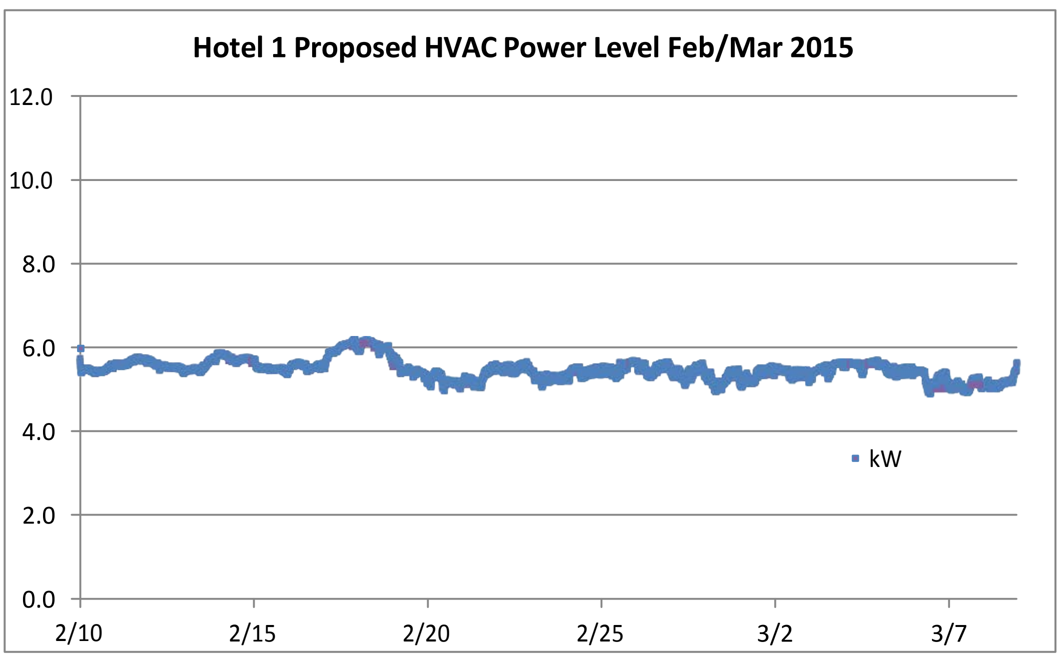


FIGURE 12: PROPOSED HVAC POWER LEVEL FEB/MAR 2015

Water Consumption and Evaporation Estimates

At Hotel 1, the hotel staff provided information on when the sand filters were back washed so the amount of water added after the back wash could be track separately. This allowed for a more accurate estimate of the pool evaporation rate. Table 4 shows that while overall water consumption was reduced by approximately 19%, the evaporation rate was reduced by 40%.

TABLE 4: WATER USAGE AND EVAPORATION LOSSES

Test Condition	Start	End	Duration, Days	Water Added, Gallons/Day	Back Wash, Gallons/Day	Evaporation, Gallons/Day
Base - No Pool Cover	8/20/14	9/29/14	40	6.83	3.44	3.40
Proposed - Pool Cover	9/30/14	11/3/14	34	5.56	3.53	2.03
Savings, %				**19%**		**40%**

Testing at Hotel 2

The following data was obtained at Hotel 2 which was located in a different suburb of Minneapolis, Minnesota. Hotel 2 had an HVAC system using outdoor air dilution to dehumidify the space with a DX coil to dehumidify during summer months. The HVAC system could operate between 20% and 100% fresh air and air was heated by natural gas. There was a rooftop unit that provided direct expansion cooling to a coil in the supply duct. The pool water temperature was maintained at 87°F. Table 5 provides a summary of the data logging periods. The surface area of the pool water was 630 ft^2.

TABLE 5: MONITORING PERIODS FOR HOTEL 2

Test Condition	Start	End	Duration, Days
Base - No Pool Cover	8/18/14	9/8/14	21
Proposed - Pool Cover	9/9/14	10/6/14	27

Environmental Conditions

Figure 13 shows the poolroom conditions in the baseline condition without the liquid pool cover. The average room temperature was 79°F and the average relative humidity was 79%. The pool water temperature, which was manually recorded, was 86°F. This is an example where the pool room was not being operating in an energy efficient manner. Appendix 2 provides a summary of data recorded by hotel staff. This hotel was much less engaged in the testing process so it was not easy to make adjustments to the systems.

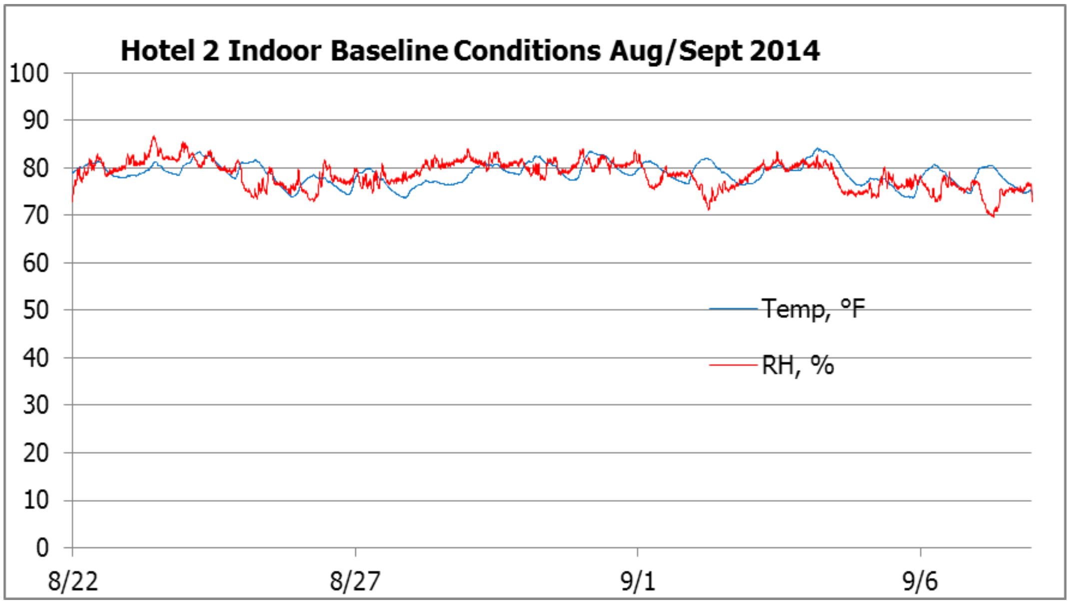


FIGURE 13: INDOOR CONDITIONS BASELINE AUG/SEPT 2014

Figure 14 shows the poolroom conditions in the proposed condition with the liquid pool cover in use. The average room temperature was 77°F and the average relative humidity was 75%.

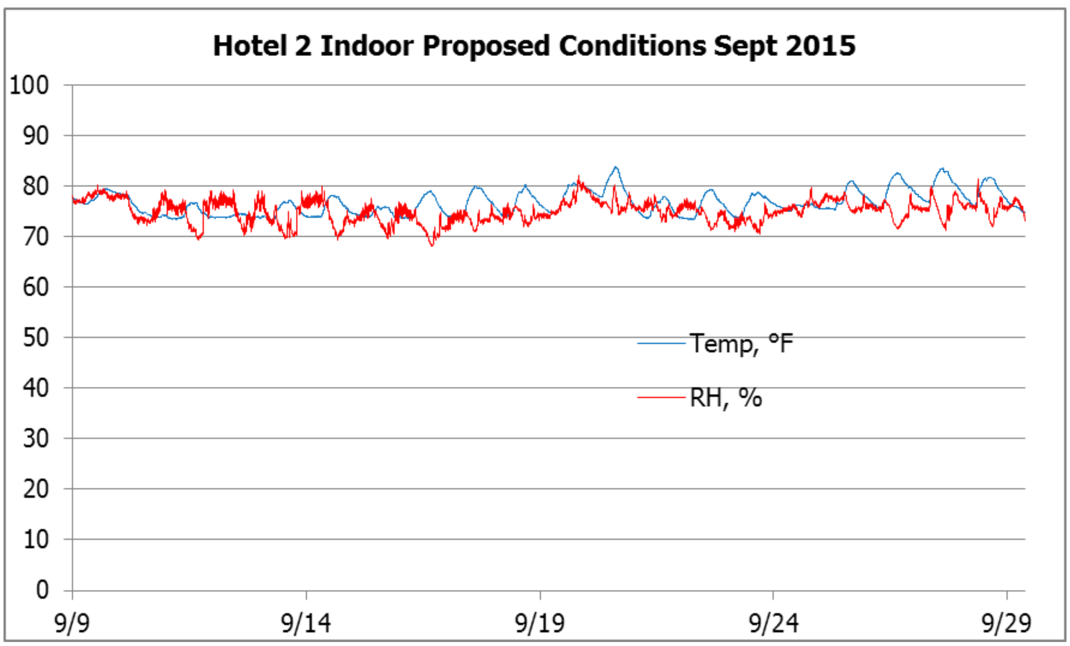


FIGURE 14: INDOOR CONDITIONS PROPOSED SEPT 2014

Figure 15 shows the outdoor conditions in the baseline condition without the pool cover. The average outdoor temperature was 72°F and the average relative humidity was 75%.

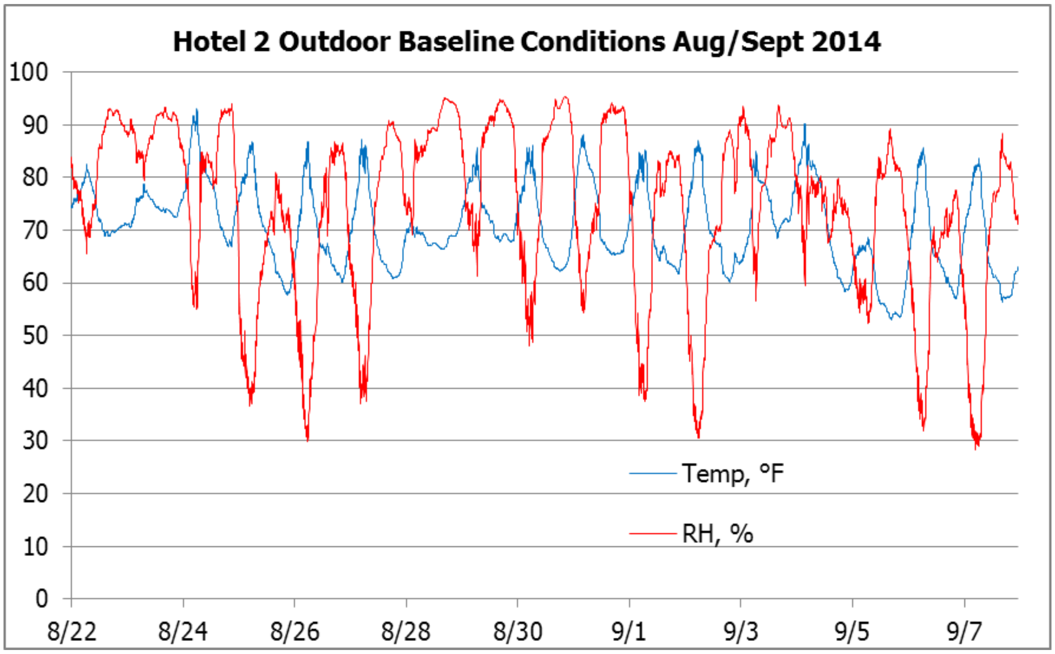


FIGURE 15: OUTDOOR CONDITIONS HOTEL 2 BASELINE CONDITION

Figure 16 shows the outdoor conditions in the proposed condition with the liquid pool cover. The average outdoor temperature was 62°F and the average relative humidity was 71%. Both the baseline and proposed conditions are reflective of typical outdoor conditions in Minnesota.

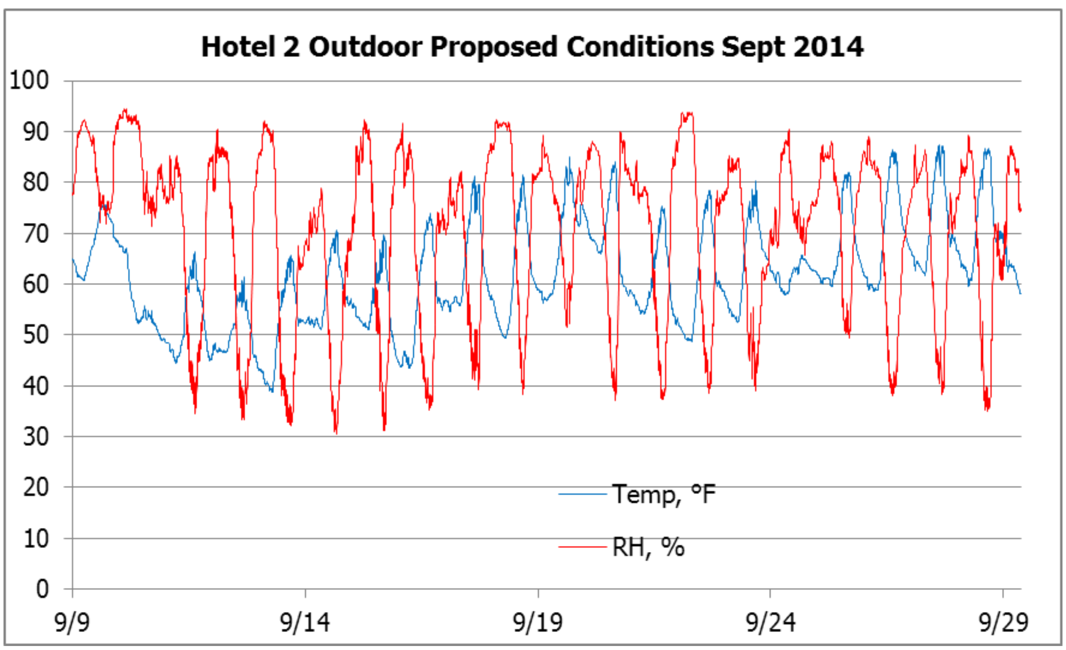


FIGURE 16: HOTEL 2 OUTDOOR CONDITIONS HOTEL 2 PROPOSED

Measured Energy Consumption

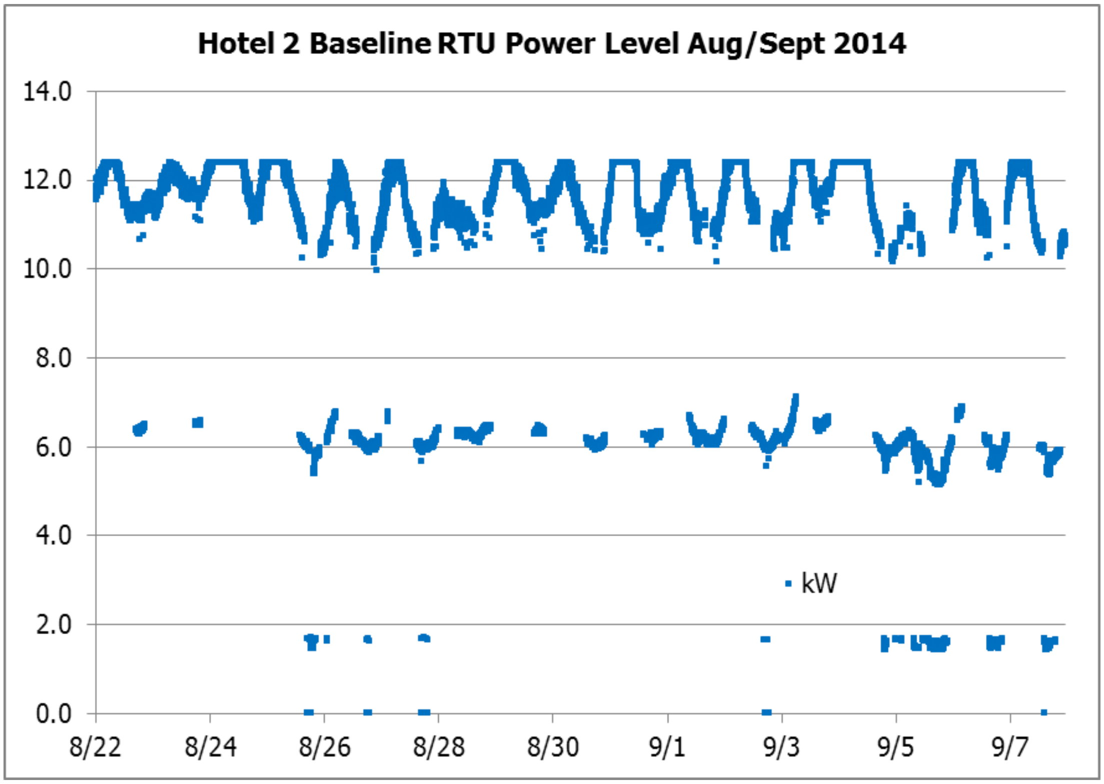


FIGURE 17: BASELINE COOLING COIL ENERGY CONSUMPTION AUG/SEPT 2014

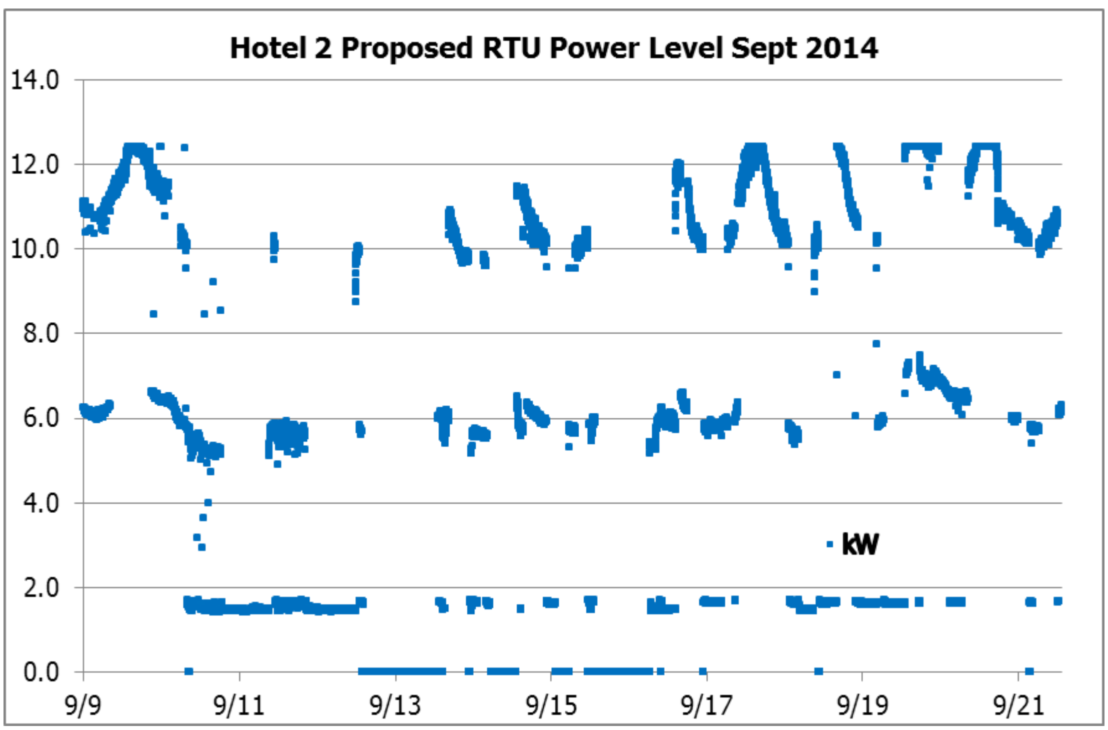


FIGURE 18: PROPOSED COOLING COIL ENERGY CONSUMPTION SEPTEMBER 2014

Figure 17 and Figure 18 show the measured energy use for the rooftop unit for the baseline and proposed periods observed. This unit supplied the main HVAC system with cooling and dehumidification capacity so it is only measuring a portion of the energy consumed by the HVAC system. The average kW load in the baseline condition was 10.0 kW. In the proposed condition in the month of September, the average kW load was 6.6 kW. Since outdoor air conditions were different no conclusions can be made about whether this data indicates energy was saved.

Water Consumption and Evaporation Estimates

At Hotel 2, the hotel staff did not track when the sand filters were back washed. Table 4 shows the overall water consumption was reduced by approximately 19%. This number can be compared to the 19% savings measured in Hotel 1, for that pool the evaporation savings was 40%. Since backwash could not be accounted for in this test, this savings estimate is likely conservative.

TABLE 6: WATER USAGE AND ESTIMATED SAVINGS

Test Condition	Start	End	Duration, Days	Water Added, Gallons/Day
Base - No Pool Cover	8/18/14	9/8/14	21	13.0
Proposed - Pool Cover	9/9/14	10/6/14	27	10.5
Savings, %				**19%**

Testing at Hotel 3 and Hotel 4

Hotel 3 and Hotel 4 are both located in the suburbs of Minneapolis. These hotels were offered an opportunity to participate in the testing. The installations occurred in January 2015 and the hotels were provided with the liquid pool cover system with approximately a 6 month supply of chemicals.

Qualitative Feedback from Hotels

All hotels were interviewed to obtain qualitative data on their experience. While this is only qualitative data, the key findings are that there were no guest complaints and they would recommend this product to others. These were significant concerns at the start of the test.

TABLE 7: SUMMARY OF HOTEL FEEDBACK

Question	Hotel 1	Hotel 2	Hotel 3	Hotel 4
Any guest complaints?	None	None	None	None
Other problems?	None	No	Pump lost prime	None
Would you recommend this product to others?	Yes	Yes	Yes	Yes
Have you noticed less chlorine usage?	Yes	No	No	No
Have you noticed less water usage?	No	No	Not asked	Yes

Question	Hotel 1	Hotel 2	Hotel 3	Hotel 4
Have you noticed other benefits?	Safe and easy to use, no affect pool water quality, painless test	None	Less humidity and condensation on windows	Peace of mind
Estimated hour usage during the week	1 hour	1 hour	6-12 hours	1 hour
Estimated hour usage on weekends	10+ hours	10+ hours	8-15 hours	10+ hours

Analysis

Environmental Conditions

Poolroom conditions in Hotel 2 were poorly maintained from an optimal efficiency perspective, this results in additional energy use. Table 8 shows the measured conditions for Hotel 2 compared to recommended values. It appears the humidity controls were not working properly. Higher water temperatures will increase evaporation rates. Keeping room air temperatures below water temperatures also increases the energy consumed by the cooling system because the pool water is always giving off heat to the room.

TABLE 8: ROOM AIR AND WATER TEMPERATURES

Parameter	Recommended	Hotel 2 Baseline	Hotel 2 Proposed
Room Air Temperature	82°F	79°F	77°F
Water Temperature	80°	86°F	86°F
Relative Humidity	50% - 60%	79%	75%

Energy Savings

Effectiveness as Compared to Solid Pool Cover

Once the evaporation savings were determined for the liquid pool cover, a calculation spreadsheet could be used to estimate annual energy savings. The key factors that affect the analysis include:

- The overall U-value of wall and ceiling areas exposed to the outdoors;
- The pool surface area;
- The hours per day the pool is used by the swimmers;
- The outdoor air conditions; and
- The type of HVAC system used to condition the space and the control set points.

Table 9 shows the parameter values used for the evaluation. Bin data was used for outdoor air conditions. Hotel 1 used direct expansion cooling to provide dehumidification, with hot gas heat recovery used to heat pool water. Natural gas was used for supplemental heat for the pool water and electricity used to heat the room air. Hotel 2 dehumidified the space via outdoor air and gas heat. The outdoor air was allowed to vary between 20% to 100% outdoor air. A direct expansion cooling coil was used to dehumidify during summer months.

The energy savings calculation was based on determining a percent effectiveness for the liquid pool cover, as compared to a solid pool cover. For each hotel, percent effectiveness value was adjusted until the evaporation rate reduction matched the values observed in the test. For Hotel 1 this resulted in an effectiveness level of 73% and for Hotel 2 the effectiveness level was 64%. These values are shown in Table 9.

TABLE 9: HOTEL PARAMETERS FOR ANALYSIS

Parameter	Hotel 1	Hotel 2
Building UA Product, Btu/Hr-F	333	378
Pool Surface Area, ft^2	360	630
Pool not in Use Hours per Year	5,460	5,101
Pool in Use Hours per Year	3,287	3,648
Pool Water Temperature	82°F	86°F
Room Air Temperature	82°F	78°F
Pool Air Relative Humidity	61%	77%
Evaporation Rate Reduction	40%	19%
% Effectiveness	73%	64%

Overall Energy Savings

Table 10 and Table 11 summarize the energy savings.

TABLE 10: ESTIMATED ENERGY SAVINGS FOR HOTEL 1

Direct Expansion System with Water Heat Recovery	Baseline	Proposed	Savings	%
Energy Usage for HVAC and Water Heating, kWh	59,000	46,000	13,000	22%
Estimated Demand, kW	10.9	8.5	2.4	22%

TABLE 11: ESTIMATED ENERGY SAVINGS FOR HOTEL 2

Outdoor Air Dilution System with DX Cooling Coil	Baseline	Proposed	Savings	%
Therm Usage for HVAC and Water Heating	2,200	1,600	600	27%
kWh Usage for HVAC and Water Heating	4,400	1,300	3,100	70%
Estimated Demand, kW	1.2	0.4	0.9	71%

Financial Analysis

Table 12 summarizes the estimated energy savings from the liquid pool cover for these two hotels. Even though the energy savings is less for the direct expansion system with water heat recovery, electricity costs more than gas, so the payback is still attractive. Since the chemical feed pump is a one-time cost, the initial investment would pay off in 7-14 months. Each following year the chemicals would be paid for in approximately 2-5 months. Since backwash could not be accounted for at Hotel 2 these energy savings estimates are conservative

TABLE 12: ESTIMATED ENERGY SAVINGS BASED ON REDUCING EVAPORATION BY 30%

	Hotel 1	Hotel 2
HVAC System Type	DX with Water Heat Recovery	Outdoor Air Dilution with DX Cooling
kW Savings, at $9.43/kW	$ 300	$ 100
kWh Savings at $0.07/kWh	$ 900	$ 200
Therm Savings at $0.79/Therm	$ -	$ 400
Total Energy Savings, $	$1,200	$ 700
One Time Equipment Cost	$ 500	$ 500
Annual Chemical	$ 180	$ 320
Payback First Year, months	7	14
Payback After First Year, months	2	5

Conclusions

The following conclusions are presented based on the data obtained and analysis conducted.

- Expect concerns about guest complaints, questions on how the technology works, and the effect on pool water quality and chemical usage.
- Electric and gas savings are possible and based on the HVAC system in place.
- Energy savings of $800 to
- $1,200 dollars per year were calculated for these hotels.
- Utility rebates can help legitimize the energy savings and technology.

The challenge for this measure is that the technology is not well understood, the HVAC systems are diverse and the energy analysis is complex. While this report provides the evidence needed to demonstrate the energy savings, there still will be concerns about guest complaints or adverse effects on operations. These concerns should diminish when there is more market penetration and familiarity with the product.

The liquid pool cover provides a significant savings opportunity for hotels that have indoor pools. The savings will be either gas or electric depending on the type of HVAC system in place. For the two hotels evaluated, energy savings of $800 and $1,200 annually will cover the initial investment of $800 and on-going chemical costs.

These savings can be considered representative of typical mid-scale hotels, based the 38 hotels studied in conjunction with this pool cover research, however other

pool systems in other facilities could have significantly different savings. Savings are dependent on the pool and HVAC systems, the building envelope, and patterns of use.

There is no technology that can replace good equipment maintenance and proper control set points. Hotel 2 provided an example of a hotel where the control set points were not ideal.

Energy waste occurs if pool water and room air temperatures are excessive or if the desired relative humidity is lower than 50%. Likewise, if the relative humidity levels are too high significant damage can occur to the building structure

The non-energy benefits include ease of use compared to a solid pool cover, reduced chemical usage and less condensation on the windows. The liquid cover is effective whenever the pool surface is still. So savings can be achieved even when the pool area is open if no one is using the pool. This condition is common during the week for hotels that cater to the business traveler. While this report did not quantify the pool sanitation chemical usage, it is expected that there will be savings from reduced chemical usage because of the savings demonstrated by solid pool covers.

Utilities may want to consider rebating the initial capital cost of the feed pump to help get hotel owners to try the product. Despite the fast payback, utility rebates for this technology would legitimize the energy savings and help gain market penetration. Rebates could be based on the initial first year costs and chemical costs over the measure lifetime. Measure savings could be calculated on the expected life of the pumps, which should easily last 3 to 5 years.

Appendices

Appendix 1: Manual Data Recorded at Hotel 1

Time	Meter Start	Meter End	Total Gallons	Comfort Rating
8/18/14 1:40 PM	12.0	28.14	16.14	
9/8/14 9:30 AM	28.1	281.83	253.69	
9/9/2014 9:30	281.8	330.2	48.3	3
9/11/2014 9:30	330.2	355.0	24.9	3
9/16/2014 9:30	355.0	399.0	44.0	3
9/22/2014 9:30	399.0	459.0	60.0	
9/26/2014 9:30	459.0	484.0	25.0	
9/30/2014 0:00	484.0	517.0	33.0	
10/3/2014 0:00	517.0	532.0	15.0	
10/6/2014 0:00	532.0	561.0	29.0	
Pool Size	630	**SF**		
Test Period #1	20.8	**Days**		
Water Added	270	**Gallons**		
Water Added	13.0	**Gallons/Day**		
Test Period #2	26.6	**Days**		
Water Added	279	**Gallons**		
Water Added	10.5	**Gallons/Day**		
% Water Savings	**19%**			

Appendix 2: Manual Data Recorded at Hotel 2

Time	Meter Start	Total Meter End	Gallons Pool	Pool Water Temp	Pool Room Temp	Pool Room RH	Comfort Rating	Condensation Rating	Bather Load	Backwash?	Comments	Total Meter Start	Meter End	Gallons Spa	Spa Water Temp	Pool Room Temp	Pool Room RH	Bather Load	Backwash or Drained
Wednesday, August 20, 2014												228.85	234.95	6.1	102	86	55%		
Thursday, August 21, 2014									4			234.95	246.75	11.8	102	86	53%		
Friday, August 22, 2014									10			246.75	257.9	11.15	102	86	55%		
Saturday, August 23, 2014									5			257.9	265.8	7.9	102	86	55%		
Sunday, August 24, 2014									10			265.8	273.9	8.1	102	86	55%		
Monday, August 25, 2014	367.1	389.9	22.8	82	86	53%			0	Yes		273.9	367.1	93.2	102	86	53%		Yes
Tuesday, August 26, 2014	394.5	409.8	15.3	82	86	56%			1			389.9	394.5	4.6	102	86	56%	1	
Wednesday, August 27, 2014			0			56%			2			409.8	413.3	3.5	102		56%	1	
Thursday, August 28, 2014			0			59%			4			413.3	417.3	4	102		59%	4	
Friday, August 29, 2014	421.9	434.2	12.3	82	87	80%	2	3	2			417.3	421.9	4.6	102	87	80%	2	
Saturday, August 30, 2014			0	82	87									0	102	87			
Sunday, August 31, 2014			0	82	85							434.2	443	8.8	102	85			
Monday, September 01, 2014	443	474	31	82	85	67%	2		6		ok	474	478.8	4.8	102	85	67%	4	
Tuesday, September 02, 2014	570	583.8	13.8	82	85	57%				Yes	slight moisture on windows	478.8	570	91.2	102	85	57%		Yes
Wednesday, September 03, 2014			0	82	87	78%						583.8	590.8	7	102	87	78%		
Thursday, September 04, 2014			0	82	85	68%								0	102	85	68%		
Friday, September 05, 2014			0	82	85	75%					heavy moisture on windows	590.8	601.7	10.9	102	85	78%		
Saturday, September 06, 2014	601.7	622	20.3	82	86	55%			6			622.6	630.2	7.6	102	85	58%	4	
Sunday, September 07, 2014			0	82	86	55%	2	0.5	4		very slight moisture on windows very	630.2	638.8	8.6	102	86	55%	2	
Monday, September 08, 2014	729.7	756.7	27	83	87	81%	4	0.5	4	Yes	slight moisture on windows very	638.8	729.7	90.9	102	87	81%		Yes
Tuesday, September 09, 2014			0	83	87	79%	4		6		slight moisture on windows very	756.7	765.9	9.2	90				
Wednesday, September 10, 2014			0					0.5			slight moisture on windows very								
Thursday, September 11, 2014	765.9	780.7	14.8	83	85	82%		0.5			slight moisture on windows very								
Friday, September 12, 2014			0	83	86	81%		0.5	4		slight moisture on windows								
Saturday, September 13, 2014			0	83	85	81%		0.5	5										
Sunday, September 14, 2014			0	83	85	82%		0.5	3										
Monday, September 15, 2014	780.7	806.8	26.1	83	86	79%				Yes	slight moisture								
Tuesday, September 16, 2014			0	82	87	81%			7		slight moisture								
Wednesday, September 17, 2014			0	82	87	81%					slight moisture								
Thursday, September 18, 2014																			
Friday, September 19, 2014																			
Saturday, September 20, 2014	806.8	835.1	28.3	83	86	80%	4	0.5	10		slight moisture								
Sunday, September 21, 2014																			
Monday, September 22, 2014	835.1	855	19.9	82	87	80%				Yes	slight moisture								
Tuesday, September 23, 2014	855	867.7	12.7	82	85	79%		0.5	4		slight moisture								
Wednesday, September 24, 2014			0	82	87	80%		0.5			slight moisture								
Thursday, September 25, 2014				82	85	80%					slight moisture								
Friday, September 26, 2014			0	82	85	81%					slight moisture	867.7	883.5	15.8					
Saturday, September 27, 2014			0	84	85	81%		0.5	6			883.5	880.5	-3	102			5	
Sunday, September 28, 2014			0	83	86	82%		0.5	3										
Monday, September 29, 2014	980.2	1006.8	26.6	85	83	78%		5		Yes	Dectron not working, Horizon Fixed Feed Syste	880.5	980.2	99.7					Yes
Tuesday, September 30, 2014			0	83	87	54%					slight moisture, Feed started at midnight								
Wednesday, October 01, 2014			0	83	87	59%					slight moisture	1006.8	1017.6	10.8					Yes
Thursday, October 02, 2014			0									1017.6	1021.7	4.1	102			1	Yes
Friday, October 03, 2014												1021.7	1026.4	4.7	102				Yes
Saturday, October 04, 2014	1032.7	1050.8	18.1	82	84	50%	3	0.5	7		5 - 10 people, slight moisture	1026.4	1032.7	6.3					Yes
Sunday, October 05, 2014			0	82	81	81%	3	0.5	10	Yes	7 - 12 people, slight moisture								Yes
Monday, October 06, 2014	1150.8	1180.9	30.1	82	86	82%		0.5	4	Yes	slight moisture								Yes
Tuesday, October 07, 2014																			Yes

Time	Meter Start	Meter End	Total Gallons Pool	Pool Water Temp	Pool Room Temp	Pool Room RH	Comfort Rating	Condensation Rating	Bather Load	Backwash?	Comments	Meter Start	Meter End	Total Gallons Spa	Spa Water Temp	Pool Room Temp	Pool Room RH	Bather Load	Backwash or Drained
Saturday, October 11, 2014												1217.8	1222.9	5.1	102				**Yes**
Sunday, October 12, 2014												1222.9	1229.4	6.5	102				**Yes**
Monday, October 13, 2014	1322.6	1367.2	44.6	82.5	87	81%		0.5	9	Yes	8-9 people, slight moisture	**1229.4**	**1322.6**	**93.2**					**Yes**
Tuesday, October 14, 2014												**1367.2**	**1379.9**	**12.7**					
Wednesday, October 15, 2014																			
Thursday, October 16, 2014												1379.9	1384.8	4.9	102				
Friday, October 17, 2014	1391.8	1404.9	13.1									1384.8	1391.8	7	102				
Saturday, October 18, 2014																			
Sunday, October 19, 2014																			
Monday, October 20, 2014	1505	1544	39	82	85	82%				Yes		**1404.9**	**1505**	**100.1**					**Yes**
Tuesday, October 21, 2014																			
Wednesday, October 22, 2014												**1544**	**1566.2**	**22.2**					
Thursday, October 23, 2014																			
Friday, October 24, 2014																			
Saturday, October 25, 2014												1566.2	1571.4	5.2	102				
Sunday, October 26, 2014	1571.4	1596.3	24.9		86	82%						1596.3	1600.9	4.6	102				
Monday, October 27, 2014												1600.9	1606.8	5.9	102				
Tuesday, October 28, 2014	1606	1617	11	82	86	81%			0										
Wednesday, October 29, 2014									4										
Thursday, October 30, 2014									0			1617	1634.2	17.2	102				
Friday, October 31, 2014									0			1634.2	1647.7	13.5	102				
Saturday, November 01, 2014									0										
Sunday, November 02, 2014									2										

Pool Size 360 **SF**

Baseline 39.6 **Days**

Total Water Added	6.83	**Gallons/Day**
Back Wash Lost	3.44	**Gallons/Day**
Amount Lost to Evaporation	3.40	**Gallons/Day**
Avg Pool Water Temp	82	
Avg Pool Room Temp	86	
Avg Pool Room RH	74%	

Base Test Period 40.4 **Days**

Total Water Added	12.6	**Gallons/Day**
Back Wash Lost	9.3	**Gallons/Day**
Amount Lost to Evaporation	3.3	**Gallons/Day**

Proposed 33.0 **Days**

Total Water Added	5.56	**Gallons/Day**
Back Wash Lost	3.53	**Gallons/Day**
Amount Lost to Evaporation	2.03	**Gallons/Day**
% Savings Accounting for Backwash	40%	
% Savings if Backwash not Accounted for	19%	
Avg Pool Water Temp	82	
Avg Pool Room Temp	85	
Avg Pool Room RH	74%	

Proposed 32.6 **Days**

Total Water Added	11.0	**Gallons/Day**
Back Wash Lost	8.1	**Gallons/Day**
Amount Lost to Evaporation	2.9	**Gallons/Day**